UNIVERSITY of PENNSYLVANIA

School of Arts and Sciences
Department of Physics and Astronomy

PHYSICS 008 – Fall, 2009

General Information:

The class will meet in DRL A2 from 12:00 noon to 12:50 p.m. on Mondays, Wednesdays, and Fridays. There will be two "midterm" examinations. The first will be on October 7, 2009 and the second will be on November 9, 2009. The final examination is currently scheduled from 12:00 noon until 2:00 p.m. on Thursday, December 17, 2009. I also expect to give several short quizzes during the semester. These quizzes will have only a modest effect on your grades in the course, but they will give me some idea of how effectively you are learning the material and give you some idea of what to expect on the examinations.

I will use *Blackboard* (https://courseweb.library.upenn.edu) to post assignments, announcements, reminders, and general information about the course. I will assign homework problems regularly, and provide solutions to those problems shortly after they are "due". The homework problems will neither be collected nor graded. However, most students who have ignored them in the past have encountered difficulty on the quizzes and on the examinations.

Text:

The text for the course is Volume I of the sixth edition of *Physics – Principles with Applications* by Douglas C. Giancoli (Pearson/Addison Wesley – 2005). I hope to be able to cover most of the material in the first fifteen chapters by the end of the semester.

Grades:

Grades on quizzes, midterm examinations, and the final examination will be weighted in the following fashion to determine grades for the course:

Quizzes	10%
Midterm Examinations	20% (each)
Final Examination	50%

Office Hours:

My "regular" office hours will be from 1:00 p.m. to 2:00 p.m. on Mondays. It has been my experience that any office hours I schedule are inconvenient for most students. Accordingly, I will be happy to make appointments to see students at other times. Since I am on campus most of the time during the week I believe that it will not be difficult to find mutually-convenient times for any appointments you wish to make. The best way to reach me is by e-mail.

Walter D. Wales
2N18 David Rittenhouse Laboratory
Telephone: 215 898-7942
E-mail: wales@physics.upenn.edu

September 9, 2009

SEPTEMBER 9, 2009 – PHYSICS 008

→ HAND OUT

TEXT: OBSCENTLY EXPENSIVE, BUT COVERAGE GOOD
→ W/O CALCULUS, BUT I WILL USE IT ON OCCASION

→ MICROPHONE: CAN EASILY FILL ROOM WITH VOICE BUT NOT FACING BLACKBOARD

BASICALLY, PHYSICS 008-009 IS A ONE-YEAR INTRODUCTORY COURSE IN PHYSICS

I INTEND TO EMPHACISE ANY ASPECTS OF POTENTIAL USE TO PROSPECTIVE ARCHITECTS

ARCHITECT – RESPONSIBLE FOR CREATION OF STRUCTURES – OFTEN INHABITED BY HUMANS

1. SHOULD NOT FALL DOWN (PHYSICS CAN HELP)

2. SHOULD BE ATTRACTIVE & FUNCTIONAL (PHYSICS NOT MUCH HELP)

3. SHOULD BE ECONOMICAL (TO HEAT, LIGHT, ETC
→ MAIN CONCERN: PROCURMENT, TRANSPORT, & USE OF ENERGY
(PHYSICS IS KEY)

SO: GET TEXT, READ CHAPTER 1

TODAY: HIGH POINTS OF CH. 1, START CHAPT 2

FRIDAY: WILL ASSIGN SOME PROBLEMS:

<u>SECTION 1-3</u>: IMPORTANT FEATURE OF SCIENCE

BASED ON OBSERVATION — THEORIES & LAWS ARE ALWAYS TENTATIVE

OBSERVE

CREATE THEORY TO EXPLAIN OBSERVATION

TEST THEORY WITH NEW OBSERVATIONS

→ FAILS → BACK TO DRAWING BOARD

→ SUCCEED → TRY A HARDER TEST

EXAMPLE: CHAPTER 4: NEWTON'S LAWS

→ FOUNDATION OF CLASSICAL MECHANICS

ACCEPTED & USED FOR 200 YEARS

<u>BUT</u>

TEST NOW SHOW THAT THEY ARE INADEQUATE AT VERY HIGH VELOCITIES

SECTION 1-4:

MEASUREMENT, UNCERTAINTY, & SIGNIFICANT FIGURES

→ IN LABORATORY COURSE WE PROVIDE COHERENT APPROACH TO ANALYSIS OF EXPERIMENTAL UNCERTAINTIES

BUT THIS ISN'T SUCH A COURSE:

1) REALIZE EACH NUMBER HAS UNCERTAINTIES

2) ALSO REALIZE THEY MAY NOT BE KNOWN OR STATED

→ FREQUENTLY USED RULE : UNCERTAINTY IS HALF OF ~~DIGIT~~ UNIT IN LAST DIGIT

$\rightarrow 3.57 = 3.57 \pm .005$

BUT WHAT ABOUT 8' 2X4

IS IT $8 \pm \frac{1}{2}$? NO WAY!

GENERAL RULE FOR THIS COURSE:

3 FIGURES IS GENERALLY MORE THAN ADEQUATE

DO NOT DEVOTE TOO MUCH WORRY TO THIS

SCIENTIFIC NOTATION: USE POWER OF TEN TO DENOTE LARGE OR SMALL NUMBERS.

$C = 3.00 \times 10^{8}$ m/s NOT 300,000,000 M/S

UNITS: SCIENCE USES METRIC (MKS) SYSTEM

UNFORTUNATELY U.S. HAS NOT JOINED THE REST OF THE WORLD AND CONTINUES TO USE ENGLISH UNITS

BUILD SOMETHING – OR HAVE SOMETHING BUILT
→ USE FEET + INCHES

NOTE ON TABLE 1-4 "METRIC PREFIXES"

VERY USEFUL FOR SPECIALISTS IN SOME AREAS

→ BUT WE AREN'T, SO WE'LL MOSTLY STICK TO POWERS OF TEN

(i.e. DON'T WASTE TIME MEMORIZING TABLE)

CONVERSION OF UNITS → EITHER WITHIN METRIC OR TO ENGLISH

MULTIPLY BY UNITY

TO USE IN EQUATIONS $\frac{50 KM}{HR} \times \frac{1 HR}{3600 s} \times \frac{1000 m}{KM} = 13.9 \frac{m}{s}$

(NOT 13.888888)

$\frac{25 m}{s} \times \frac{3.28 F}{M} \times \frac{1 MILE}{5280 FT} \frac{3600 s}{MIL}$

$= 55.9 MPH \sim 55 MPH$

TO GET SENSE OF MAGNITUDE

CHAPTER 2:

ESSENTIALLY DEFINITIONS → BUT USEFUL ONES (IN ONE DIMENSION)

POSITION – RELATIVE TO SOMEWHERE

TRACK – CONVENTIONAL TO CALL HORIZONAL POSITION ~~DISTANCE~~ "X"

DISTANCE = $X_2 - X_1$ → NOTE COULD BE NEGATIVE

NOT VERY INTERESTING – TURN ON AIR, LET GLIDER MOVE – ESSENTIALLY FREE OF ALL INFLUENCE

VELOCITY

$$= v_{AVG} = \frac{X_2 - X_1}{t_2 - t_1}$$

(NOT $\bar{v}$ BECAUSE $\bar{v}$ USED LATER)

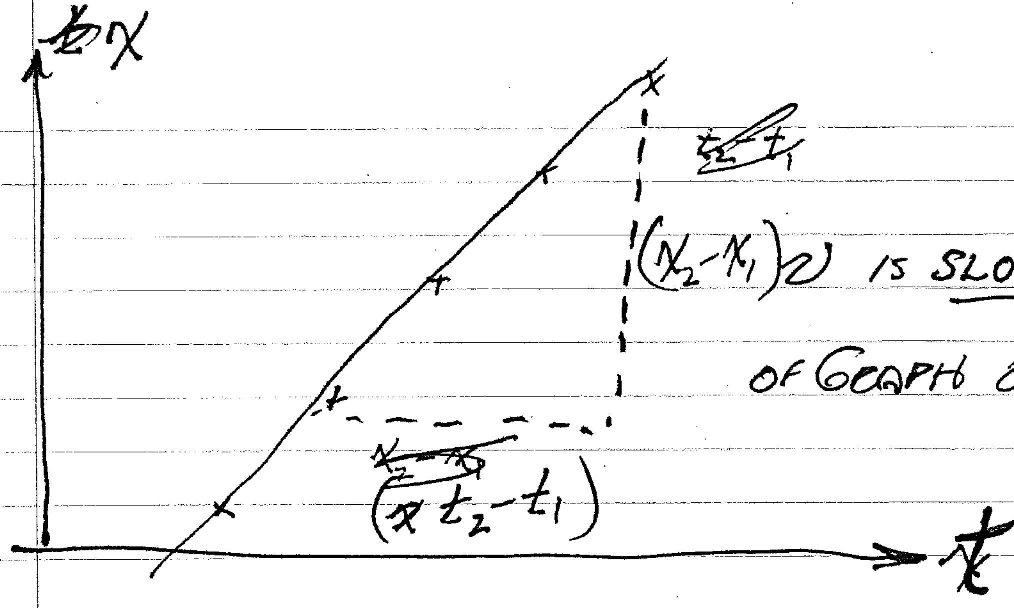
NOTE THAT v HAS DIRECTION:

$X_2 > X_1$ v POSITIVE

$X_2 < X_1$ v NEGATIVE

LOOKS REASONABLY CONSTANT:

IF WE TOOK DATA (X OF t) WE WOULD GET A TABLE OF X + t & COULD MAKE GRAPH:



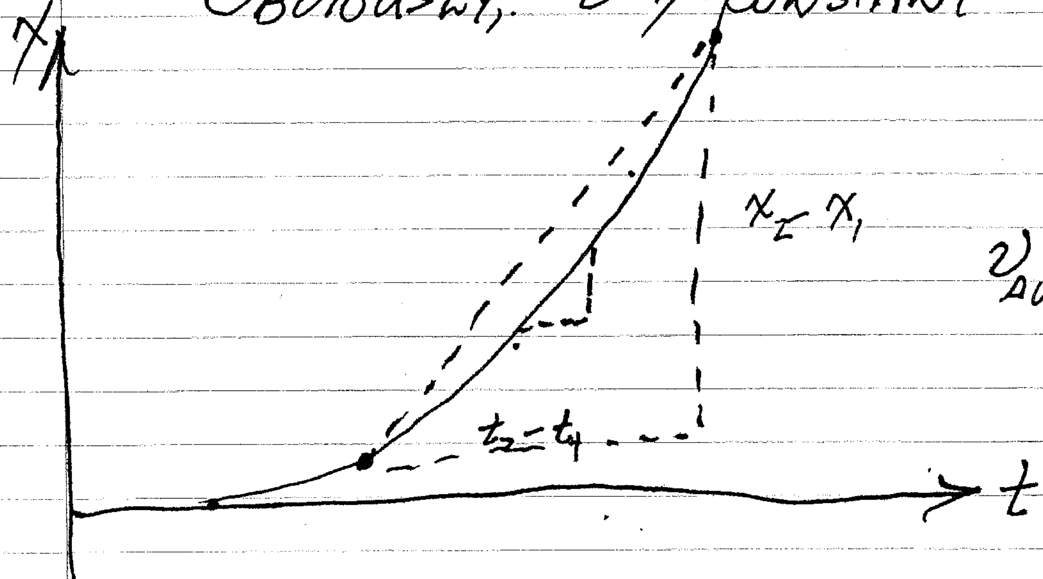
v IS SLOPE

OF GRAPH OF X VS t

NOW TILT TRACK:

STARTS AT REST ($v = 0$),
GOES FASTER

OBVIOUSLY, $v \neq$ CONSTANT



$$v_{AVG} = \frac{x_2 - x_1}{t_2 - t_1}$$

MEASURE X VS t

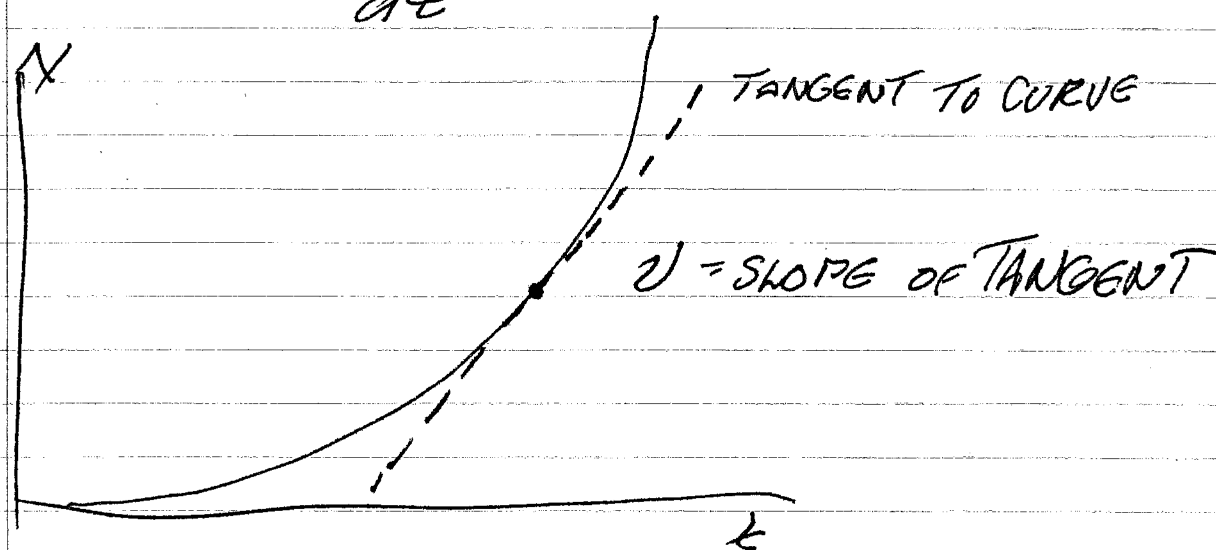
NOW SUPPOSE WE TAKE SMALLER $x_2 - x_1$

$$v_{INST.} = \frac{\Delta x}{\Delta t}$$

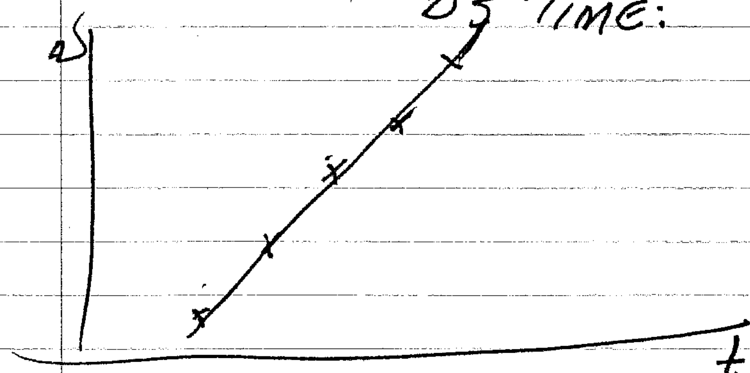
OR: $v = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t}$

THIS IS DEFINITION OF DERIVATIVE:

$v = \frac{dx}{dt}$ = SLOPE AT ANY POINT



SUPPOSE WE CALCULATED SLOPE, PLOTTED IT vs TIME:



IN THIS CASE, WE WOULD FIND A STRAIGHT LINE

SEPTEMBER 11, 2009

ADMINISTRATIVE DETAILS:

QUIZ #1 - WEDNESDAY
1 PROBLEM
FORM PROVIDED, USE CALCULATOR

OFFICE HOURS NEXT WEEK:

TUESDAY: 1PM - 3PM

(OR BY APPOINTMENT - wales@physics.upenn.edu

FOR MONDAY: READ CHAPTER 2

PROBLEMS: CHAPT. 2: 27, 39, 46, 53, 63, 64, 66, 75

LAST TIME: DEFINITIONS: $v_{AVG} = \frac{\Delta x}{\Delta t}$

$$v = v_{INST} = \frac{dx}{dt}$$

$$a_{AVG} = \frac{\Delta v}{\Delta t}$$

$$a = a_{INST} = \frac{dv}{dt}$$

SPECIAL CASE: a = CONSTANT

ACCELERATION = a

DEFINE: $a_{AVG} = \dfrac{v_2 - v_1}{t_2 - t_1}$

AND $a_{INST} = a$ = SLOPE OF TANGENT

$= \dfrac{dv}{dt}$

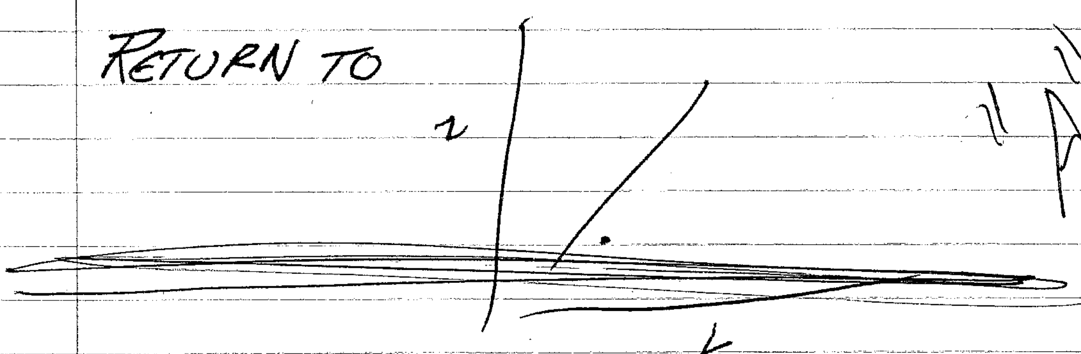
→ COULD LOOK AT MORE GENERAL CASE

$\dfrac{da}{dt}$, ETC

→ BUT NOT USEFUL

"A" LEVEL PHYSICS

RETURN TO



$a_{INST} = a_{AVG}$ = CONSTANT ←

"UNIFORMLY-ACCELERATED MOTION:

SPEND SOME TIME ON IT BECAUSE

a) REAL WORLD HAS SITUATIONS WHERE a = CONST IS CLOSE TO REALITY

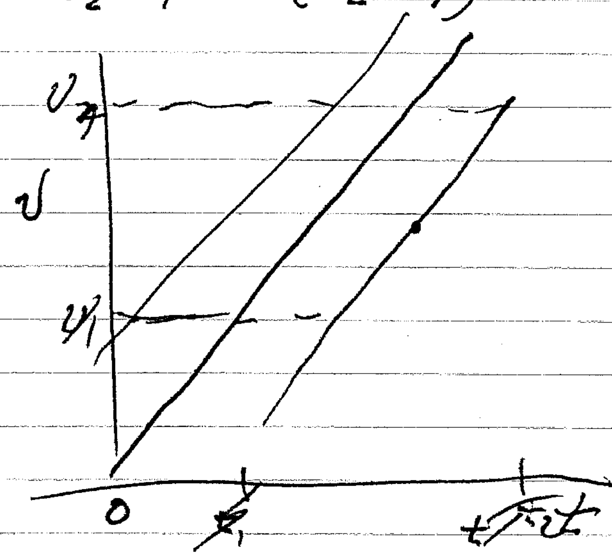
b) SIMPLE EQUATIONS PROVIDE OPPORTUNITY TO REFRESH ALGEBRA SKILLS

SUPPOSE a = CONSTANT

(1) THEN $v = v_0 + at$ (OR $v_2 - v_1 = a(t_2 - t_1)$)

$$v_{AVG} = \frac{v + v_0}{2}$$

$$= v_0 + \frac{at}{2}$$



$$x = x_0 + v_{AVG}\, t$$

(2) $$= x_0 + v_0 t + \frac{at^2}{2}$$

COMBINING (1) & (2)

$$at = v - v_0 \qquad t = \frac{v - v_0}{a}$$

$$x - x_0 = v_0 \frac{(v - v_0)}{a} + a\frac{(v - v_0)^2}{2a^2}$$

$$= \frac{v^2 - v_0^2}{2a}$$

SIMPLER USING CALCULUS:

a = CONST

$$\int_{v_0}^{v} dv = \int_0^t a\,dt$$

$$v - v_0 = at$$

$$v = v_0 + at = \frac{dx}{dt}$$

$$dx = (v_0 + at)\,dt$$

INTEGRATE: $x - x_0 = v_0 t + \frac{at^2}{2}$

THIRD: $v = \frac{dx}{dt}$

$$\int_{v_0}^{v} v\,dv = \frac{dx}{dt}\,dv = \frac{dx}{dt}\,a\,dt = \int_{x_0}^{x} a\,dx$$

$$\frac{v^2 - v_0^2}{2} = a(x - x_0)$$

NOW FORGET ORIGIN, LOOK AT FEW EXAMPLES:

a = (ALMOST) CONSTANT : DROP DENSE OBJECT NEAR EARTH'S SURFACE

$2m = \frac{10t^2}{2} = 5t^2$

$a \simeq -9.8\,m/s^2$ (DOWN)

$t = \sqrt{.4} \sim .65$

– WHY DENSE? → AIR RESISTANCE IS BIG FACTOR FOR LIGHT OBJECTS

WHY NEAR EARTH?

a SMALLER AS YOU GET FAR FROM EARTH

DROP OBJECT FROM BUILDING 45 M HIGH

HOW LONG, HOW FAST, ETC.

USE $y = y_0 + v_0 t + \frac{at^2}{2}$

USE $a = -10$ (TO MAKE ARITH. EASIER)

AT $t = 0$ $y_0 = 45$, $v_0 = 0$

AT t $y = 0$

$$0 = 45 + 0(t) + (-10)\frac{t^2}{2}$$

$$t^2 = 9$$

$t = \pm 3$ sec $t = 3$ ANSWER

$t = -3$ THROW FROM GROUND STOPS AT 45

VELOCITY $v = v_0 + at$

$$= 0 + (-10)(3) = -30 \text{ m/s}$$

NOTE: $v^2 = v_0^2 + (y - y_0)2a$

$$= 0 + (0 - 45)(2(-10))$$

$$= 900$$

$v = \pm 30$ -30 DROP

$+30$ THROW TO REACH TOP

I WILL ASSIGN A FEW TO GIVE YOU PRACTICE DOING PROBLEMS

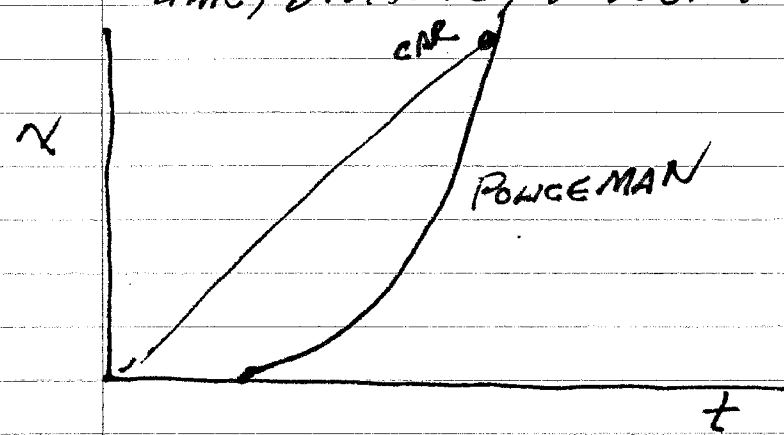
MORE COMPLICATED

POLICEMAN AT TRAFFIC LIGHT

MOTOR BUSY TEXTING BLOWS LIGHT AT 15 m/s (~35mph)

POLICEMAN DOES DOUBLE TAKE, ONE SECOND TO RECOVER FROM SURPRISE, THEN STARTS PURSUIT AT 6 m/s²

TIME, DISTANCE, VELOCITY:



$$x_M = v_0 t = 15t$$

$$x_p = \frac{at^2}{2} = \frac{6t^2}{2}$$

SET $x_m = x_p$ $\quad 15t = \frac{6t^2}{2}$

$t = 0, 5$ sec

?

PROBLEM: NOT SAME "t"

$$x_M = 15t$$

$$x_p = \frac{6(t-1)^2}{2} = 3t^2 - 6t + 3$$

$$3t^2 - 6t + 3 = 15t$$

$$3t^2 - 21t + 3 = 0$$

$$t^2 - 7t + 1 = 0$$

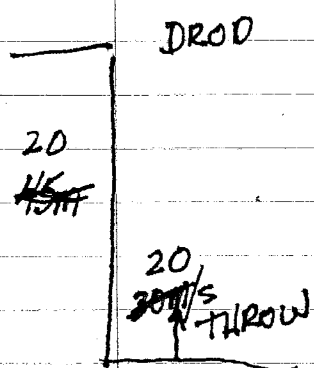
$$t = \frac{7}{2} \pm \sqrt{\frac{49}{4} - 1}$$

$$= 3.5 \pm 3.35 \text{ SEC}$$

$t = 7.8$ SEC, .15 SEC (REFER TO GRAPH)

$$v_p = \cancel{6}at = 6(6.8) = 41 \text{ m/s}$$

DISTANCE $15(7.8) = 117$ m



HOW HIGH WHEN THEY PASS?

(1) $h = \overset{20}{\cancel{45}} - 5t^2$

(2) $h = \overset{20}{\cancel{30}}t - 5t^2$

---

(1) - (2) $\overset{20}{\cancel{45}} - \overset{20}{\cancel{30}}t = 0$

$t = \underset{1}{\cancel{1.5}}$ SEC

$$h_1 = \overset{20}{\cancel{45}} - 5t^2 = 45 - 5(\underset{15}{1.5})^2 = 45 - 11.25$$
$$= 33.75 \text{ m}$$

$$h_2 = \overset{20}{\cancel{30}}t - 5t^2 = 45 - 5(\underset{15}{1.5})^2 = 33.75$$

WORKS!

SEPTEMBER 14, 2009

1. OFFICE HOURS 1-3 PM TUESDAY
   2N18 wales@physics.upenn.edu
2. QUIZ ON CHAPTER 2
   - ONE PROBLEM: 15-20 MIN

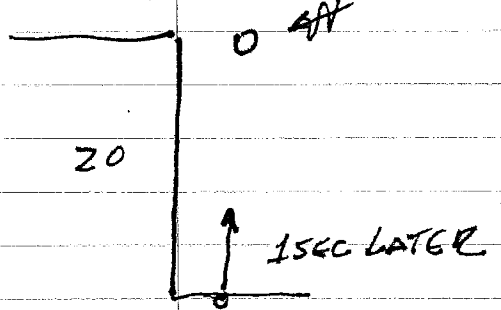
   CALCULATORS ALLOWED, EQUATIONS PROVIDED

TODAY

1. COUPLE MORE EXAMPLES

2. ASSIGNED PROBLEMS

3. ONWARD



$$h_1 = 20 - 5t^2$$

$$h_2 = 20t - 5t^2 \leftarrow \text{BUT NOT SAME } t$$

$$h_2 = 20(t-1) - 5(t-1)^2$$

$$20 - \cancel{5t^2} = 20(t-1) - 5(t-1)^2$$

$$= 20t - 20 - \cancel{5t^2} + 10t - 5$$

$$20 = \cancel{20t}\, 30t - 25$$

$$t = 1.5 \text{ SEC}$$

$$h = 20 - 5(t^2) = 20 - 11.25 = 8.75 \text{ m}$$

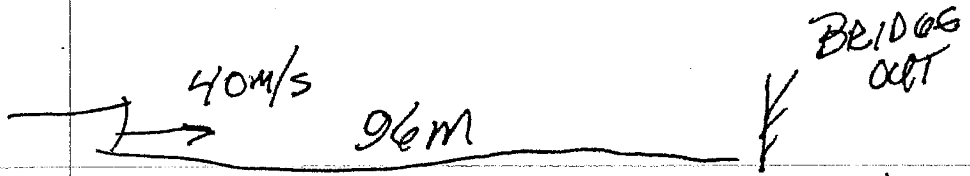
$$h = 20(.5) - 5(.5)^2 = 8.75 \text{ m}$$

HOW FAST?

$$v_1 = 0 - 5(t) = -7.5 \text{ m/s}$$

$$v_B = 20 - 5(.5) = 17.5 \text{ m/s}$$

AUTO



$a_{MAX} = -8\,m/s^2$

$\longrightarrow$ MAKE IT?

$\boxed{1}$ FIND t, THEN VELOCITY

$96 = 40t - 4t^2$

$t^2 - 10t + 24 = 0 \qquad (t-4)(t-6) = 0$

$v = 40 - 8t = 8\,m/s \longrightarrow$ TOO BAD!

($t=6$: ON WAY BACK)

$\boxed{2}$ FIND DISTANCE TO STOP:

$v^2 - v_0^2 = 2a(x - x_0)$

$0 - (40)^2 = 2(-8)(x - x_0)$

$x - x_0 = 100\,m$ (TOO BAD!)

$\boxed{3}$ TO STOP: $v = v_0 + at$

$0 = 40 - 8t \qquad t = 5\,sec$

$x - x_0 = v_{AVG}(t) = \left(\frac{40+0}{2}\right)5 = 100\,m$

(TOO BAD!)

HAND OUT

PROBLEM 53:

→ MORE REALISTIC

NOTE ON ANSWERS – 6TH EDITION ⇒ MOSTLY CORRECT

BUT: SOMETIMES MATTER OF JUDGEMENT (AS IN READING TINY GRAPHS)

PROBLEM 64:

t FOR FOUR METERS

$0 = 4 - 4.9t^2 \quad t = 0.9\text{ SEC}$ (TO SURFACE)

$v = at = -9.8(.9) = -9\text{ m/s}$

HITS SURFACE, STOPS

$$v_{AVG} = \frac{-9+0}{2} = -4.5\text{ m/s}$$

$$h - h_0 = v_{AVG}\, t$$

$-2 - 0 = -4.5t \quad t \sim .45\text{ SEC}$

$$-2 = 0 - 9(.45) + \frac{a(.45)^2}{2}$$

$$-2 = -4 + a\left(\frac{.2}{2}\right)$$

$$a = \frac{2}{.1} = 20\text{ m/s}^2$$

GENERALLY: SEVERAL WAYS – USE ONE YOU'RE MOST COMFORTABLE WITH

CHAPTER 2:

PHYSICS 008
SEPTEMBER 14, 2009

27. $85\frac{km}{HR} \times .278 = 23.6\,m/s$

$v^2 - v_0^2 = 2a(x - x_0)$

$0 - (23.6)^2 = 2a(.8 - 0)$

$a = -349\,m/s^2 = 35.6$ "g"

UNFORTUNATE!

39. $y = y_0 + v_0 t + at^2/2$

$0 = 125 + 5.2t - 4.9t^2$

$t = \frac{5.2 \pm \sqrt{(5.2)^2 + 4(4.9)125}}{9.8}$

$= 5.61s, -4.55s$

46. $y = y_0 + v_0 t + at^2/2$

$0 = 1.5 + v_0(t) - 4.9t^2$

$v_0 = \frac{4.9(2)^2 - 1.5}{2}$

$v_0 = 9.05\,m/s$

53. a) SLOPE $= \frac{50}{10} \cong 5\,m/s^2$

b) SLOPE $= \frac{40}{1.8} \cong 2.2\,m/s^2$

c) SLOPE $= \frac{10}{30} \cong 0.3\,m/s^2$

d) SLOPE $= \frac{44}{27} \cong 1.6\,m/s^2$

63. FRONT REACHES WORKER:

$(25)^2 - 0 = 2a(180)$

$a = \frac{(25)^2}{360}$

BACK REACHES WORKER:

$v^2 - 0 = 2a(x - x_0) = \frac{2(25)^2}{360}(180 + 95)$

$v^2 = 955$; $v = 30.9\,m/s$

64. $v^2 - v_0^2 = 2a(y - y_0)$

INTO WATER:

$v^2 - 0 = 2(-9.8)(0 - 4)$

$= 78.4$

IN WATER: $v_0^2 = 78.4$, $v^2 = 0$

$0 - 78.4 = 2a(-2 - 0)$

$a = 19.6\,m/s^2$

66. $y = y_0 + v_0 t + \frac{at^2}{2}$

TOTAL TIME TO WATER:

$0 = 16 + 0(t) - 4.9t^2$

$t = \sqrt{\frac{16}{4.9}}$

HEIGHT AT $t - .2$ SEC

$h = 16 - 4.9\left(\sqrt{\frac{16}{4.9}} - .2\right)^2$

$= 3.35m$

75. a) $v^2 - v_0^2 = 2a(y - y_0)$

$v^2 - 0 = 2(3.2)1200$

$v = 87.6\,m/s$

b) $t = \frac{h - h_0}{v_{AVG}} = \frac{1200}{87.6/2}$

$= 27.4$ SEC

c) $v^2 - v_0^2 = 2a(y - y_0)$

$0 - (87.6)^2 = 2(-9.8)(y - 1200)$

$y = 1590\,m$

(GO TO TOP OF PAGE)

75. (CONT'D)

d) TIME FROM 1200 TO MAX:

$t = \frac{1590 - 1200}{v_{AVG}}$

$= \frac{390}{87.6/2} = 8.9$ SEC

TOTAL TIME TO MAX:

$8.9 + 27.4 = 36.3$ SEC

e) $v^2 - v_0^2 = 2a(y - y_0)$

$v^2 - 0 = 2(-9.8)(-1590)$

$v = \pm 176.5\,m/s$

(NEGATIVE, IN THIS CASE)

f) TIME TO FALL:

$0 = 1590 - 4.9t^2$

$t = 18.0s$

TOTAL TIME IN AIR:

$36.3 + 18.0 = 54.3$ SEC

CHAPTER 3: _ READ CHAPTER 3:

SPACE IS 3 DIMENSIONAL

LINEAR MOTION IS TOO RESTRICTIVE

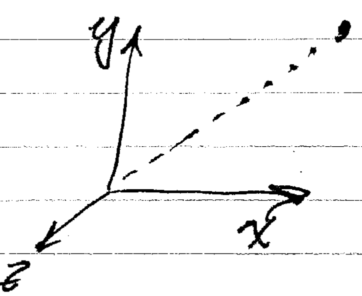
3-DIMENSIONAL IS MESSY

BUT 2-DIMENSIONAL IS EASIER AND

MOST PROBLEMS CAN BE REDUCED TO

TWO DIMENSIONS

(EXAMPLE: PROJECTILE)



ROTATE COORDINATE FRAME

IMPORTANCE – NOT FOR PROJECTILE MOTION,

BUT FOR PRACTICE WITH VECTORS:

MATHEMATICALLY, VECTOR ≡ DIRECTED LINE SEGMENT

PHYICALLY: MANY IMPORTANT ~~Q~~ PHYSICAL ELEMENTS

HAVE MAGNITUDE AND DIRECTION

VELOCITY, ACCELERATION (FORCE, GRAVITATIONAL FIELD ETC)

SEPTEMBER 16, 2009

TODAY: CONTINUE CHAPT. 3

QUIZ ON CHAPTER 2

READ CHAPTER 3

FRIDAY: REVIEW QUIZ, FINISH CHAPTER 3

MONDAY: CHAPTER 3 PROBLEMS

21, 31, 37, 46, 64, 65, 67, 69

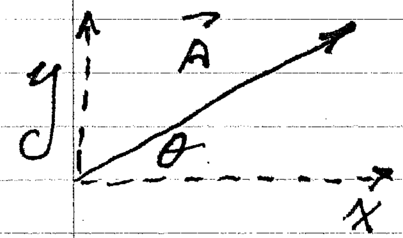
WEDNESDAY: QUIZ #2 CHAPTER 3

BLACKBOARD NOW CONTAINS:

PROBLEM ASSIGNMENTS

PROBLEM SOLUTIONS

TO SPECIFY:



$|A|$ AT $\measuredangle\ \theta$

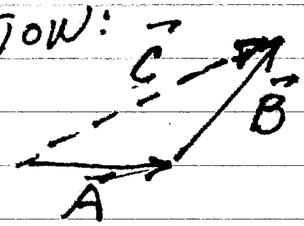
OR A_x, A_y WHERE

$$A_x = A\cos\theta$$

$$A_y = A\sin\theta$$

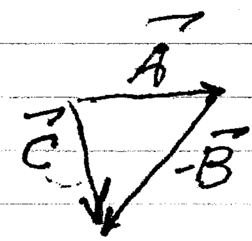
ADDITION & SUBTRACTION:

$$\vec{C} = \vec{A} + \vec{B}$$



$$\vec{C} = \vec{A} - \vec{B} = \vec{A} + (-\vec{B})$$

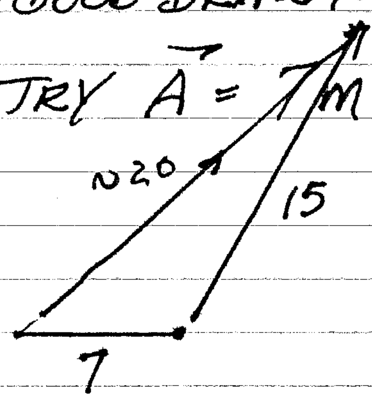
⟹



MANIPULATION:

1 GOOD DRAWING

TRY $\vec{A}$ = 7 m EAST, $\vec{B}$ = 15 m @ 53° N of E

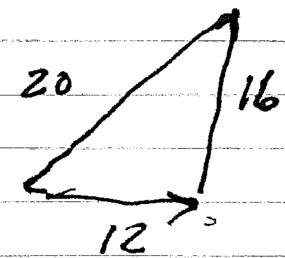


2

COMPONENTS:

$A_x = 7 \quad A_y = 0$

$B_x = 15\cos 53 = 9 \quad B_y = 15\sin 53 = 12$



$C_x = A_x + B_x = 16$

$C_y = A_y + B_y = 12$

$\vec{C} = 20 @ 37°$ N OF E

3 LAW OF COSINES:

✓ EXT. ANGLE

$$C^2 = A^2 + B^2 + 2AB\cos\theta$$

$$= 49 + 225 + 2(7)15(.6)$$

$$= 49 + 225 + 126 = 400$$

USING COMPONENTS: DULL BUT RELIABLE

SPECIAL CASE: PROJECTILE MOTION:

→ ACCELERATION = 0 IN ONE DIRECTION

= CONSTANT IN ⊥ DIRECTION

→ NEITHER PROFOUND NOR VERY USEFUL

: BUT GOOD PRACTICE WITH VECTORS, SOLVING PROBLEMS

MOST COMMON INSTANCE — OBJECTS MOVING NEAR EARTH:

$a_y = -9.8\ m/s^2$

$a_x = 0$

UP ≡ POSITIVE

$y = y_0 + v_{0y} t + \frac{at^2}{2} \rightarrow y_0 + v_{0y} t - 4.9t^2$

$x = x_0 + v_{0x} t$

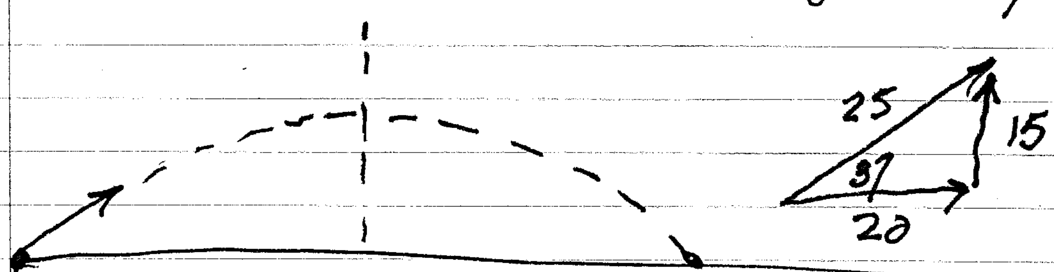
t SAME FOR BOTH

DEMO: IN y → UP, STOP, DOWN

x → CONSTANT VELOCITY

TRY SIMPLEST EXAMPLE:

THROW OBJECT AT $37°$ WITH $v_0 = 25\ m/s$



HOW HIGH? HOW LONG IN AIR?

HOW FAR? SET $x_0 = 0$, $y_0 = 0$

$x = v_{0x} t = 25(\cos 37°)t = 20t$

CAN'T SOLVE, GO TO y

SEPTEMBER 18, 2009

QUIZ - MOSTLY NO PROBLEM: (IN FILES)

NOTE 1 - 10^- TRIVIAL MISTAKE

$9\frac{1}{2}$ LESS TRIVIAL

RECORD: ONLY WHOLE NUMBER

$10^- \equiv 10$

$8\frac{1}{2} \equiv 9$

NOTE 2: QUIZ GRADE FOR SEMESTER

→ WILL DROP 2 LOWEST GRADES

OFFICE HOURS: MONDAY 1PM → 3PM

-OR-

e-MAIL wales@physics.upenn.edu

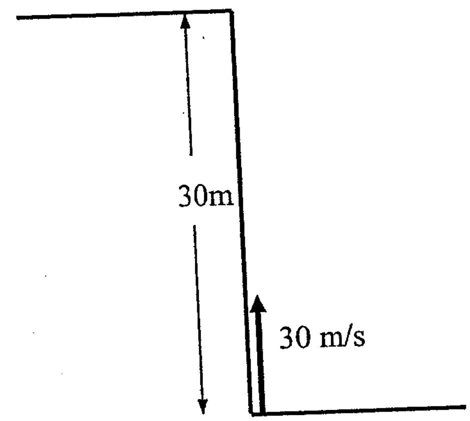
Name________________________________
(Please print)

PHYSICS 008

First Quiz
September 16, 2009

Please do all work on this sheet. Your score will depend both on the work you show and on the answers you obtain. You may use a calculator and the information on the reverse side of this sheet.

A stone is thrown vertically upward with a velocity of 30 meters per second from the base of a cliff that is 30 meters high. The stone reaches a height higher than the cliff, and then falls back and lands on the cliff.



a) Determine the <u>maximum height</u> above the base of the cliff that the stone reaches.

$$y-y_0 = \frac{v^2-v_0^2}{2a} = \frac{0-(30)^2}{-19.6} = 45.9\,m$$

-OR-

$$v-v_0 = at \qquad t = \frac{-30}{-9.8} = 3.06\,s \text{ (up)}$$

$$y = (v_{AVG})t = 15(3.06) = 45.9\,m$$

b) Determine the <u>velocity</u> of the stone just before it lands on the cliff.

$$v^2 - v_0^2 = 2a(y-y_0)$$

$$v^2-(30)^2 = -19.6(30) \qquad v = \pm\sqrt{312} = \pm 17.7\,m/s\ (-)$$

-OR-

TIME TO FALL: $y-y_0 = v_0t + \frac{at^2}{2}$; $-15.9 = -4.9t^2$

$t = 1.80\,s$ $\qquad v = at = -9.8(1.8) = -17.7\,m/sec$

c) Determine the <u>total time</u> the stone was in the air.

$$y-y_0 = v_0t + \frac{at^2}{2} \quad \text{(QUADRATIC)}$$

$$30 = 30t - 4.9t^2 \qquad t = \frac{+30 \pm \sqrt{900+588}}{9.8} = 4.86\,s,\ -1.26\,s$$

-OR-

$$v - v_0 = at \qquad -17.7-30 = -9.8t \qquad t = 4.87\,s$$

-OR-

$$\text{TOTAL} = t_{up} + t_{DOWN} = 3.06 + 1.80 = 4.86\,s$$

One-dimensional kinematics:

$$AverageVelocity = v_{avg} = \frac{(x_f - x_i)}{(t_f - t_i)} \qquad Velocity = v = \frac{dx}{dt} \qquad Acceleration = a = \frac{dv}{dt}$$

If a = constant: $v = v_o + at$

$$x = x_o + v_o t + \frac{at^2}{2}$$

$$v^2 - v_o^2 = 2a(x - x_o)$$

Acceleration of gravity near surface of earth: -9.8 m/s^2

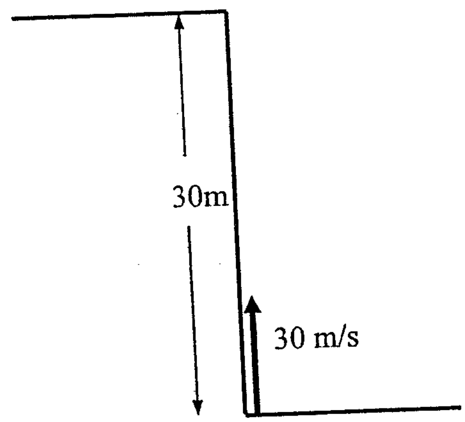
Name______________________________
(Please print)

PHYSICS 008

First Quiz
September 16, 2009

Please do all work on this sheet. Your score will depend both on the work you show and on the answers you obtain. You may use a calculator and the information on the reverse side of this sheet.

A stone is thrown vertically upward with a velocity of 30 meters per second from the base of a cliff that is 30 meters high. The stone reaches a height higher than the cliff, and then falls back and lands on the cliff.



a) Determine the maximum height above the base of the cliff that the stone reaches.

$y - y_0 = \frac{v^2 - v_0^2}{2a} = \frac{0 - (30)^2}{-19.6} = 45.9\,m$

-OR-

$v - v_0 = at \quad t = \frac{-30}{-9.8} = 3.06\,s$ (up)

$y = (v_{AVG})t = 15(3.06) = 45.9\,m$

b) Determine the velocity of the stone just before it lands on the cliff.

$v^2 - v_0^2 = 2a(y - y_0)$

$v^2 - (30)^2 = -19.6(30) \quad v = \pm\sqrt{312} = \pm 17.7\,m/s$ (-)

-OR-

TIME TO FALL: $y - y_0 = v_0 t + \frac{at^2}{2}$; $-15.9 = -4.9t^2$

$t = 1.80\,s \quad v = at = -9.8(1.8) = -17.7\,m/sec$

c) Determine the total time the stone was in the air.

$y - y_0 = v_0 t + \frac{at^2}{2}$ (QUADRATIC)

$30 = 30t - 4.9t^2 \quad t = \frac{+30 \pm \sqrt{900 + 588}}{9.8} = 4.86\,s,\ -1.26\,s$

-OR-

$v - v_0 = at \quad -17.7 - 30 = -9.8t \quad t = 4.87\,s$

-OR-

$TOTAL = t_{up} + t_{DOWN} = 3.06 + 1.80 = 4.86\,s$

$y = v_{oy} t \cancel{+} 4.9t^2 = 15t - 4.9t^2$

TIME TO REACH MAXIMUM:

$v_y = v_{oy} + a_y t$

$0 = 15 - 9.8t \quad t = 1.53\text{ sec}$

$y_{MAX} = 15(1.53) - 4.9(1.53)^2$

$= \cancel{22.8}\text{ m} \quad 11.25$

TIME TO REACH GROUND:

$0 = 15t - 4.9t^2$

$t = 0, \frac{15}{4.9} = 3.06\text{ s}$ (TIME UP = TIME DOWN → NOT SURPRISING)

$\underline{\text{DISTANCE} = 20t = \cancel{60.1\text{ m}}\ 61.2\text{ m}}$

ALL PROBLEMS ARE VARIATIONS ON SAME THEME

NOTE: $y - y_o = (v_o)_y t + \frac{at^2}{2}$ (1)

AND $v_y - v_{oy} = at$ (2)

$\rightarrow t = \frac{v_y - v_{oy}}{a}$

SEPTEMBER 21:

TODAY: FINISH EXAMPLES FROM CHAPT. 3

FEW PROBLEMS FROM CHAPT 3

→ CHAPTER 4

WEDNESDAY: QUIZ ON CHAPT. 3

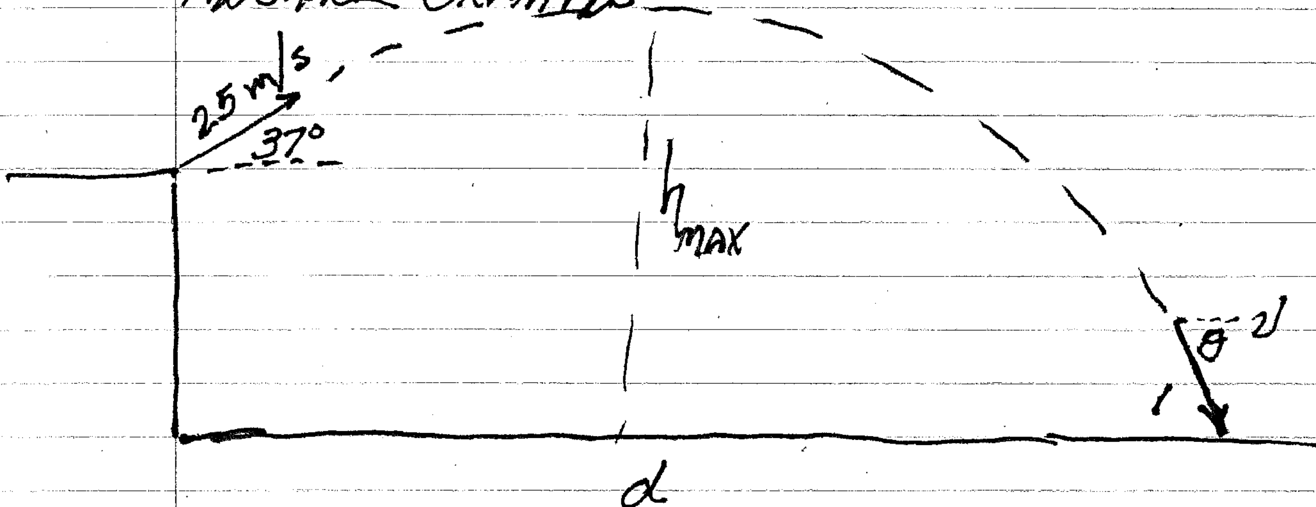
PUT 2 BACK IN 1

$$y - y_0 = v_{0y}\left(\frac{v_y - v_{0y}}{a}\right) + a\frac{(v_y - y_{0y})^2}{2a^2}$$

$$= \frac{v_y^2 - v_{0y}^2}{2a}$$

THIRD EQUATION FOR y

ANOTHER EXAMPLE



$x = 20t$

$y = 20 + 15t - 5t^2 \qquad (g \simeq -10)$

$t^2 - 3t - 4 = 0$

$t = \dfrac{3 \pm \sqrt{3^2 + 16}}{2} = 4\text{ SEC}, -1\text{ SEC}$

–OR– FIND t_{up} : $0 - 15 = -10t$

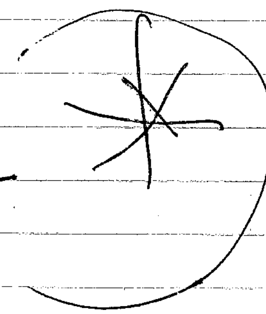
$t = 1.5\text{ SEC}$

$$h = 20 + 15(1.5) - 5(1.5)^2$$

$$= 20 + 11.25 = 31.25\,m$$

$$\text{-OR-}\quad 0 - (15)^2 = \frac{(h-20)}{\cancel{2(-10)}}\,2(-10)$$

$$h - 20 = \frac{-225}{-20} = 11.25$$



$$h = 31.25\,m$$

$$\text{TIME TO FALL: } 0 - 31.25 = -5t^2$$

$$t^2 = 6.25$$

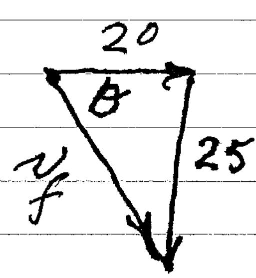
$$t = 2.5\text{ SEC}$$

$$\text{TOTAL} = 1.5 + 2.5 = 4$$

$$d = 20(4) = 80\,m$$

$$(v_x)_{FINAL} = 20$$

$$(v_y)_{FINAL} = 15 + 4(-10) = -25\,m/s$$



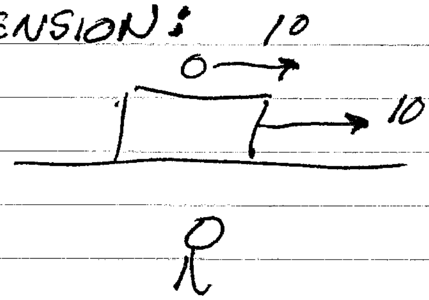
$v_f = \sqrt{(20)^2 + (25)^2} = 32\,m/s$

$\tan\theta = 1.25$

$\theta = 51.3^\circ$ BELOW HORIZONTAL

ANOTHER APPLICATION OF VECTORS
→ RELATIVE VELOCITY

IN ONE DIMENSION:



$v_{BE} = v_{BT} + v_{TE}$

SAME GAME WITH VECTORS

EXAMPLE PLANE HAS AIR SPEED OF 200 m/s

WISHES TO FLY NORTH WITH NE WIND
OF 100 m/s

(THIS IS HURRICANE OF ABOUT CLASS 7
— BUT IT'S JUST
A PROBLEM

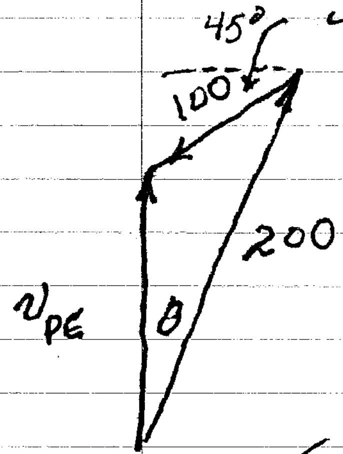
PILOT SHOULD STAY HOME

WHAT DIRECTION SHOULD PILOT AIM
PLANE?

$\vec{v}_{PE} = \vec{v}_{PA} + \vec{v}_{AE}$

NORTH 200 m/s 100 m/s NE

DRAW!



$\vec{v}_{PE} = \vec{200} + \vec{100}$

BASICALLY DONE!

COULD FIDDLE WITH DRAWING

(LOOKS LIKE $\theta \sim 20°$, $v_{PE} = 130$ m/s)

OR CALCULATE:

(x) $200\sin\theta - 100\overset{\cos}{\cancel{\sin}}45 = 0$

$\sin\theta = \frac{1}{2}\sin 45 = .35$

$\theta = 20.5°$

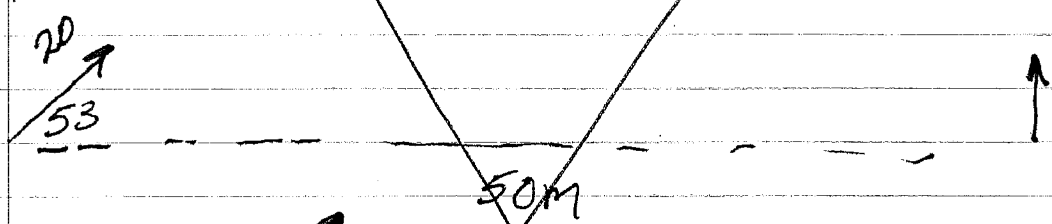
(y) $\cancel{v}\ 200\cos\theta - 100\overset{\sin}{\cancel{\cos}}45 = v_{PE}$

$187 - 71 = v_{PE} = 116$ m/s

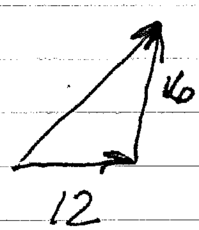
MORE COMPLICATED?

QB THROWS PASS AT $20\,m/s$ AT $53°$
AIMING AT RECEIVER WHO IS $50\,m$ DOWNFIELD.

RECEIVER WAITS UNTIL PASS AT MAX HEIGHT
TO JUDGE WHEN HE SHOULD RUN TO CATCH IT



FIRST:



TIME TO MAX:

$16 - 9.8t = 0 \qquad t = 1.63\,\text{sec}$

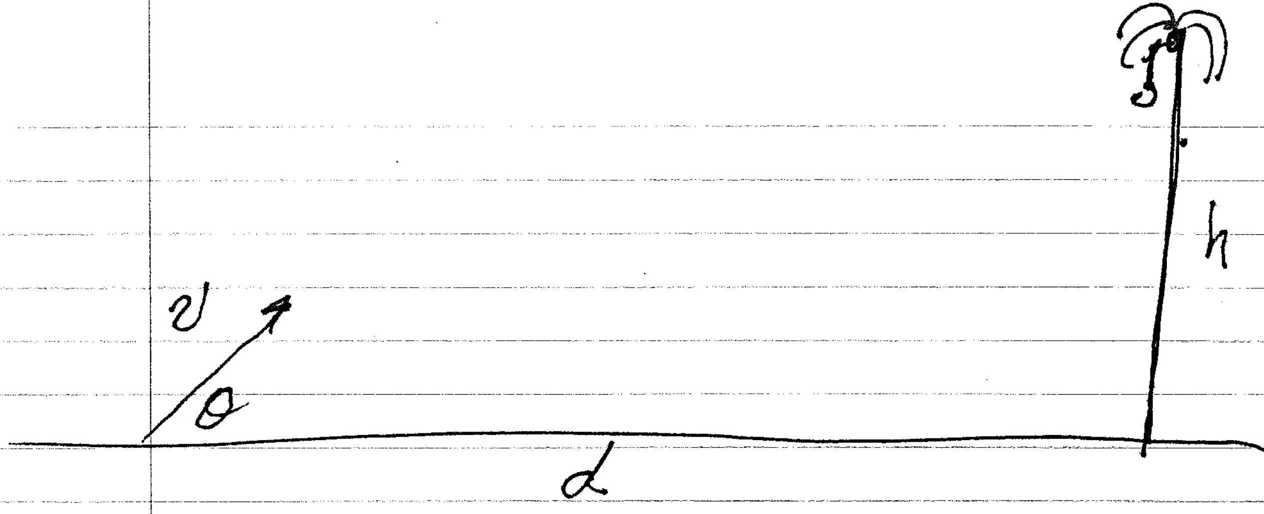
TOTAL TIME $= 3.26\,\text{sec}$

BALL LANDS: $12(3.26) = 39.2\,m$

VELOCITY OF RECEIVER $= \dfrac{39.2 - 50}{1.63} = -6.6\,m/s$

($\sim 15\,mph$ EASY!)

SLIGHTLY MORE INTERESTING:



MONKEY SEES FLASH OF GUN, DROPS OUT OF TREE AS BULLET IS FIRED

v, θ TO HIT?

t = TIME AFTER FIRING

y = HEIGHT ABOVE GROUND

$$y_m = h - \frac{gt^2}{2}$$

$$y_B = (v\sin\theta)t - \frac{gt^2}{2}$$

$$t = \frac{d}{v_x} = \frac{d}{v\cos\theta}$$

$$y_B = \frac{v\sin\theta\, d}{v\cos\theta} - \frac{gt^2}{2}$$

$$= d\tan\theta - \frac{gt^2}{2} =$$

PHYSICS 008
SEPT. 21, 2009

CHAPTER 3:

21. $y - y_0 = v_y t + at^2/2$

$0 - 45 = 0(t) - 4.9t^2$

$t = 3.03\ \text{SEC}$

$x - x_0 = (v_0)_x t$

$24 = (v_0)_x (3.03)$

$(v_0)_x = v_0 = 7.92\ \text{m/s}$

31. $(v_0)_x = 65\cos 37 = 51.9\ \text{m/s}$

$(v_0)_y = 65\cos 37 = 39.1\ \text{m/s}$

a) $y - y_0 = v_{0y} t + at^2/2$

$0 - 125 = 39.1t - 4.9t^2$

$t = +10.43\text{s}, \cancel{-2.45\text{s}}$

b) $x - x_0 = (v_0)_x t$

$= 51.9(10.43) = 541\ \text{m}$

c) $v_x = (v_0)_x = 51.9\ \text{m/s}$

$v_y = (v_0)_y + at$

$= 39.1 - 9.8(10.43)$

$= -63.1\ \text{m/s}$

d) $v = \sqrt{v_x^2 + v_y^2} = 81.7\ \text{m/s}$

e) $\tan\theta = \dfrac{v_y}{v_x} = \dfrac{-61.3}{51.9}$

$\theta = -50.6^\circ$

f) $t_{up} = \dfrac{v_y - v_{0y}}{a} = \dfrac{0 - 39.1}{-9.8} = 3.99\text{s}$

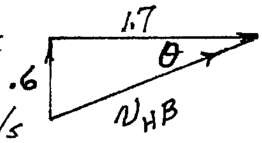
$v_{AVG} = \dfrac{39.1}{2}$ h (ABOVE CLIFF)

$= \dfrac{39.1}{2}(3.99) = 78\text{m}$

37. $\vec{v}_{HB} = \vec{v}_{HR} + \vec{v}_{RB}$

$|\vec{v}_{HB}| = \sqrt{.6^2 + 1.7^2}$

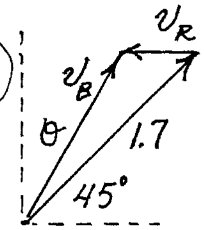
$= 1.80\ \text{m/s}$



$\theta = \tan^{-1}\dfrac{.6}{1.7} = 19.4^\circ$

46. $\theta = \tan^{-1}\left(\dfrac{110}{260}\right)$

$= 22.9^\circ$



$v_B \cos 22.9$

$= 1.7\sin 45$

$v_B = 1.31\ \text{m/s}$

$1.7\cos 45 - v_R = v_B \sin 22.9$

$v_R = .70\ \text{m/s}$

64. "y" t TO NET

$.9 = 2.5 + 0(t) - 4.9t^2$

$t = 0.57\ \text{SEC}$

"x" $v_0 t = x = 15$

$v_0 = \dfrac{15}{.57} = 26.3\ \text{m/s}$

TOTAL TIME: ("y")

$0 = 2.5 - 4.9t^2$

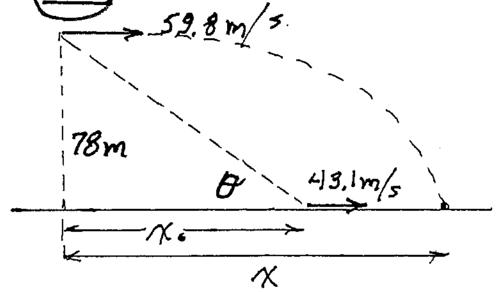
$t = 0.71\ \text{SEC}$

TOTAL DISTANCE

$= (26.3)(.71) = 18.8\ \text{m}$

(LESS THAN 22m: FAIR SERVE)

65.



TIME IN AIR: $0 = 78 - 4.9t^2$

$t = 3.99\text{s}$

$x = 59.8(3.99) = 239\text{m}$

$x - x_0 = 43.1(3.99) = 172\text{m}$

$x_0 = 239 - 172 = 67\text{m}$

$\theta = \tan^{-1}\left(\dfrac{78}{67}\right) = 48.5^\circ$

67. "x" $195 = v_0 \cos\theta\, t$

$v_0\cos\theta = \dfrac{195}{7.6} = 25.7\ \text{m/s}$

"y" $155 = 0 + v_0 \sin\theta\, t - 4.9t^2$

$155 = v_0\sin\theta(7.6) - 4.9(7.6)^2$

$v_0 \sin\theta = 57.6\ \text{m/s}$

$\tan\theta = 57.6/25.7$

$\theta = 66^\circ$

$v_0 = (25.7^2 + 57.6^2)^{1/2} = 63.1\ \text{m/s}$

69. "x" $v_0\cos 38^\circ t = 11.22$

$t = 11.22/v_0\cos 38^\circ$

"y" $26 = 2.1 + v_0\sin\theta t - 4.9t^2$

$.5 = 11.22\tan 38^\circ - 4.9\left(\dfrac{11.22^2}{v_0^2\cos^2 38^\circ}\right)$

$v_0 = 10.96\ \text{m/s}$

THEN TRY $t = 10.78/(v_0\cos 38^\circ)$

$v_0 = 10.76\ \text{m/s}$

TO HIT $h - \frac{gt^2}{2} = d\tan\theta - \frac{gt^2}{2}$

$h = d\tan\theta$

$\tan\theta = \frac{h}{d}$ → AIM AT MONKEY!

(VELOCITY DOESN'T MATTER!)

DEMO

CHAPTER 3 PROBLEMS DUE MONDAY

QUIZ # 2 ON WEDNESDAY

CHAPTERS 2 & 3; DEFINITIONS

CHAPT 4: NEWTONS LAWS: STATEMENTS ABOUT NATURE!

FORCE: LUCKILY, YOU HAVE DEVELOPED A GOOD INTUITIVE FEELING FOR FORCE

(LUCKY, BECAUSE WITHOUT IT OUR ANCESTORS WOULD HAVE BEEN EATEN BY WILD ANIMALS OR KILLED IN ACCIDENTS)

→ PUSH, PULL

→ ~~MOST COMMON~~

PRIMARY FORCES
- GRAVITY
- E-M
- NUCLEAR

MORE COMMON FORCES ARE SECONDARY, AND ALMOST ALL ARE ELECTRICAL

→ BUT IGNORE THIS FOR NOW

NEWTON #2: $\vec{a} \propto \vec{F}$

NOTE: BOTH ARE VECTORS

NEWTON #1 $\vec{F} \Rightarrow 0 \Rightarrow \vec{a} = 0$

($v = 0$ OR CONSTANT

→ CONTAINED IN NEWTON #2

PROPORTIONALITY CONSTANT:

$$\vec{a} = (\text{CONST})\vec{F} \equiv \frac{\vec{F}}{m}$$

M = MASS — ALSO INTUITION CONFIRMED

→ EFFECTLY: AMOUNT OF "STUFF"

UNIT ≡ KILOGRAM (TEXT ≈ .5 KILOGRAM)

$\vec{\text{FORCE}} = M\vec{a}$ $\left(\text{KILOGRM-}\frac{M}{\text{SEC}^2} \equiv \text{NEWTON}\right)$

FORCE OF GRAVITY ⇒ ACCELERATION

$$\vec{F} = m\vec{g} \quad (\text{DOWN})$$

SINCE EVERYTHING FALLS WITH

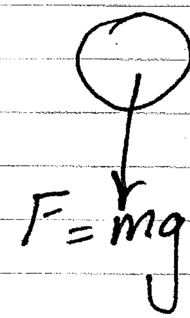
SAME ACCELERATION, FORCE ~ MASS

OTHER FUND FORCES ~ CHARGE, N. PROPERTIES

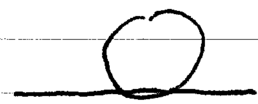
SOME SIMPLE EXAMPLES:

DROP BALL $\vec{F} = m\vec{g}$ (DOWN)

$\vec{a} = \frac{\vec{F}}{m} = \vec{g}$ (DOWN)



ON BENCH



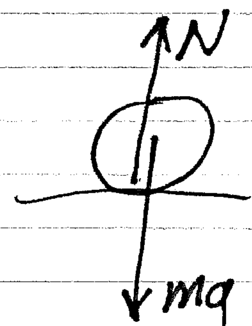
$\vec{a} = 0$

NO FORCE ?

$\vec{a} = \frac{\vec{F}}{m}$ $\quad \vec{F}$ = TOTAL FORCE

GRAVITY TURNED OFF BY TABLE ?

UNLIKELY:



N = NORMAL FORCE

= (IN THIS CASE) mg

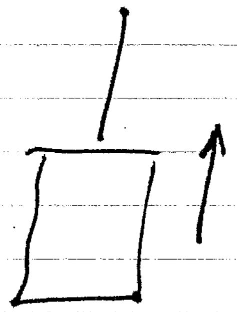
mg (GRAVITY)

FORCE OF GRAVITY = mg ≡ WEIGHT

PERSON: 50 kg = 490 NEWTONS ≅ 110 POUNDS

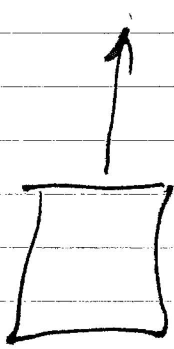
N = FORCE OF SEAT = 110 LB = 490 NEWTONS

SUPPOSE YOU ARE IN ELEVATOR:

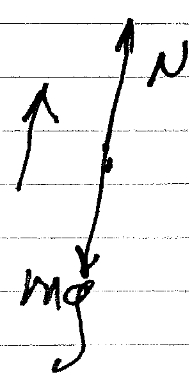


$v = 0 \quad a = 0 \quad N = mg = 110$ LBS

NOW ACCELERATE:



$a = 2\,m/s^2$



FORCES IN DIRECTION OF ACCELERATION

$$N - mg = ma$$

$$N = mg + ma = 490N + 100N = 590N$$

(132 POUNDS)

YOU FEEL HEAVIER

SEPTEMBER 23, 2009

TODAY: QUIZ #2

MONDAY, SEPT 28: CHAPT. 4 PROBLEMS

13, 15, 23, 29, 41, 51, 65, 76

MORE PRACTICE? MOST OF PROBLEMS IN TEXT REASONABLY GOOD — DO SOME!

LOOKING FARTHER AHEAD:

WEDNESDAY SEPT. 30 ~~FRIDAY, OCT 2~~: QUIZ

FRIDAY, OCT 2: CHAPT. 5 PROBLEMS

WEDNESDAY OCT 7: EXAM #1 CH. 2-5

APPARENT WEIGHT ≡ NORMAL FORCE

MASS: DETERMINED BY TOTAL COMPOSITION OF YOUR BODY

= CONSTANT (MORE OR LESS)

WEIGHT = mg → DETERMINED BY WHERE YOU ARE

TRY IT!

(ON MOON, $g \doteq 1.6$ ~~__~~ m/s^2

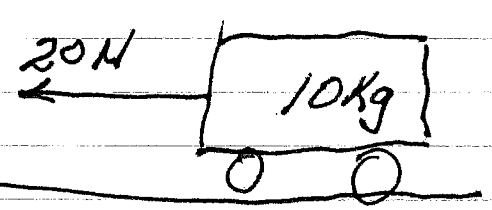
WEIGHT = $50(1.6)$ = 80 NEWTON

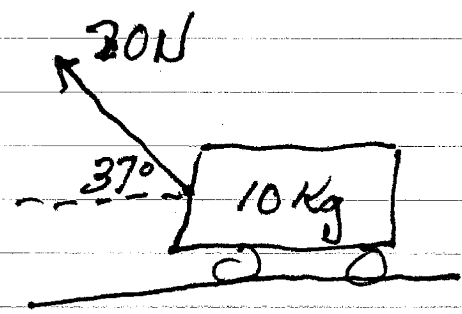
~ 18 POUNDS

APPARENT WEIGHT = N

(DEPENDS ON ACCELERATION AND LOCATION)

$$a = \frac{F}{m} = 2\ m/s^2$$





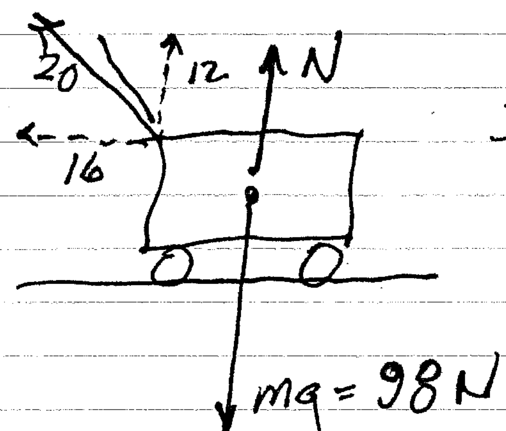
$$F_x = 20(\cos 37) = 16$$

$$a_x = 1.6\ m/s^2$$

$$F_y = 20(\sin 37^\circ) = 12\,N$$

$$a_y = \frac{12}{10} = 1.2\,m/s^2 \quad ?$$

NO WAY! $\rightarrow$ FORGOT GRAVITY:

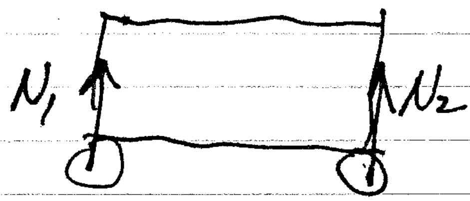


DOESN'T FLY UP:

$$N + 12 - 98 = 0$$

$$N = 86 \text{ NEWTONS}$$

PURIST OBJECTION: (BUT REASONABLE)



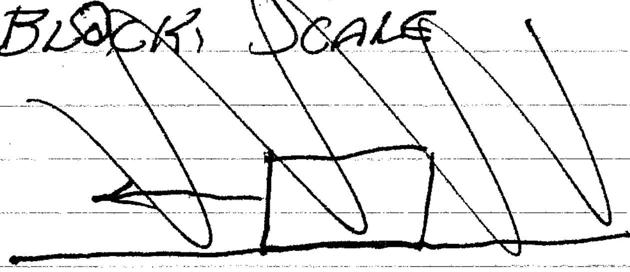
$$N_1 + N_2 + 12 - 98 = 0$$

$$N_1 + N_2 = 86 \text{ NEWTONS}$$

N_1, N_2 INDIVIDUALLY?

$\rightarrow$ HAVE TO WAIT TO DISCUSSION OF TORQUE

BLOCK; SCALE



NEWTON #2 : $\vec{a} = \dfrac{\vec{F}}{m}$

NEWTON #1 $\rightarrow$ SPECIAL CASE OF NEWTON #2

IF $\vec{F} = 0$, $\vec{a} = 0$

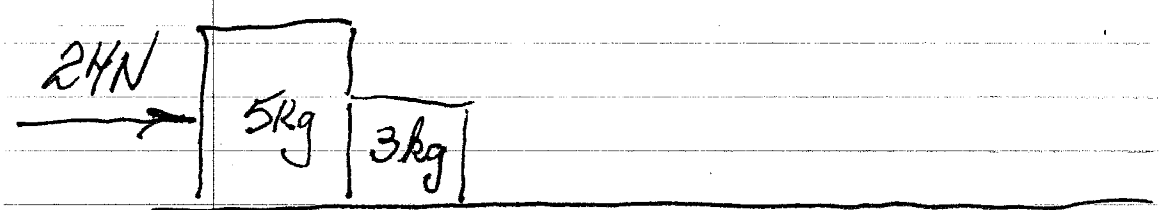
$\hookrightarrow$ IF $v = 0$, $\vec{F} = 0$ $\rightarrow$ NO MOTION

(OBVIOUS)

$\rightarrow$ IF $v = v_0$, $\vec{F} = 0$ $\rightarrow$ CONSTANT VELOCITY

$\rightarrow$ CONTINUES FOREVER

CONTRARY TO EXPERIENCE, BUT FORCES NOT ALWAYS OBVIOUS

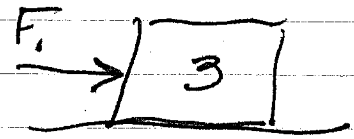


SMOOTH SURFACE (NO RESISTANCE TO MOTION)

$$a = \frac{F}{\Sigma m} = \frac{24}{8} = 3\,m/s^2$$

BUT 24N IS ONLY ON FIRST BLOCK

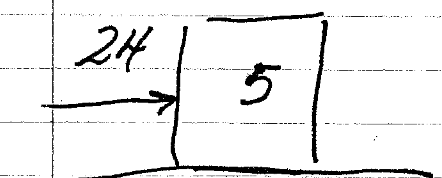
WHICH PUSHES ON SECOND BLOCK



$F_1 = \cancel{8}\ ma = 3(3)$

$= 9N$

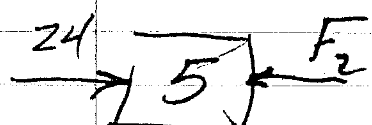
NOW LOOK BACK AT FIRST BLOCK:



$24 = \underline{5a}$

$a = 4.8\ m/s^2 \rightarrow$ RIDICULOUS!

SECOND BLOCK MUST PUSH BACK:



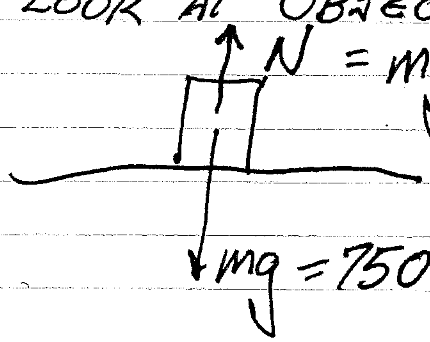
$24 - F_2 = 5a = 5(3)$

$F_2 = 24 - 15 = 9N$

THIS IS AN EXAMPLE OF NEWTON'S THIRD LAW:

$$\vec{F}_{12} = -\vec{F}_{21}$$

LOOK AT OBJECT ON FLOOR (SAY ME)



$N = mg = 750N$

$mg = 750N$

Name WALES

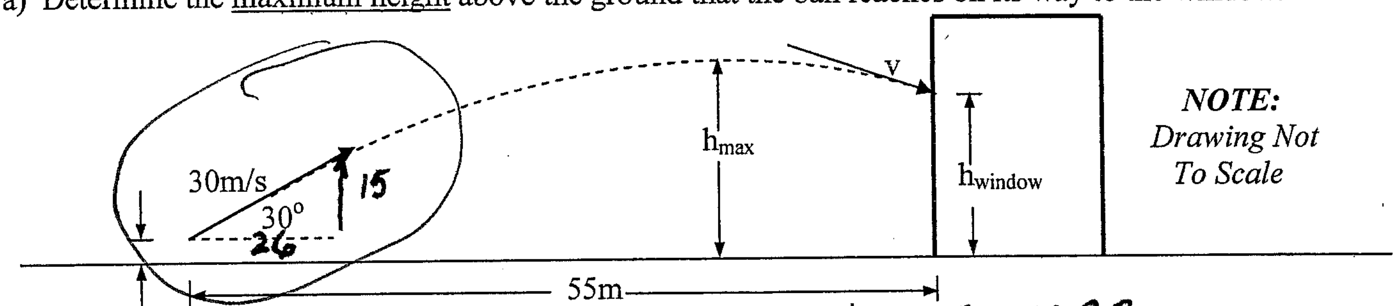
PHYSICS 008 *(Please Print)*

Second Quiz
September 23, 2009

Please do all work on this sheet. Your score will depend both on the work you show and on the answers you obtain. You may use a calculator and the information on the reverse side of this sheet.

A baseball is thrown with a velocity of 30 meters per second at an angle of 30° to the ground. The height of the ball at the instant it is thrown is 1.5 meters. The person who threw the ball was not paying much attention to where the ball was headed. As the result the balls smashes a hole in a third-story window of a building that is 55 meters from the thrower. (Note: You may use "g" = -10m/s² if you wish.)

a) Determine the maximum height above the ground that the ball reaches on its way to the window.



$t = \frac{15}{g}$ $t = 1.53$ $h = 7.5t + 1.5 = 12.98\ m$

-OR-

$0 - 15^2 = 2(-9.8)(h - 1.5)$ $h = 12.98 m$

b) Determine the height above the ground of the hole in the window.

$t = \frac{55}{26} = 2.12 s$ $h = 1.5 + (2.12)15 - 4.9(2.12)^2 = 11.28 m$

-OR-

$v_f = 15 - 9.8(2.12) = -5.78\ m/s$

$h = 1.5 + \frac{15 - 5.78}{2}(2.12) = 11.28\ m$

c) Determine the velocity (magnitude only) of the baseball immediately before it hits the window.

$v^2 = (5.78)^2 + (26)^2$

$v = 26.63\ m/s$

$\theta = \tan^{-1} \frac{5.78}{26} = 11.5°$

Name *WALES*

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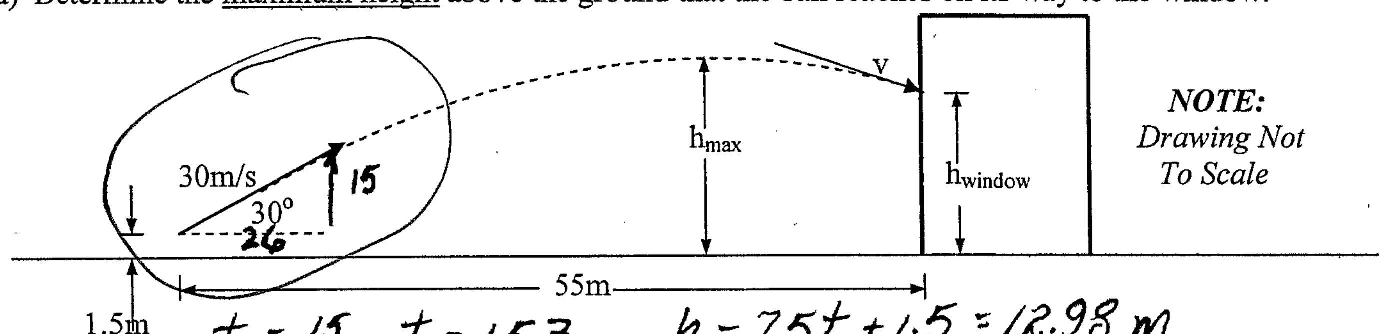

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One-dimensional kinematics:

$$Average\,Velocity = v_{avg} = \frac{(x_f - x_i)}{(t_f - t_i)} \qquad Velocity = v = \frac{dx}{dt} \qquad Acceleration = a = \frac{dv}{dt}$$

If a = constant: $v = v_o + at$

$$x = x_o + v_o t + \frac{at^2}{2}$$

$$v^2 - v_o^2 = 2a(x - x_o)$$

Acceleration of gravity near surface of earth: -9.8 m/s^2

Projectile Motion:

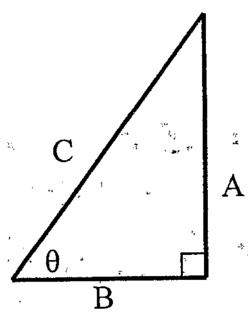
Same equations with a_y = -9.8 m/s^2 and $a_x = 0$

Trigonometric Functions:

Sin θ = A/C

Cos θ = B/C

Tan θ = A/B



35A

SEPTEMBER 25, 2009

QUIZ - RESULTS

- SOLVE

- COMMENT

MORE PROBLEMS WILL DO

OFFICE HOURS
MON 1-3
THURS 1-3

MONDAY: CHAPTER #4 PROBLEMS

WED/FRI QUIZ #3 (CHAPT 4)

MONDAY OCT 5 - CHAPT 5 PROBLEMS

WED OCT 7 - EXAM #1

NOTE 1: PREVIEW OF EXAM FORMULA SHEET WILL BE PROVIDED ON MONDAY, OCTOBER 5

2: OLD EXAM AT SOME POINT

TODAY - FRICTION
- INCLINED PLANES
- PULLEYS

N & mg : EQUAL AND OPPOSITE

BUT NOT PAIRED FORCES IN

NEWTON'S THIRD LAW:

BOTH FORCES ON ME

FLOOR PUSHES UP, I PUSH DOWN
ON ME. ON FLOOR

EARTH (GRAVITY) PULLS DOWN ON ME

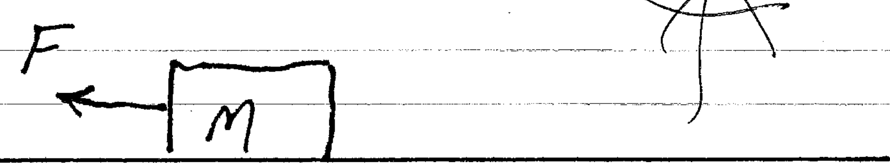
~~B~~ 75 kg (MY MASS) PULLS UP ON EARTH

→ CLIMB ON BENCH, JUMP OFF (NO WAY!)

$$a_m = \frac{mg}{m} = -9.8\,m/s^2$$

$$a_E = \frac{mg}{M_e} = \frac{75}{6\times10^{24}} = -12.5\times10^{-24}\,m/s^2$$

"SMOOTH" SURFACES:



REAL SURFACE

DOESN'T MOVE → OPPOSING FORCE IS FORCE OF FRICTION

↳ INCREASES AS I PULL HARDER

UNTIL IT SLIPS → AND THEN GETS SMALLER (UGLY!)

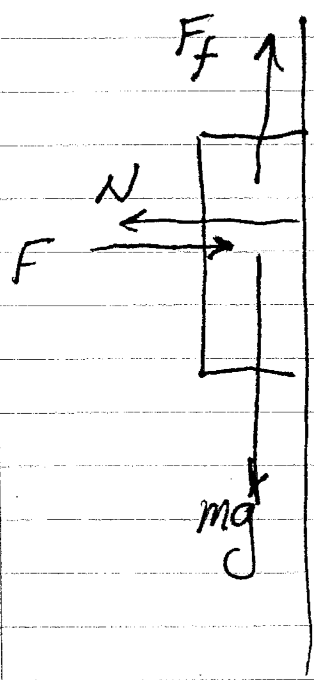
TRY DIFFERENT SURFACE, MORE WEIGHT

F_f OPPOSES MOTION

MOVING $F_f = \mu_k mg$ (OR N?)

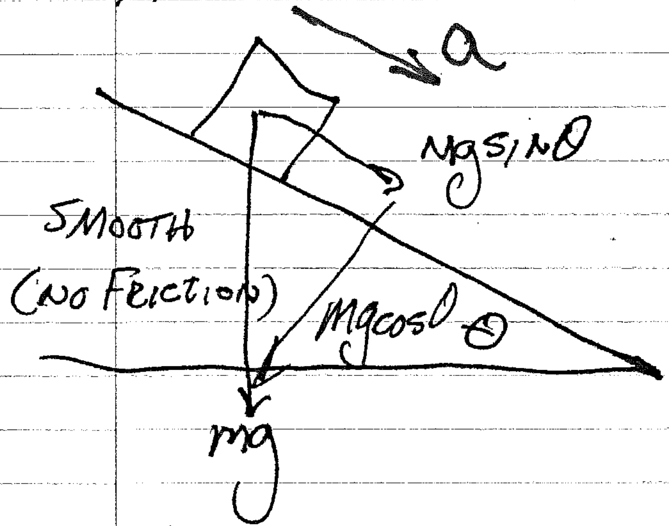
NOT MOVING $F_f \leq \mu_s N$

BLOCK AGAINST WALL:



CLEARLY $F_f \sim N$, NOT mg

MORE INTERESTING: PULLEYS & INCLINED PLANES



$F_{\perp}$ TO PLANE $= 0$

$N = mg\cos\theta$

$F_{\parallel}$ TO PLANE

$mg\sin\theta = ma$

$a = g\sin\theta$

(FASTER THE STEEPER)

~~OR~~ OK – TRY IT: DOESN'T MOVE

$F_f \leq \mu_s N = \mu_s mg\cos\theta$

STARTS TO MOVE WHEN

$$mg\sin\theta = \mu_s mg\cos\theta$$

AND THEN ACCELERATES

$$mg\sin\theta - \mu_k mg\cos\theta = ma$$

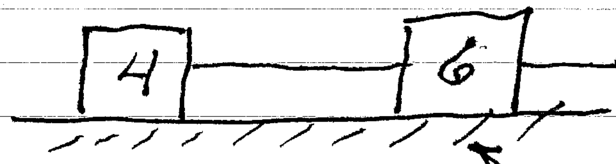
$$a = g(\sin\theta - \mu_k\cos\theta)$$

PULLEYS

STRING, CORD, ROPE ETC

UNLESS SPECIFIED ASSUME MASSLESS, AND COMPLETELY FLEXIBLE

CAN ONLY PULL

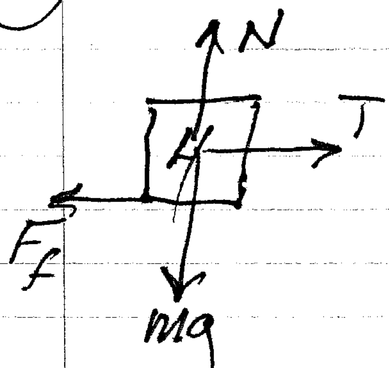


$\mu_s = .4$ ~~$\mu_k = 0.20$~~

$\mu_k = .2$

(1) ASSUME $\longrightarrow a$ (SAME FOR BOTH)

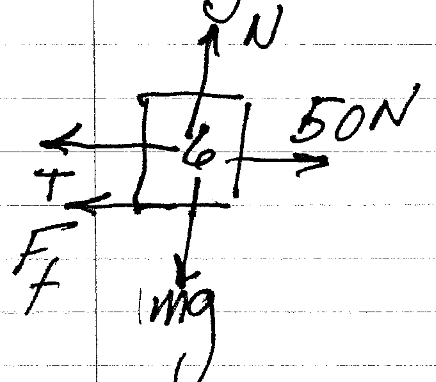
(2) LOOK AT FORCES ON EACH BLOCK



$N = 40$

$F_f = 16$

$T - 16 = 4a$



$N = 60$

$F_s = 12$

$50 - 12 - T = 6a$

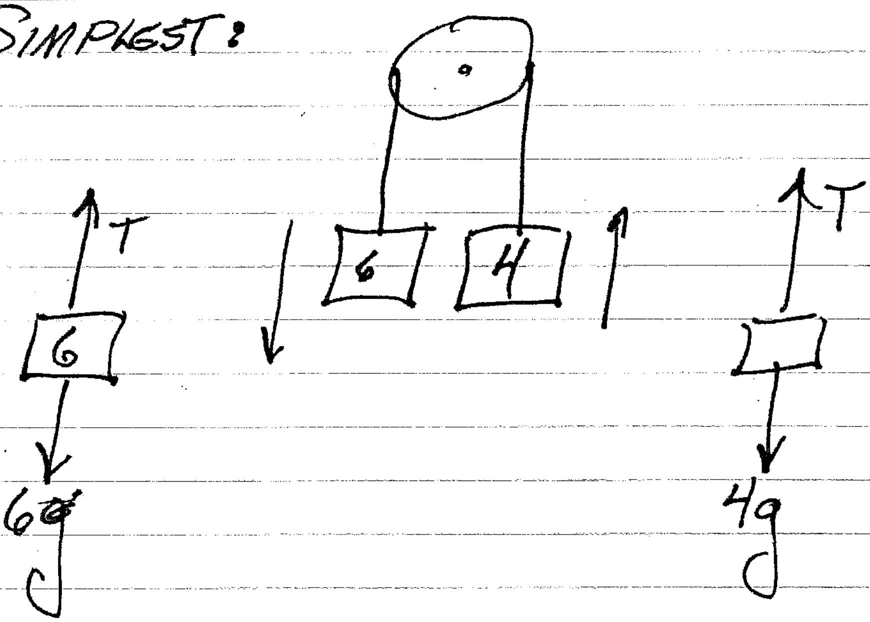
$50 - 28 = 10a$

$a = 2.2\,m/s^2$

PULLEY: CHANGES DIRECTION OF TENSION IN CORD, BUT NOT MAGNITUDE

→ TRUE IF PULLEY IS COMPLETELY FRICTIONLESS & MASSLESS
(OBVIOUSLY NOT COMPLETELY REALISTIC
→ HAVE TO DEAL WITH THAT IN LATER CHAPTER)

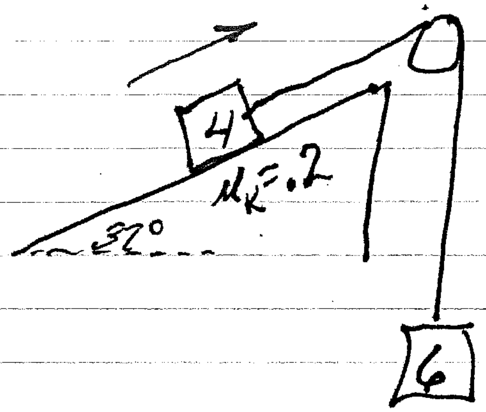
SIMPLEST:



ASSUME a (6 GOES DOWN)

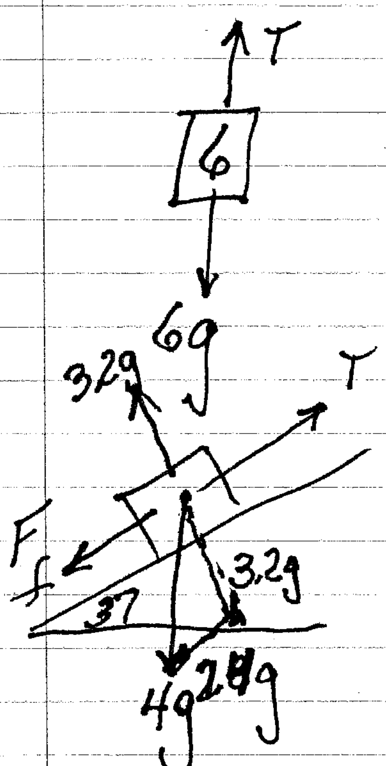
$$6g - T = 6a$$
$$T - 4g = 4a$$
$$2g = 10a \quad a = 0.2g = 2\ (1.96)\ m/s^2$$
$$T = ? = 4a + 4g = 4.8g$$
$$= 6g - 6a = 6g - 6(.2g) = 4.8g$$

NOW THROW EVERYTHING IN:



① ASSUME DIRECTION OF a AND ASSUME MOTION

② LOOK AT FORCES ON EACH ELEMENT



$$6g - T = 6a$$

$$F_f = \mu N = .2(3.2g) = .64g$$

$$T - .64g - 2.4g = 4a$$

$$6g - 3.04g = 10a$$

$$a = \frac{2.96g}{10} = .296g \sim 3 m/s^2$$

WHAT IF YOU GUESSED WRONG?

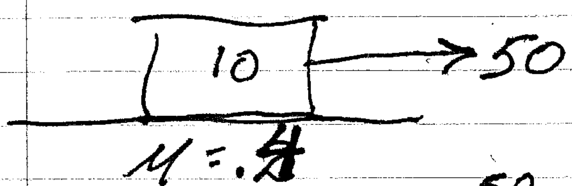
SEPTEMBER 28, 2009

FRIDAY: QUIZ ON CHAPTER 4

MONDAY: CHAPTER 5 PROBLEMS

OFFICE HOURS THIS WEEK: MON, THURS 1-3PM

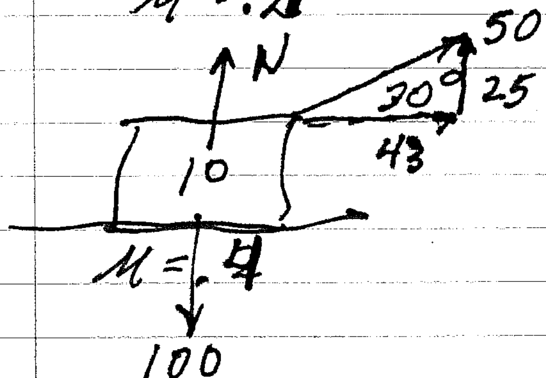
COUPLE LAST BITS:



$50 - 40 = 10a$

$a = \cancel{3\,m/s^2}$

$1\,m/s^2$

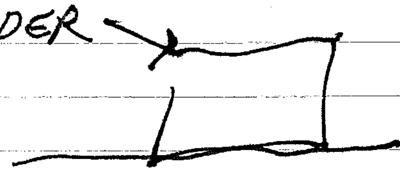


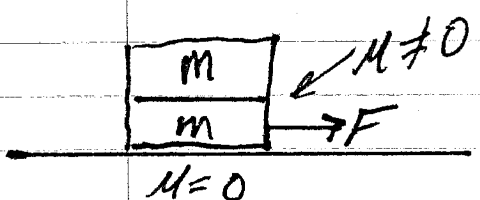
$N = 75$

$43 - .4(75) = 43 - 30 = 10a$

$a = 1.3\,m/s^2$

CONSIDER





WHAT MOVES TOP BLOCK?

$F_f = ma$

$F - F_f = ma$

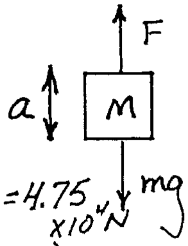
$a = F/2m$

PROBLEMS

PHYSICS 008
SEPT. 28, 2009

CHAPTER 4:

13. $F - mg = ma$



$F = mg + ma$

$mg = 4850(9.8) = 4.75 \times 10^4\,N$

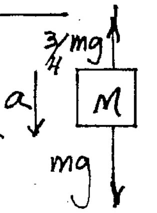
$ma = 4850(\pm .068g) = \pm .32 \times 10^4$

$F = 4.75 \times 10^4 \pm .32 \times 10^4$

$F = 5.07 \times 10^4,\ 4.43 \times 10^4\,N$

---

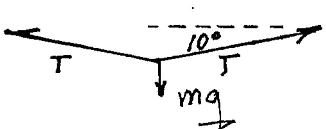
15. a IS DOWN:



$mg - \frac{3}{4}mg = ma$

$a = \frac{1}{4}g$

23.



$\vec{a} = 0;\ \vec{F} = 0$

VERTICAL FORCES:

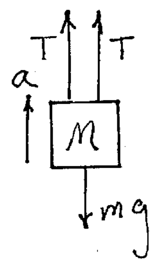
$2T\sin 10^\circ - mg = 0$

$T = \frac{mg}{2\sin 10^\circ} = 1.41 \times 10^3\,N$

---

29. a) $2T - mg = ma = 0$

$T = \frac{mg}{2} = 318N$



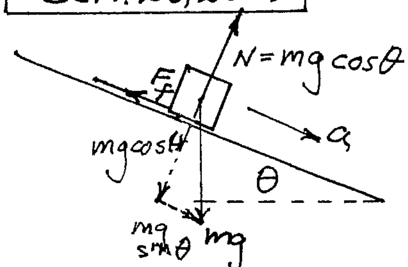
b) $2T = 1.15mg$

$1.15mg - mg = ma$

$a = .15g = 1.47\,m/s^2$

DEMO ?

41.



$mg\sin\theta - F_f = ma$

$F_f = 15(9.8)\sin\theta - 15(.3)$

$= 73.4N$

$F_f = \mu_K N = \mu_K\, mg\cos\theta$

$\mu_K = 73.4 / 15(9.8)\cos 32^\circ$

$= 0.59$

---

51. USE DRAWING IN PROB. 41:

$\mu_K = 0;\ a = g\sin 28^\circ$

$v_1^2 = 2as = 2g\sin 28^\circ s$

$\mu_K \neq 0 \quad a = g\sin 28^\circ - \mu_K g\cos 28^\circ$

$v_2^2 = 2g\left[\sin 28^\circ - \mu_K \cos 28^\circ\right]$

$v_2^2 / v_1^2 = \left(\frac{1}{2}\right)^2 = \frac{1}{4}$

$\frac{1}{4} = \frac{\sin 28^\circ - \mu_K \cos 28^\circ}{\sin 28^\circ}$

$\mu_K = \left(1 - \frac{1}{4}\right)\frac{\sin 28^\circ}{\cos 28^\circ}$

$= 0.40$

---

65. EFFECTIVE FORCE OF GRAVITY $= mg\sin 6^\circ$

F_A = RESISTIVE FORCE

F_R = FORCE PRODUCED BY RIDER

DOWN HILL: $F_R = 0$

$mg\sin\theta - F_A = 0$

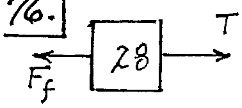
$F_A = mg\sin 6^\circ$

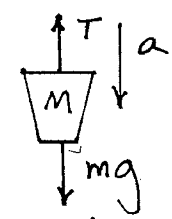
UP HILL:

$F_R = mg\sin 6^\circ + F_A$

$= 2mg\sin 6^\circ = 133N$

76.





NOTE: M = MASS OF SAND + MASS OF BUCKET

a) $a = 0,\ \mu = \mu_s = .450$

$T = F_f = \mu_s N = \mu_s(28g)$

$T = Mg$

$M = \mu_s(28) = 12.6\,kg$

(MASS ADDED $= 12.6 - 1.35 = 11.3\,kg$)

b) $F_f = \mu_K N = .32(28)(9.8)$

$= 87.8N$

$T - 87.8 = 28a$

$12.6g - T = 12.6a$

$123.5 - 87.8 = 40.6a$

$a = 0.88\,m/s^2$

READ CHAPT. ~~4~~ DO PROBLEMS

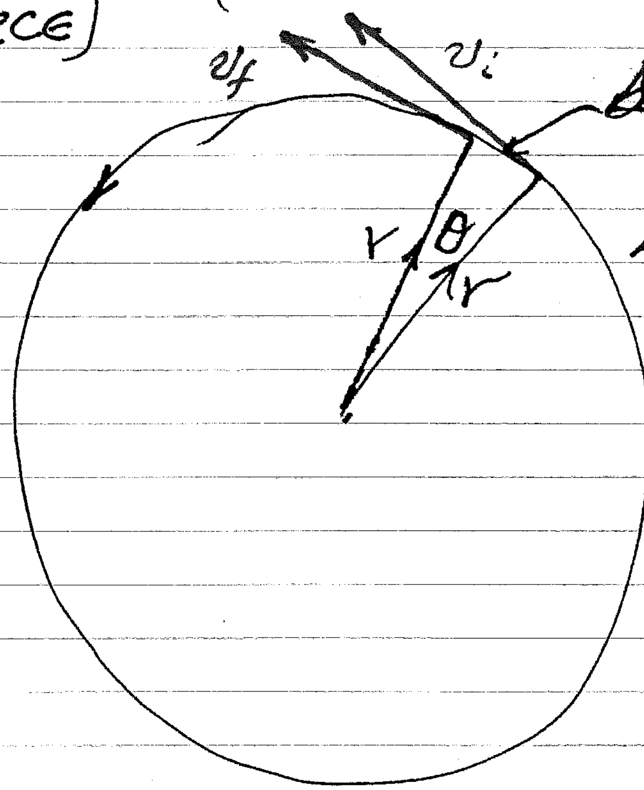
CHAPTER 5: SPECIAL CASE OF CHAPTER 4

BALL ON STRING:

SPEED IS UNCHANGING

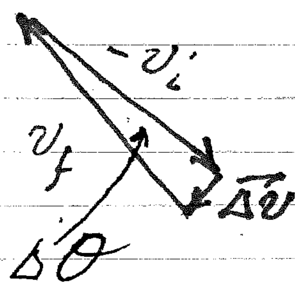
$a = 0$?

NO, $\vec{v}$ IS CHANGING (+ I AM EXERTING A FORCE)



$\Delta s = \cancel{\Delta\theta}\ R\Delta\theta$

$\Delta\theta = \frac{\Delta s}{r}$



$\Delta v = v\Delta\theta$

$\Delta\theta = \frac{\Delta v}{v}$

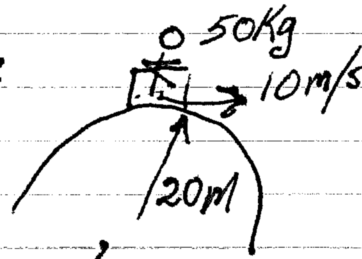
$$\frac{\Delta v}{v} = \frac{\Delta s}{r} = \frac{v\Delta t}{r}$$

$$\frac{\Delta v}{\Delta t} = \frac{v^2}{r} \rightarrow \frac{dv}{dt} = a$$

$\vec{a}$ TO CENTER $\rightarrow$ CENTRIPETAL ACCELERATION

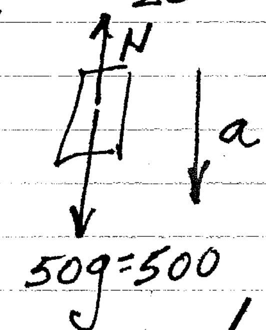
CIRCULAR MOTION → ACCELERATION ⇒ FORCE

EXAMPLE:



SKIER OVER TOP OF HILL

$$a_c = \frac{v^2}{R} = \frac{100}{20} = 5\,m/s^2$$



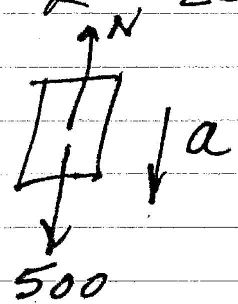
$500 - N = 250$

$N = 250N$ (~~110~~ 55#)

FEEL LIGHTER!

TRY 15 m/s

$$a_c = \frac{v^2}{R} = \frac{(15)^2}{20} = 11.25\,m/s^2$$



$500 - N = 50(11.25)$

$= 562\,New$

NORMAL FORCE = −62 NEW!

SNOW MUST PULL DOWN.

→ NEVER HAPPEN: AIRBORNE

(GREAT FUN OR WIPEOUT)

OR BOTH

SEPTEMBER 30, 2009

BALL ON STRING, PAIL

(1) OFFICE HOUR: THURSDAY
1-3 PM

(2) "PRACTICE" PROBLEMS - IN "COURSE DOCUMENTS"

→ SEEM REASONABLE AT QUICK GLANCE

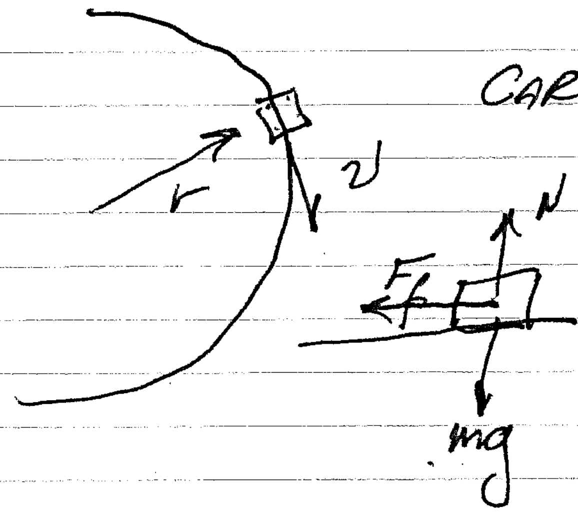
FRIDAY: QUIZ ON CHAPTER 4
OLD EXAM DISTRIBUTED

MONDAY: EXAM SOLUTIONS ON BLACKBOARD
PROBLEMS FROM CHAPTER 5
(7, 9, 13, 18, 19, 50, 66, 69, 72, 79)

ONWARD:

$$a_c = \frac{v^2}{R} \rightarrow F = \frac{mv^2}{R}$$

ANOTHER EXAMPLE:



CAR ON CURVE!

TENDS TO SLIDE OUT

FRICTION OPPOSES

$$F_f = \frac{mv^2}{r}$$

BUT $F_f(\text{MAX}) = \mu_s N = \mu_s mg$

$$v_{MAX}^2 = r\mu_s g$$

EXCEED → SLIPS → μ_K → WIPEOUT!

TRY ~~v = 20 m/s (45 mph)~~ $r = 20\text{m}$

$$\mu_s = 0.6$$

$$v_{MAX}^2 = 20(.6)10 = 120$$

$$v_{MAX} = 11\text{ m/s} \quad (\sim 24\text{ mph})$$

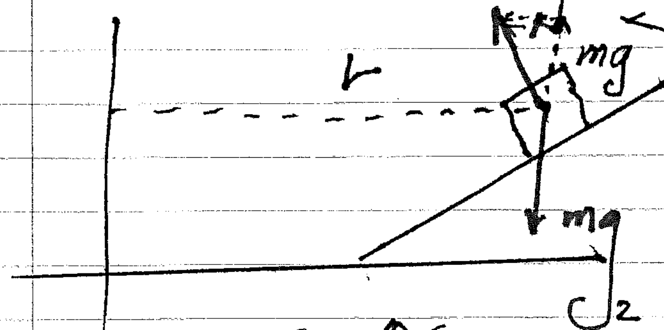
REAL WORLD – ICE $\mu_s \to 0.1$

DRY $\mu_s \to 1.0$

OILY $\mu_s \to 0.3$

BUT YOU DON'T ALWAYS KNOW!

PARTIAL SOLUTION – BANK CURVE:



$mg\tan\theta$

NO FRICTION!

$$mg\tan\theta = \frac{mv^2}{R}$$

$$\tan\theta = \frac{v^2}{rg}$$

TRY $v = 20$ (45mph)

$r = 100\,m$

$$\tan\theta = \frac{400}{1000}$$

$$\theta = 22^\circ$$

SLOWER – SLIDE DOWN BANK

FASTER – SLIDE UP BANK

(BUT STILL HAVE FRICTION!)

BORED WITH DULL PROBLEMS: TRY 93

REAL FORCE → GRAVITY ⇄ 45A

NEAR EARTH: $F_g \simeq mg$ ($g \sim 10\,m/s^2$)

NEAR EARTH SATELLITE:

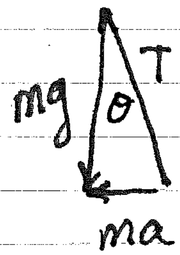
$$\frac{mv^2}{R} = mg \qquad v^2 = rg = 6.4\times10^6\times10$$

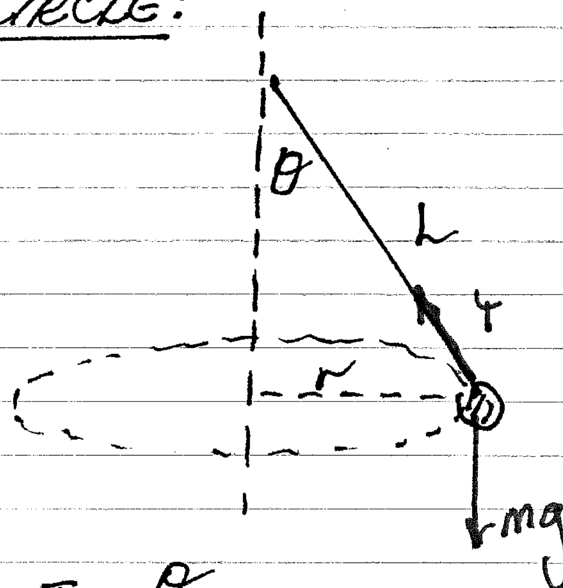
$$= 64\times10^6$$

$$v = 8\times10^3\,m/s\ (17{,}000\,mph)$$

COUPLE MORE EXAMPLES:

WHIRL BALL IN CIRCLE:





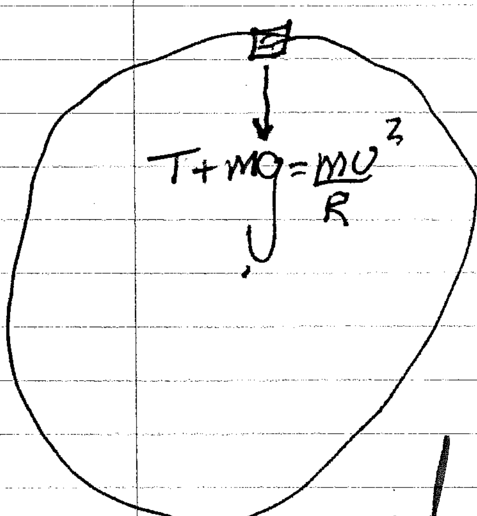
$$\vec{T} + m\vec{g} = m\vec{a}$$

$$ma = \frac{mv^2}{r} = mg\,\mathrm{TAN}\,\theta$$

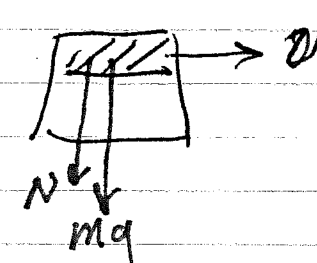
$$r = L\,\mathrm{SIN}\,\theta$$

$$\frac{v^2}{\cancel{R}} = Lg\,\mathrm{SIN}\,\theta\,\mathrm{TAN}\,\theta$$

SWING PAIL OVERHEAD



PUT WATER IN



$$N + mg = \frac{mv^2}{R}$$

$$N = \frac{mv^2}{R} - mg \qquad \frac{v^2}{R} > g \quad \text{OK}$$

$$\frac{v^2}{R} < g \quad \text{WATER ON HEAD}$$

$$v^2 = Rg \sim 10$$

BACK!

TIME AROUND = "PERIOD" = $T = \frac{2\pi R}{v}$

$= \frac{6(6.4\times10^6)}{8\times10^3} = 4800$ SEC ($\sim$ 80 MINUTES!)

TRY SAME APPROACH TO MOON:

ASSUME $F_m = M_m g$

$M_m g = \frac{mv^2}{R}$

$v^2 = Rg = 3.8\times10^8 \times 10 = 38\times10^8$

$v \sim 6\times10^4$

$T = \frac{2\pi R}{v} = \frac{2\pi(\cancel{38}\ 3.8\times10^8)}{6\times10^4} \simeq 3.8\times10^4$ SEC

$\simeq$ 10 HOURS!

WRONG!

NEWTON'S COMPARISON OF ACTUAL PERIOD OF MOON LED HIM TO CONCLUDES GRAVITATIONAL FORCE OF EARTH ON OBJECTS VARIED AS

$\frac{1}{r^2}$ WHERE r = CENTER-TO-CENTER DISTANCE

LAW OF UNIVERSAL GRAVITATION

$$F_{GRAV} = \frac{GM_1M_2}{r^2} \quad \left(\text{OR } -\frac{GM_1M_2}{r^2}\hat{r}\right)$$

46A

OCTOBER 2, 2009

QUIZ #3 TODAY

CHAPT 5 - PROBLEMS - MONDAY

EXAM #1 - WEDNESDAY

OFFICE HOURS
MON 1-4
TUES 10:-2:30

2/3 - 1
4 - 2
5 - 1 → BUT NOT USING "G"

→ OLD EXAM: TRY IT FOR PRACTICE TYPO

SOLUTIONS ON BB THIS AFTERNOON

→ BUT TRY IT FIRST OR IT WILL BE OF MUCH LESS USE

NOTE PROB 4 - THIS TYPE WON'T BE ON EXAM
(BUT "G" WILL FIGURE IN FUTURE EXAMS/QUIZZES

→ NOTE "WILL BE HAVE CLASS ON NOV. 25 → NO!

$$F_G = -\frac{G M_1 M_2}{R^2}\hat{r}$$

$G = 6.67 \times 10^{-11}$

$$mg = \frac{G M_e m}{R_e^2}$$

$$M_e = \frac{R_e^2 g}{G} \rightarrow \text{CAN "WEIGH" EARTH}$$

SAME SIZE OF G MAKES GRAVITATIONAL FORCE TINY EXCEPT WHEN MASSES (OR AT LEAST ONE MASS) IS HUGE → MOON, SUN, EARTH, ETC

YOUR WEIGHT $\frac{G M_e}{R_e^2} m = \text{"}g\text{"} m = 50g$ (500N)

FORCE BETWEEN STUDENTS IN ADJACENT SEATS:

$$\frac{G M_1 M_2}{r^2} = \frac{6.67 \times 10^{-11} \times (50)^2}{(.5)^2} = 6.67 \times 10^{-7} N$$

$\sim 10^{-6}$ POUNDS
(HARD TO FEEL,
HARD TO MEASURE

FOR SMALL OBJECT IN ORBIT AROUND LARGE OBJECT:

$$\frac{G M_L M_S}{R^2} = \frac{M_S v^2}{R}$$

$$v^2 = \frac{G M_L}{R} \qquad v = \frac{2\pi R}{T}$$

$$\frac{4\pi^2 R^2}{T^2} = \frac{GM_L}{R}$$

$$\frac{R^3}{T^2} = \frac{GM_L}{4\pi^2}$$ = CONSTANT FOR GIVEN LARGE BODY

KEPLER CONCLUDED THIS FROM EXPERIMENTAL DATA WELL BEFORE LAW OF UNIV. GRAVITATION

(TOOK DECADES & SEVERAL BLIND ALLEYS)

~~R~~ FOR EARTH: $\frac{R^3}{T^2}$ = CONSTANT

INC R, INC T

FOR $R = R_e$ $T = 80$ MIN

$$\frac{R^3}{T^2} = \frac{R_e^3}{(80)^2}$$

SINCE T GETS LARGER WITH R, OUGHT TO BE POSSIBLE TO FIND R TO MAKE $T = 1$ DAY

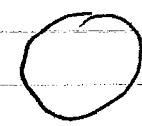
(AS EARTH ROTATES, SATELLITE WOULD APPEAR STATIONARY)

$$\frac{R_e^3}{(80)^2} = \frac{R^3}{[(24)(60)]^2}$$

$$R^3 = \left[\frac{(24)(60)}{80}\right]^2 R_e^3 = (18)^2 R_e^3 = 324 R_e^3$$

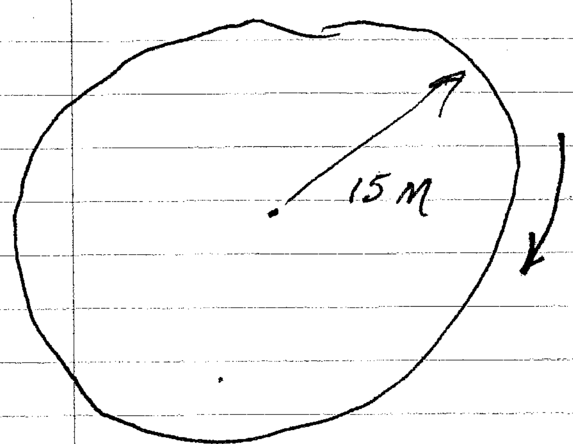
$R \sim 7 R_e$

NICE SIZE!



CAN BE SEEN EVERYWHERE EXCEPT BY PEOPLE LIVING AT N OR S POLE

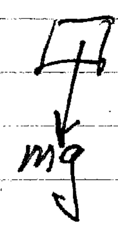
FEW MORE EXAMPLES: PROBLEMS: MONDAY 18



MAD MAN'S ~~FERRIS WHEEL~~

"WEIGHTLESS" AT TOP

FEEL?

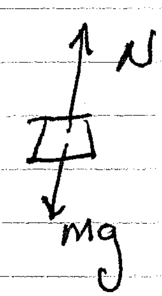


$$mg = \frac{mv^2}{R}$$

$$v^2 = Rg = 150$$

$$v = 12.2 \text{ m/s}$$

AT BOTTOM:



$$N - mg = \frac{mv^2}{R}$$

$$N = \frac{mv^2}{R} + mg \quad = 2mg$$

YOU WOULD "WEIGHT" $240^{\#}$ (NOT $120^{\#}$)

OCTOBER 5, 2009

QUIZ: TERRIBLE! — SHOW, CONSIDER EACH
— GO OVER
→ GLOBAL APPROACH → ALL MESSED UP!
→ → SOMEWHAT SIMILAR PROBLEM ON EXAM!)
PLEASE GET IT RIGHT (EASIER TO GRADE!)

CHAPTER 5 PROBLEMS:

18.| APPARENT WEIGHT?

50.|

69.|

72| COMMENT

79| (DEMO)

EXAM: USE ALTERNATE SEATS

READY TO GO AT 12:00 → 12:55
(SHARP)

BRING CALCULATOR:

DON'T SPEND EXCESSIVE TIME ON ONE PROBLEM
→ GIVE ME EXCUSE FOR PARTIAL CREDIT

NOV. 25 — NO CLASS!

Name______________________________

PHYSICS 008 *(Please Print)*

Third Quiz
October 2, 2009

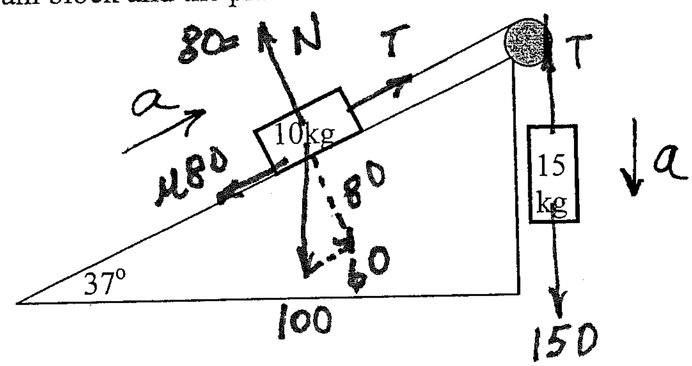
Please do all work on this sheet. Your score will depend both on the work you show and on the answers you obtain. You may use a calculator and the information on the reverse side of this sheet.

A block of mass of 10 kilograms is on a plane that is inclined at an angle of 37° to the horizontal. A cord passes from this block over a massless and frictionless pulley to a second block, of mass 15 kilograms, that hangs freely. The system is released and the 10-kilogram block is pulled up the plane. . (Note: You may use "g" = 10m/s^2 if you wish.)

a) Assume that there is no friction between the 10-kilogram block and the plane and determine:

i) The acceleration of the 10 kilogram block.

ii) The tension in the cord.



$150 - T = 15a$

$T - 60 = 10a$

$90 = 25a$

$a = 3.6\,m/s^2$

$T = 150 - 15a = 150 - 54 = 96N$

$T = 60 + 10a = 60 + 36 = 96N$

b) Now assume that the coefficient of kinetic friction (μ_k) between the 10-kilogram block and the plane is 0.50, and determine:

i) The acceleration of the 10 kilogram block.

ii) The tension in the cord.

$150 - T = 15a$

$T - 60 - .5(80) = 10a$

$50 = 25a$

$a = 2\,m/s^2$

$T = 150 - 15(2) = 120N$

Name______________________________

PHYSICS 008 *(Please Print)*

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October 2, 2009

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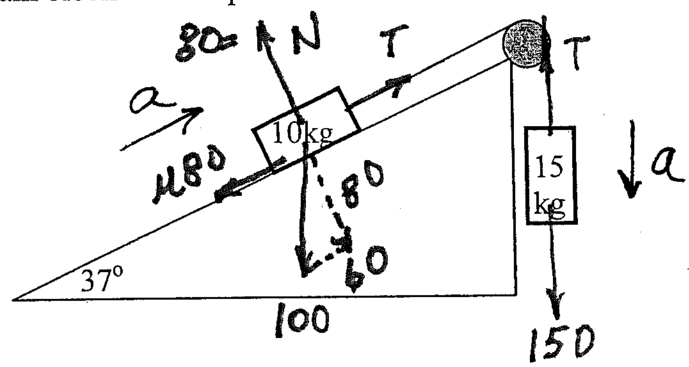

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$50 = 25a$

$a = 2m/s^2$

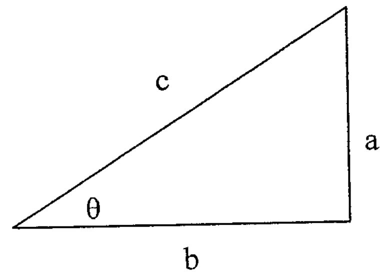
$T = 150 - 15(2) = 120N$

Trigonometric Functions:

$\sin\theta = {}^{a}\!/_{c}$

$\cos\theta = {}^{b}\!/_{c}$

$\tan\theta = {}^{a}\!/_{b}$



Quadratic Formula:

If: $ax^2 + bx + c = 0$, then: $x = \dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

Kinematics:

$Velocity = v = \dfrac{dx}{dt}$ $\quad AverageVelocity = v_{avg} = \dfrac{(x_f - x_i)}{(t_f - t_i)}$ $\quad Acceleration = a = \dfrac{dv}{dt}$

If a = constant: $v = v_o + at$

$$x = x_o + v_o t + \frac{at^2}{2}$$

$$v^2 - v_o^2 = 2a(x - x_o)$$

Centripetal Acceleration: $a_c = \dfrac{v^2}{r}$; directed toward center of circle

Newton's Law and Forces:

$\vec{F} = m\vec{a}$ (or $\vec{a} = {}^{\vec{F}}\!/_{m}$) Kinetic Friction: $F_f = \mu_k N$

Static Friction: $F_f \leq \mu_s N$

Force of gravity: $F = mg$, where g = 9.8 m/s^2: (Near earth, pointed down)

$F = \dfrac{GM_1M_2}{r^2}$, general case (attractive)

Some Useful (?) Constants:

$G = 6.67x10^{-11}\dfrac{Nm^2}{kg^2}$, $\quad R_e = 6.37x10^6\,m$, $\quad M_e = 5.98x10^{24}\,kg$

CHAPTER 5:

PHYSICS 008
OCTOBER 5, 2009

7. $F_c = \frac{mv^2}{R} = \frac{.3(4)^2}{.72} = 6.67N$

$mg = 3(9.8) = 2.94N$

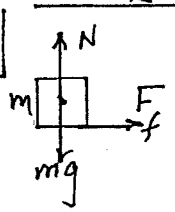
a) $mg + F_{T1} = mv^2/R$

$F_{T1} = \frac{mv^2}{R} - mg = 3.73N$

b) $F_{T2} - mg = mv^2/R$

$F_{T2} = \frac{mv^2}{R} + mg = 9.61N$

9.



$F_f = mv^2/R$

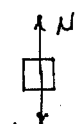
$(F_f)_{MAX} = \mu_s N = \mu_s mg$

$\mu_s mg = mv_{MAX}^2/R$

$v_{MAX}^2 = \mu_s Rg = .8(77)9.8$

$v_{MAX} = 24.6\, m/s$ (~55 mph)

3.



$a = v^2/R$

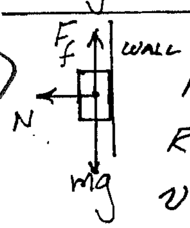
$mg - N = mv^2/R$

N MUST NOT BE LESS THAN 0:

$\frac{mv_{MIN}^2}{R} = mg$

$v_{MIN}^2 = Rg \quad v_{MIN} = 8.52\, m/s$

18.



$N = \frac{mv^2}{R}$

R = 4.6 METERS

$v = \frac{2\pi(4.6)}{2\,SEC}$

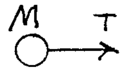
$= 14.45\, m/s$

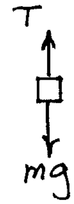
$N = \frac{mv^2}{R} = m(45.4)$

$mg = F_f \leq \mu_s N$

$\mu_s \geq \frac{g}{N} = \frac{mg}{m(45.4)} = 0.216$

19.





$T = \frac{Mv^2}{R}$

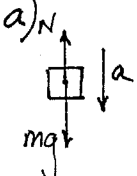
$\frac{Mv^2}{R} = mg$

$v^2 = mgR/M$

50. $v = \frac{2\pi R}{T} = \frac{2\pi(12)}{15.5} = 4.86 \frac{m}{s}$

$F_c = \frac{mv^2}{R} = \frac{m(4.86)^2}{12} = m(1.97)$

a)

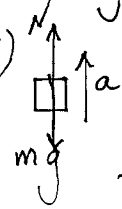


TOP: $mg - N = F_c$

$N = mg - F_c = m(7.83)$

$\frac{N}{mg} = \frac{7.83}{9.8} = 0.80$

b)



BOTTOM: $N - mg = F_c$

$N = mg + F_c = m(11.77)$

$\frac{N}{mg} = \frac{11.77}{9.8} = 1.20$

66. $T - mg = mv^2/R$

$v^2 = R(T - mg)/m$

$v_{MAX}^2 = R(T_{MAX} - mg)/m$

$= 5.5(1400 - 80 \cdot 9.8)/80$

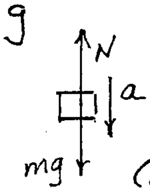
$v_{MAX}^2 = 42.3;\ v_{MAX} = 6.51\, m/s$

69. $v = \frac{2\pi R}{T} = \frac{2\pi(6.38 \times 10^6)}{24(3600)}$

$= 464\, m/s$

$a_c = \frac{v^2}{R} = 0.034\, m/s^2$

$\frac{a_c}{g} = .0034$ (~.34%)



$N = mg - F_c$

$\simeq .9966\, mg$

(NOT A BIG EFFECT!)

72. $N = \frac{mv^2}{R} = mg$

$v = \sqrt{Rg} = \sqrt{5.5 \times 10^2 \times 9.8}$

$= 73.4\, m/s$

T FOR ONE REVOLUTION

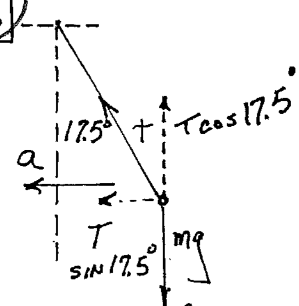
$= \frac{2\pi R}{v} = 47.1 s$

$REV/SEC = \frac{1}{T} = 0.0212$

$\frac{0.0212}{SEC} \cdot \frac{3600 \times 24 s}{DAY}$

$= 1835\, REV/DAY$

79.



$T\cos 17.5° = mg$

$T\sin 17.5° = ma$

$a = g\tan 17.5°$

$a = \frac{v^2}{R} = g \tan 17.5°$

$v^2 = Rg \tan 17.5°$

$= 235(9.8)(.315)$

$= 726$

$v = 26.9\, m/s$

49B

OCTOBER 9, 2009 NOV 25

CHAPTER SIX PROBLEMS (FRIDAY, OCTOBER 16)

19, 25, 34, 37, 63, 69, 71, 82, 88

OFFICE HOURS NEXT WEEK: ~~TUES, THURS 2-4~~ MON 2-4
WED ~~1-3~~ 1:30-3:30

EXAM: MEDIAN 70/80
→ TOO EASY
→ SOMEWHAT, BUT
MAINLY CLASS AS A WHOLE DID WELL
→ BELOW 35: SEE ME + LET'S TALK
→ GET HELP
HALPERN ROOM (MPA LIBRARY - 3N1 DRL)

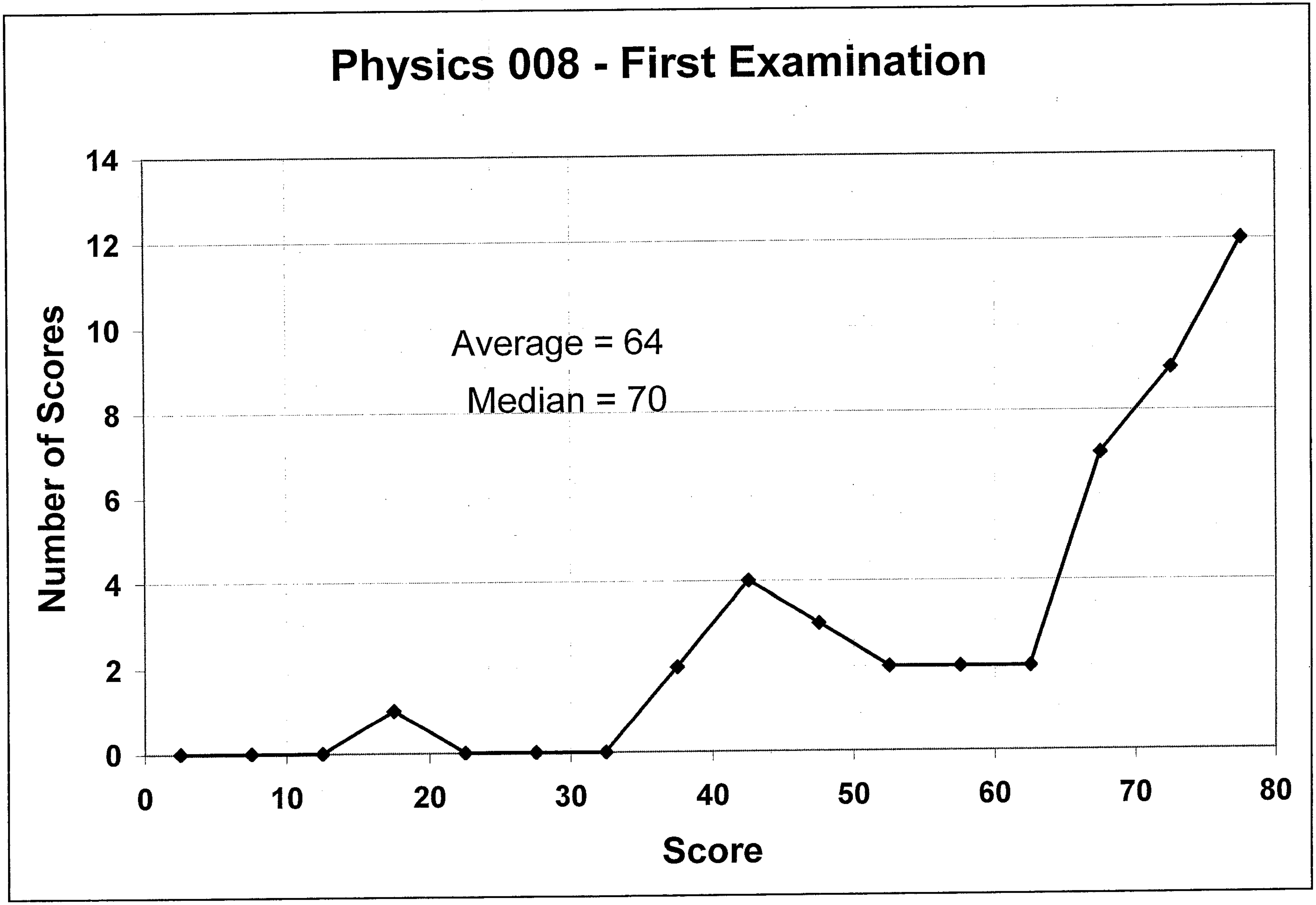
3-7 PM MTWTh

LOOK AT EXAM (NOTE ON "WEIGHT" SCHEME)

	20	→ 10, 20, 30
>70	20	→ 10, 20, 30
	50	70 50, 30
50-70		

OR COMBINATIONS

35


Physics 008 - First Examination
Average = 64
Median = 70
Number of Scores
14
12
10
8
6
4
2
0
0
10
20
30
40
50
60
70
80
Score

Kepler on

ON TO CHAPTER SIX

WORK + ENERGY:

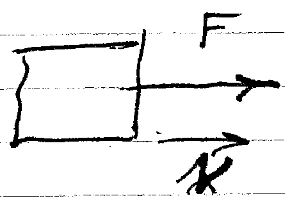
→ COMPLETELY NON-INTUITIVE

→ UNBELIEVEABLY USEFUL

ENERGY IS THE COIN OF THE REALM
IN THE PHYSICAL WORLD

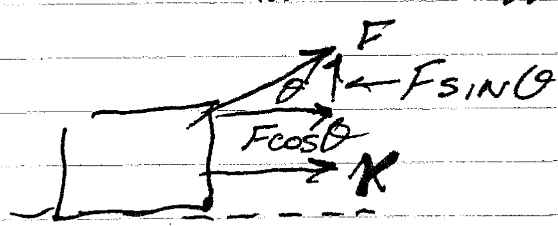
DEFINITION: FORCE DOES WORK ON OBJECT
IF IT MOVES IT IN THE DIRECTION
OF THE FORCE

(DEMO - PAIL, BENCH)



$W = Fx$

or $dW = F\,dx$

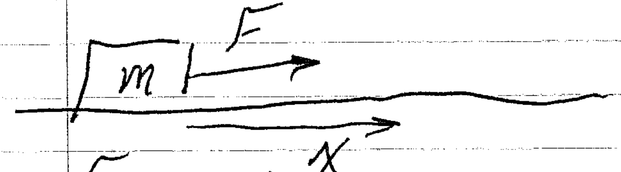


$W = F\cos\theta\, x$

$dW = (F\cos\theta)\, dx$

$(F\cos)\, x \equiv \vec{F} \cdot \vec{x}$ (DOT, OR SCALAR PRODUCT OF TWO VECTORS)

(BUT NOT ITSELF A VECTOR!)



$$a = \frac{F}{m}$$

NO FRICTION

$$dW = F\,dx = ma\,dx$$

$$W = \int dW = m \int a\,dx$$

$$a = \frac{dv}{dt} \longrightarrow a\,dx \rightarrow \frac{dv}{dt}\,dx = v\,dv$$

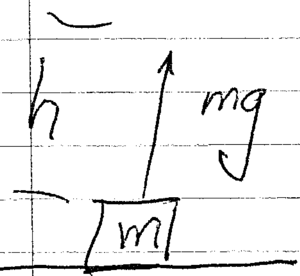
$$W = m \int_{v_i}^{v_f} v\,dv \rightarrow v^2/2$$

$$= \frac{mv_f^2}{2} - \frac{mv_i^2}{2}$$

(LOOKS A BIT LIKE $2a(x - x_0) = v^2 - v_0^2$)

DEFINE: $\frac{mv^2}{2}$ = KINETIC ENERGY = KE

→ WORK (IN THIS CASE) INCREASES KINETIC ENERGY



$$W = mg(h_f - h_i)$$

NO INCREASE IN KE:

$mg(h_f - h_i)$ = INCREASE IN POTENTIAL ENERGY PE

OCTOBER 12, 2009

FOR FRIDAY: CHAPT 6 : 19, 25, 34, 37, 63, 69, 71, 82, 88

TODAY – FINISH CHAPTER 6 (MAYBE)

WEDNESDAY – CHAPT 6 + 7

FRIDAY – CHAPT 6 PROBLEMS,

MONDAY – NO CLASS

WEDNESDAY – QUIZ ON CHAPTER 6

$WORK = F x$ → NEWTON-METER = "JOULE"

$= \vec{F} \cdot \vec{r}$ $\quad \vec{F}$ CONST

$= \int \vec{F} \cdot d\vec{r}$ $\quad \vec{F}$ VARIABLE

$KE = \frac{1}{2} m v^2$ $\quad \Delta PE = mgh_f - mgh_i$

$PE_i + KE_i$ + WORK ADDED

$= PE_f + KE_f$ + WORK LOSS

NO WORK IN OR OUT:

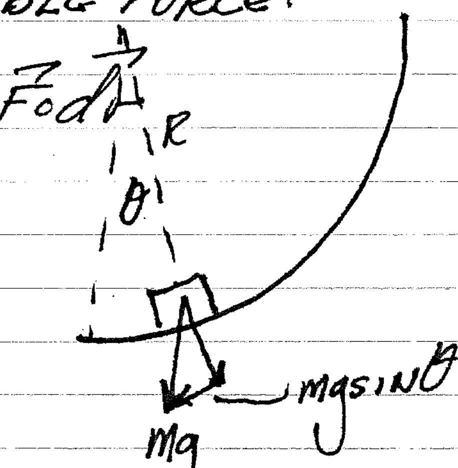
$PE_i + KE_i = PE_f + KE_f$

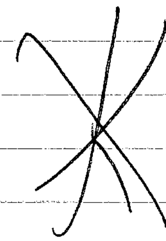
(NOT A VECTOR!)

PENDULUM

VARIABLE FORCE:

$dW = \vec{F} \cdot d\vec{l}$





$dW = (mg\sin\theta) R\,d\theta$

$= mgR\sin\theta\,d\theta$

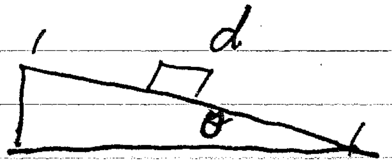
$W = \int_0^{\pi/2} \sin\theta\,d\theta\; mgR = \cancel{mgh}\; mgR = mg(h_2 - h_1)$

→ THIS IS EXAMPLE OF "CONSERVATIVE" FORCE

W DONE (1 → 2) IND. OF HOW YOU GET THERE

SUPPOSE NO EXTERNAL ENERGY

→ THEN PE + KE = CONSTANT



NO FRICTION: $F = mg\sin\theta$

$a = g\sin\theta$

$v^2 = 2ad = 2gd\sin\theta$

$KE_i = 0 \quad \frac{mv^2}{2} = KE_f \quad KE_f = mgd\sin\theta$

PUT $mgd\sin\theta = mgh_i - mgh_f$

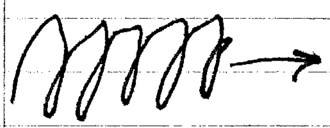
$KE_f - KE_i = mgh_i - mgh_f = PE_i - PE_f$

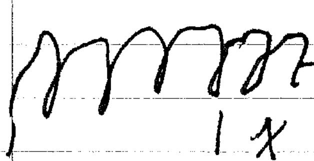
OR: $KE_i + PE_i = KE_f + PE_f$ (CON. OF ENERGY)

LOOP-THE-LOOP

OTHER CONSERVATIVE FORCES?

SPRING





$\to F = kx$

$$\text{WORK DONE} = \int_{x_i}^{x_f} kx\,dx = \frac{kx_f^2}{2} - \frac{kx_i^2}{2}$$

$$PE \to \frac{kx^2}{2}$$

BB GUN: BB ~ 10GM = 0.01KG

FIRED → ~~100~~ 50 m/s (ENOUGH TO PUT SOMEONE'S EYE OUT!)

COCK BY COMPRESSING SPRING 10CM

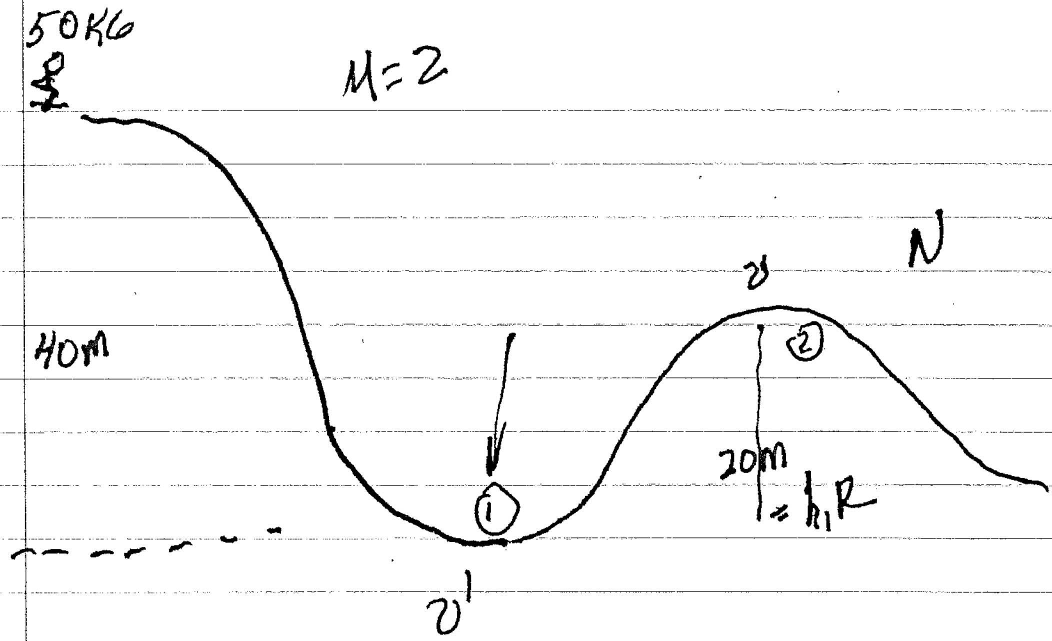
$k = ?$

$$PE_i + KE_i = PE_f + KE_f$$

$$\frac{kx_i^2}{2} + 0 = 0 + \frac{mv_f^2}{2}$$

$$k = \frac{mv_f^2}{x_i^2} = (\cancel{.01}) \frac{10^{-2} \times \overset{25\times 10^{3}}{\cancel{10^{4}}}}{10^{-2}} = \cancel{10^{4}\,N/M}\ 2500\,N/M$$

F (TO COCK) $= kx_i = \cancel{10^{3}}\,N$ 250 (~ ~~200 POUNDS~~ 50 POUNDS → PRETTY STIFF SPRING!)



$PE_i + KE_i = PE_f + KE_f$

N

1 $50g(40) + 0 = 0 + \frac{50}{2} v^2$

$v^2 = 2(40)g \sim 800$

mg

$v = 28\,m/s$ ($\sim 60\,mph$)

$N - mg = \frac{mv^2}{R}$

$N = m\left(g + \frac{800}{20}\right)$

$= m(5g!)$

$50(g)(40) + 0 = 50g(20) + \frac{50}{2} v^2$

$v^2 = 2(20)g \sim 400$

$v = 20\,m/s$ ($45\,mph$)

$\rightarrow \quad a_c = \frac{v^2}{R} = \frac{20(20)}{20} = 20\,m/s^2$

N

$20\,m/s^2$ $mg - N = ma_c =$

mg $50(10) - N = 50(20)$

$N = -500\,N \rightarrow$ AIRBOURNE!

NON-CONSERVATIVE FORCES:

MICROSCOPICALLY — DON'T EXIST

MACROSCOPICALLY — FRICTION, AIR RESISTANCE, ETC

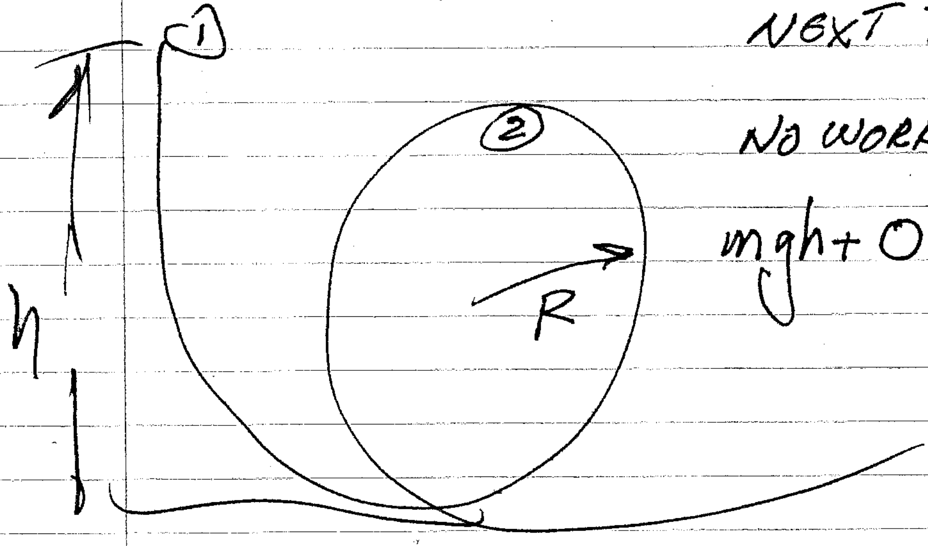
→ HEAT = MICROSCOPIC KINETIC + POTENTIAL ENERGY

BUT AT THIS POINT, ASSUME LOST

WORK DONE + $PE_i + KE_i = PE_f + KE_f$ + ENERGY LOST

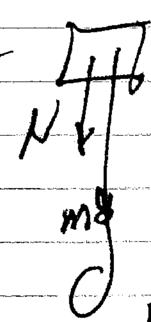
PENDULUM →

LOOP-THE-LOOP — HOW HIGH TO STAY ON
(CHECK OUT ROLLER COASTER NEXT TIME)



NO WORK DONE, NO LOSS

$$mgh + 0 = mg(2R) + \frac{mv^2}{2}$$



$N \to 0$

$$mg = \frac{mv^2}{R}$$

$$mv^2 = Rmg$$

$$\frac{mv^2}{2} = \frac{Rmg}{2}$$

$$mgh = mg(2R) + \frac{mgR}{2} = mg(2.5R)$$

$$h = 2.5R \leftarrow$$

(NOT QUITE RIGHT: ROLLING BALLS ALMOST ELIMINATE ENERGY LOSSES TO FRICTION
BUT ROTATION OF BALL ALSO HAS K.E.

$\hookrightarrow$ CHAPTER 8

POWER = RATE OF DOING WORK

(OR RATE OF USING ENERGY)

$$= \frac{dW}{dt} = \frac{d}{dt}\left(\vec{F} \cdot \vec{r}\right) = \vec{F} \cdot \frac{d\vec{r}}{dt} = \vec{F} \cdot \vec{v}$$

(OR $Fv\cos\theta$)

UNIT: $\frac{\text{JOULES}}{\text{SEC}}$ = WATT

$\rightarrow$ ELECTRIC POWER COST

UNIT = KWH = 1000 WATTS (3600 SEC)

$= 3.6 \times 10^6$ JOULES

(10¢ — PRETTY CHEAP)

(56A)

October 14, 2009

Problems for Friday

Quiz (Chapt. 6) on Wednesday (25)

Energy: KE $\frac{mv^2}{2}$ Joules

PE mgh, $\frac{kx^2}{2}$

Power: $= \frac{dW}{dt} = \vec{F} \cdot \vec{v}$ Watts

(746 Watt = 1 hp)

*

ENGLISH SYSTEM:

POWER UNIT = 1 HP = 746 WATTS

PERSON POWER — RUN UP FLIGHT OF STAIRS
IN ~~5 SECONDS~~ 10 SECONDS

$$W = mg\Delta h = (\cancel{600}\,750)N(\cancel{4}\,5M) = \cancel{2400\,J}\ 3750$$

$$POWER = \cancel{800\,J/5}\ \frac{\cancel{2400}\,3750}{\cancel{5}\,10} = \cancel{480\,WATTS}\ 375\,W$$

ME $\rightarrow$ ~~0.65 HP~~ 0.5 HP

OUT OF BREATH — KEEP GOING SEVERAL MORE FLIGHTS TO EXHAUSTION

CONSIDER AUTO WITH CONSTANT POWER OF ~~8~~50HP, IGNORE FRICTION, ETC

$$\cancel{Fv = 50 = 37000\ WATTS}$$

50HP x 746

~37,000 WATTS

$$\cancel{mg = 50}$$

$$\cancel{ma(v) = \cancel{50}\ 37000}$$

$$\cancel{a = \frac{\cancel{50}}{mv} = \frac{37000}{mv}}$$

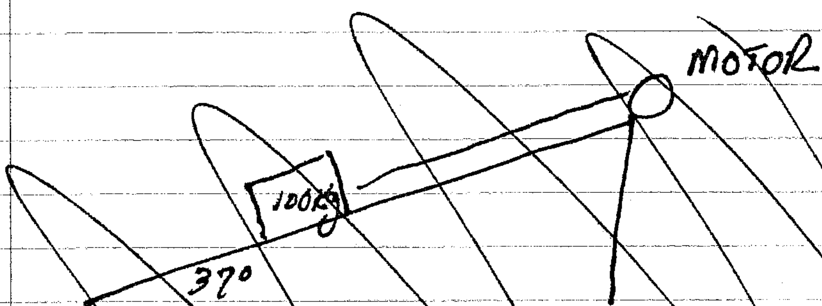
UPHILL – 5° $\quad F = mg\sin\theta \sim \frac{mg}{12} = \frac{(1000)10}{12}$

$$\frac{1000(10)}{12}\, v = 37000$$

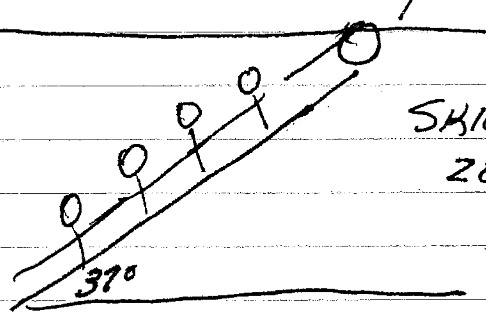
$$v_{MAX} = (3.7)(12) = 45\,m/s \ (100\,MPH)$$

UPHILL 10° $F = mg\sin\theta \sim \frac{10^4}{6}$

$v_{MAX} = 3.7(6) \sim 22\ m/s$



PULL 100Kg BOX UP 37° SLOPE WITH $\mu_s = .15$
AT 5 METERS/SEC

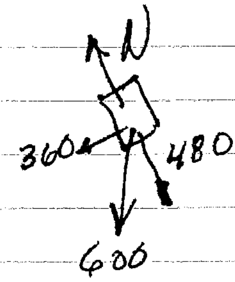


SKIERS 600 N EACH
20 ON LINE

$v = \overset{5}{\cancel{10}}\ m/s$

$\mu_k \sim .15$

POWER = ?



$F_f = .15(480) = 72$

$F_{TOTAL} = (360 + 72)(20)$

$= (432)(20) = 8640N$

$POWER = Fv = (8640)(5) = 4.3 \times 10^4\ WATTS$

$\cong 55HP$

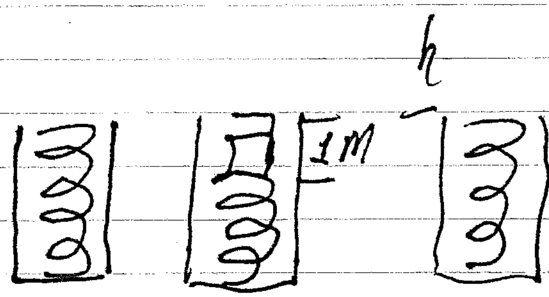
Mix Energies:

Human Cannon Ball:

$mg = 500N \quad m = 50KG$

$k = 10{,}000$

Compress by 1 m



$h = ?$

$a_{MAX} = ?$

$v_{MAX} = ?$

$kX_{MAX} = 10{,}000$

$a_{MAX} = \cancel{\frac{10{,}000}{50} = 200}$

$= \frac{10000 - 500}{20} = 190\ m/s^2$ (19g!)

$h = ?$ $PE_i + KE_i = PE_f + KE_f$

$\frac{(10{,}000)1^2}{2} + 0 = (500)(h+1)$

$10{,}000 = 100(h+1)$

$h + 1 = 10 \quad h = 9$ meter ($\approx$ 30FT)

v_{MAX}: where? $x = 0$ (as it comes out? No!)

At $a = 0$: $kx - mg = 10$

$10000x - 500 = 0 \quad x = .05m$

$PE_i + KE_i = PE_f + KE_f$

$$\frac{(10{,}000)(1)^2}{2} = \frac{(10{,}000)(.05)^2}{2} + (500)(.95) + \frac{(50)v^2}{2}$$

$$10 = 10(.05)^2 + .95 + \cancel{50}\,{}^{.05}v^2$$

$$10 = .025 + .95 - .05v^2$$

$$v^2 \simeq \frac{9}{.05} \simeq 180$$

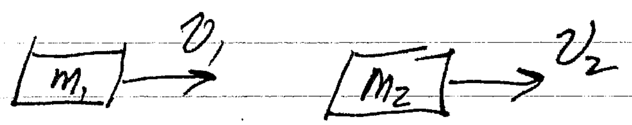
$$v \sim 13\ m/s$$

DO PROBLEMS:

ONWARD: AIR TRACK~~S~~

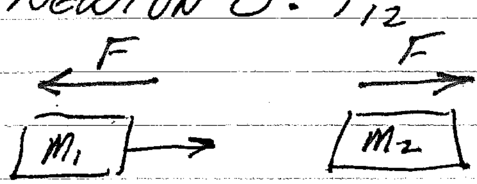
— MOMENTUM → MORE INTUITIVE THAN ENERGY → BUT ALSO HARDER TO USE, LESS USEFUL

CONSIDER TWO MOVING OBJECTS WHICH COLLIDE:

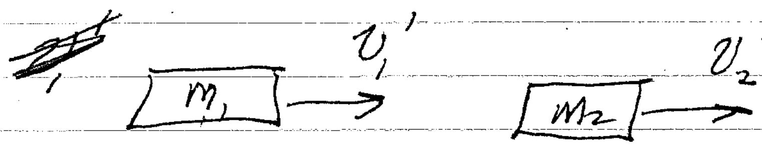


$v_1 > v_2$

NEWTON 3: $F_{12} = -F_{21}$



$$a_1 = -\frac{F}{m_1} \qquad a_2 = \frac{F}{m_2}$$



$$v_1' = v_1 + \int a_1\,dt = v_1 - \frac{1}{m_1}\int F\,dt$$

$$v_2' = v_2 + \frac{1}{m_2}\int F\,dt$$

NOW CONSIDER $m_1 v_1' + m_2 v_2'$:

$$m_1 v_1' = m_1 v_1 - \int F\,dt$$

$$m_2 v_2' = m_2 v_2 + \int F\,dt$$

$$m_1 v_1' + m_2 v_2' = m_1 v_1 + m_2 v_2 \qquad \left(\text{IND. OF} \int F\,dt\right)$$

$\vec{P} \equiv mv =$ <u>MOMENTUM</u>

CONSERVATION OF MOMENTUM:

IN ABSENCE OF <u>EXTERNAL</u> FORCE,

MOMENTUM OF SYSTEM IS CONSERVED

TRY AIR TRACK:

INELASTIC: $m_1 v_1 \Rightarrow (m_1 + m_2) v_2$

$$v_2 = \frac{m_1}{m_1 + m_2} v_1 = \frac{v_1}{2}$$

PHYSICS 008
OCTOBER 16, 2009

CHAPTER 6:

19. $W = F \cdot x = 110(.78)$

$W \rightarrow KE = \frac{mv^2}{2}$

$110(.78) = .088\, v^2/2$

$v = 44.2\ m/s$

25. a) $T - mg = ma$

$T = m(a+g) = 285(1.16)g$

$= 3.24 \times 10^3\ N$

b) NET WORK $= (T - mg)\Delta h$

$= (3.24\times10^3 - 2.79\times10^3)22$

$= 9.83\times10^3\ J$

c) $T\Delta h = 3.24\times10^3 \times 22 = 7.13\times10^4\ J$

d) $(-mg)\Delta h = 6.14\times10^4\ J$

e) $KE = W_{NET} = 9.83\times10^3$

$v = \left[\frac{2\times9.83\times10^3}{285}\right]^{1/2} = 8.30\ m/s$

34. $(PE)_i + (KE)_i = (PE)_f + (KE)_f$

$mg(185) + 0 = 0 + mv^2/2$

$v^2 = 2g(185)$

$v = 60.2\ m/s$ $(\sim 135\ mph)$

37. a) $v^2 - v_0^2 = 2g(y - y_0)$

$v^2 - 5^2 = 2(-9.8)(0-3)$

$v = 9.15\ m/s$

b) $(KE)_i + (PE)_i = (KE)_f + (PE)_f$

$\frac{mv^2}{2} + 0 = mgh + \frac{kx^2}{2}$

$\frac{65(9.15)^2}{2} = 65(9.8)x + \frac{6.2\times10^4 x^2}{2}$

$6.2\times10^4 x^2 + 1.27\times10^3 x - 5.45\times10^3 = 0$

$x = -.306\ m, +.285\ m$

63. $\text{POWER} \cong \frac{KE_f - KE_i}{\Delta t}$

$KE_f = 1150(65\cdot.278)^2/2$

$= 1.88\times10^5\ J$

$KE_i = 1150(85\times.278)^2/2$

$= 3.21\times10^5\ J$

$\text{POWER} = \frac{(1.88 - 3.21)\times10^5}{6}$

$= -2.22\times10^4$ WATTS

$(\sim 29.8\ hp)$

MUST APPLY POSITIVE POWER TO KEEP MOVING

69. TO CLIMB HILL MUST OVERCOME GRAVITY AND FRICTION:

GRAVITY $\rightarrow mg\sin\theta = 1200(9.8)\sin\theta$

TOTAL $= mg\sin\theta + 650$

$Fv = \text{POWER} = 120\ hp = 8.95\times10^4$ WATTS

$v = 75\ km/hr = 20.85\ m/s$

$(1200(9.8)\sin\theta + 650)20.85 = 8.95\times10^4$

$\sin\theta = .31;\ \theta = 18°$

71. COASTING AT $5\ m/s$:

$mg\sin\theta - F_{RES.} = 0$

$F_{RES.} = mg\sin\theta$

UPHILL: DOWNHILL FORCE

$= mg\sin\theta + F_{RES} = 2mg\sin\theta$

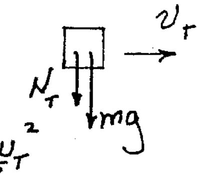
RIDER MUST EXERT $2mg\sin\theta$ TO MAINTAIN SPEED

$\text{POWER} = (2mg\sin\theta)v$

$= 2(75)(9.8)(.122)5$

$= 895$ WATTS $= 1.20\ hp$

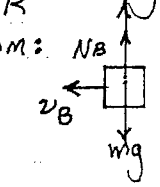
82. AT TOP:



$N_T + mg = \frac{mv_T^2}{R}$

$N_T = \frac{mv_T^2}{R} - mg$

AT BOTTOM:



$N_B - mg = \frac{mv_B^2}{R}$

$N_B = \frac{mv_B^2}{R} + mg$

BUT $\frac{mv_B^2}{2} = \frac{mv_T^2}{2} + 2mgR$

$\frac{mv_B^2}{R} = \frac{mv_T^2}{R} + 4mg$

$N_B - N_T = 4mg + 2mg$

$= 6mg$

88. STORED ENERGY

$= 1.2\times10^8\ \frac{J}{s} \times 3.6\times10^3\ s$

$= 4.32\times10^{11}\ J = mgh$

$m = \frac{4.32\times10^{11}}{9.8\times520} = 8.48\times10^7\ KG$

$\text{VOLUME} = \frac{m}{\rho} = \frac{8.48\times10^7\ KG}{10^3\ KG/M^3}$

$\text{VOL.} = 8.48\times10^4\ m^3$

$\sim$10 METERS DEEP, 100 METERS SQUARE

OCTOBER 19, 2009

(1) NEXT WEEK: OFFICE HOURS TUESDAY 2-4PM

(2) QUIZ ON CHAPTER 6: WEDNESDAY

(3) PROBLEMS IN CHAPTER 7: FRIDAY

4, 6, 7, 9, 12, 15, 23, 35, 43, 67, 77, $\boxed{81}$

NOTE ON PROBLEMS

HAND OUT SOLUTIONS!

---

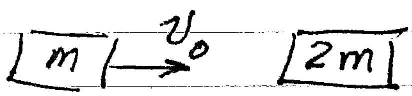
34 | 37 | a) b) 71 | 88 |

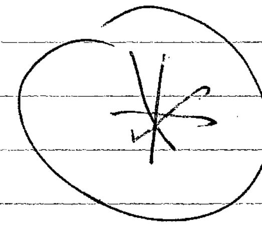
ENERGY?

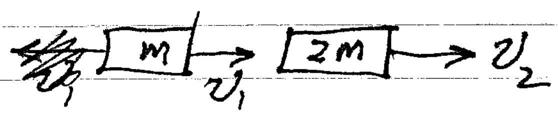
$$(KE)_i = \frac{m_1 v_1^2}{2}$$

$$KE_f = \frac{2m_1\left(\frac{v_1}{2}\right)^2}{2} = \frac{m_1 v_1^2}{4} \neq KE_f$$

ELASTIC = BOUNCE, CONS. KE







(1) $m v_0 = m v_1 + 2m v_2$ (CONS. P)

(2) $m v_0^2 = m v_1^2 + 2m v_2^2$ (CONS. KE)

SOLVE (1) FOR $v_1 = v_0 - 2v_2$

SUBS. IN (2)

$$v_0^2 = v_0^2 + 4v_2^2 - 4v_0 v_2 + 2v_2^2$$

$$0 = 6v_2^2 - 4v_0 v_2$$

$$v_2 = 0,\ \frac{2v_0}{3}$$ TEST IT!

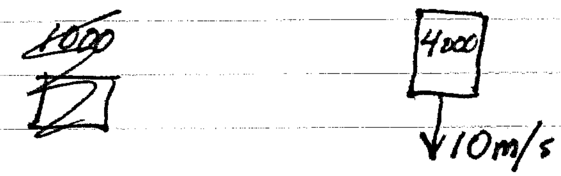
$$v_1 = v_0,\ -\frac{v_0}{3}$$

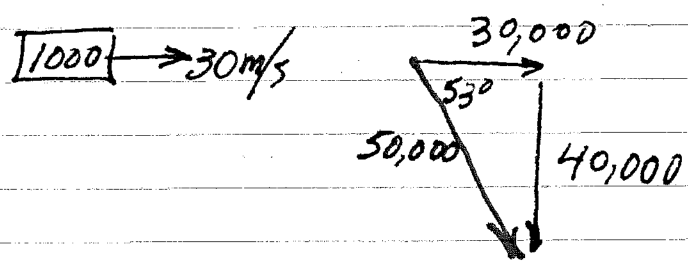
PUT IN SOME COMPLICATIONS:

$\vec{v}$ IS A VECTOR

$\therefore \vec{P} = m\vec{v}$ IS A VECTOR

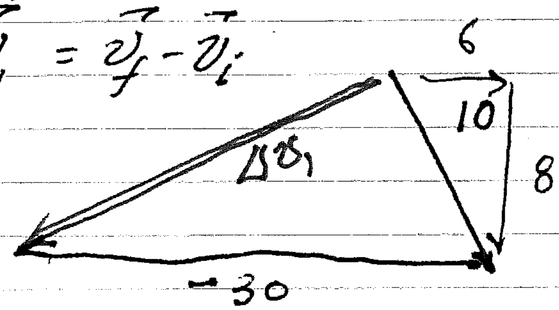
AND $\vec{P}$ IS CONSERVED AS A VECTOR





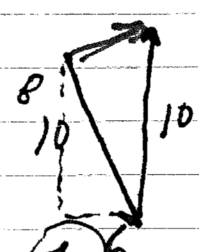
$\vec{v}_f = 10\,m/s$ @ $53°$

$\Delta\vec{v}_1 = \vec{v}_f - \vec{v}_i$



$\Delta v_1 = 25\,m/s$

$\Delta v_2 = \vec{v}_f - \vec{v}_i$



$\Delta v_2 = 6.3\,m/s$

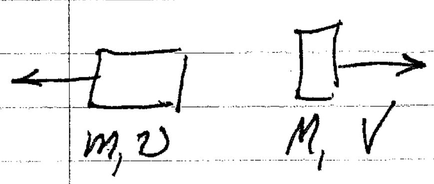
$\Delta t = 0.1\,sec$

BAD NEWS FOR 1

$a_1 = 250\,m/s^2$ $(25g)$ (DEAD

$a_2 = 63\,m/s^2$ $(6.3g)$ JOLT

CONSIDER $P = 0$ CART, ME



$$mv + MV = 0$$

$$V = -\frac{mv}{M}$$

EQUAL & OPPOSITE FORCE:

$$\Delta(mv) = \int F\,dt \equiv \text{"IMPULSE"}$$

RARELY DO INTEGRAL

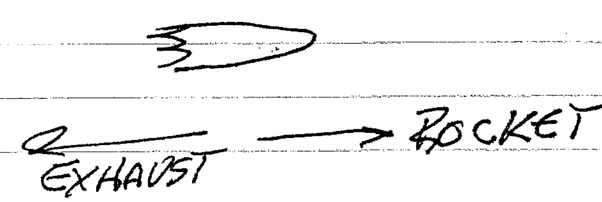
TRY m SMALL:

v LARGE, V SMALL

NOW TRY ~~#~~ m LARGE

v_{SMALLER}, V LARGER

SAME GAME WITH ROCKET:



$$P = mv = \text{CONST}$$

$$F = \frac{dP}{dt} = m\frac{dv}{dt} - v\frac{dm}{dt}$$

$m\frac{dv}{dt} = ma \rightarrow$ ACCELERATES!

$v\frac{dm}{dt} \rightarrow v$ OF EXHAUST

$\frac{dm}{dt}$ OF EXHAUSET

DEMO

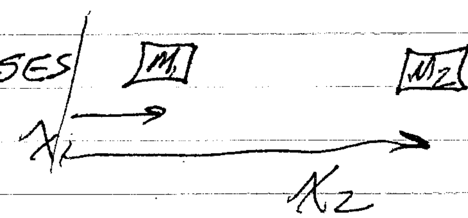
$v\frac{dm}{dt} \rightarrow$ UNITS OF FORCE $\equiv$ "THRUST"

USE AIR: v HIGH, $\frac{dm}{dt} \sim 0$ FIZZLE

USE WATER v LOWER, BUT $\frac{dm}{dt}$ MUCH HIGHER

LAST CONCEPT: CENTER OF MASS:

TWO MASSES



$$x_{cm} = \frac{m_1 x_1 + m_2 x_2}{m_1 + m_2}$$

OBVIOUSLY, IF $m_1 = m_2$

$$x_{cm} = \frac{x_1 + x_2}{2}$$

STANDARD EXAMPLE

OCTOBER 21, 2009

TODAY: EASY QUIZ ON CHAPT 6

FINISH CHAPTER 7

OFFICE HOURS TODAY 3-5PM

FRIDAY CHAPT 7 PROBLEMS

4, 6, 7, 9, 12, 15, 23, 35, 43, 47, 77, 81

(ALL FAIRLY DULL & S-F)

CENTER OF MASS:

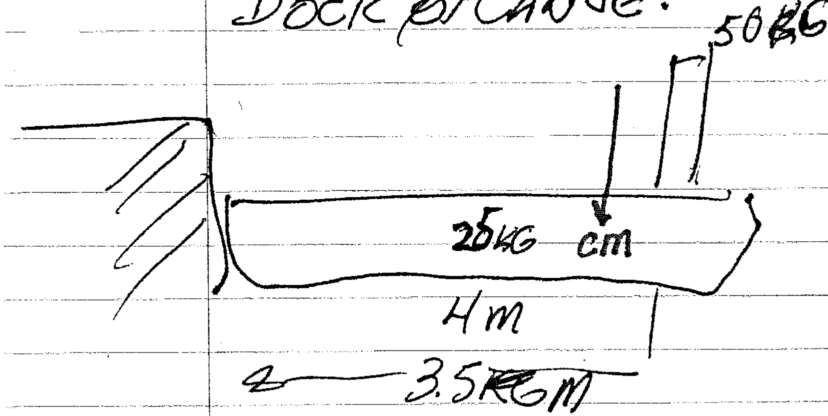
$$\rightarrow x_{cm} = \frac{\sum m_i x_i}{\sum m_i}$$

(SIMILARLY FOR y & z)

CANOE:

DEMO

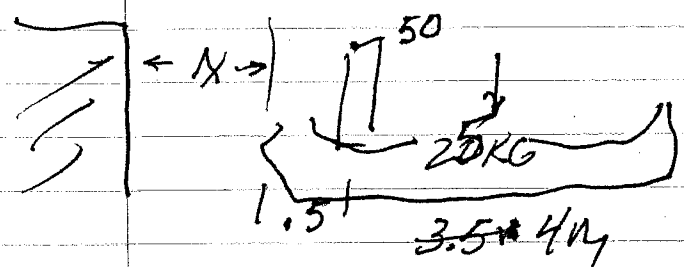
DOCK & CANOE:



$$x_{CM} = \frac{25(2)+50(3.5)}{75}$$

$$= 3.0$$

WALK TO DOCK: / NO EXT FORCE : P = 0
CM STAYS PUT:



$$\frac{50(x+.5)+25(x+2)}{75} = \frac{25(2)+50(3.5)}{75}$$

$$50x+25+25x+50 = 225$$

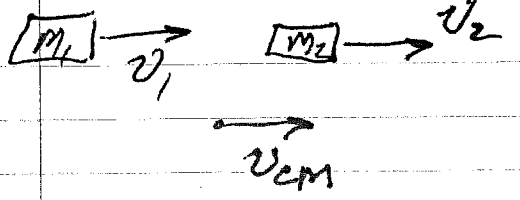
$$75x = 150$$

$$x = 2m \text{ (TOO BAD)}$$

TAKE IT A STEP FARTHER:

$$x_{CM} = \frac{m_1 x_1 + m_2 x_2}{m_1 + m_2}$$

$$v_{CM} = \frac{m_1 v_1 + m_2 v_2}{m_1 + m_2}$$



SUPPOSE WE LOOK IN FRAME OF REFERENCE OF C. OF M

$$v_1' = v_1 - v_{cm} \qquad v_2' = v_2 - v_{cm}$$

$$m v_1' + m v_2' = m_1 v_1 - \frac{m_1}{m_1+m_2}(m_1 v_1 + m_2 v_2)$$

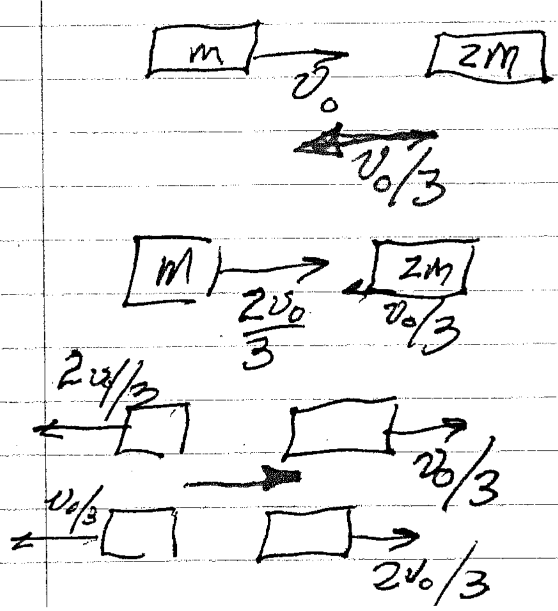
$$+ m_2 v_2 - \frac{m_2}{m_1+m_2}(m_1 v_1 + m_2 v_2)$$

$$= m_1 v_1 + m_2 v_2 - \frac{m_1^2 v_1 - m_1 m_2 v_2 - m_1 m_2 v_1 - m_2^2 v_2}{m_1+m_2}$$

$$= m_1 v_1 + m_2 v_2 - \left[m_1 v_1 + m_2 v_2 \right]$$

$$\equiv 0 \, !$$

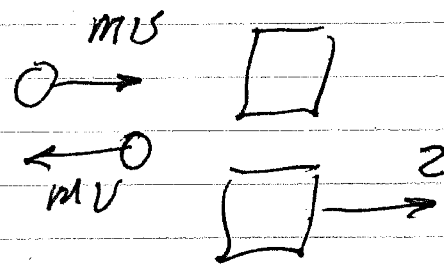
$$v_{cm} = \frac{m v_0}{3m} = \frac{v_0}{3}$$



MORE INTERESTING EXAMPLE
(~~pp~~ B-BALL ON BENCH

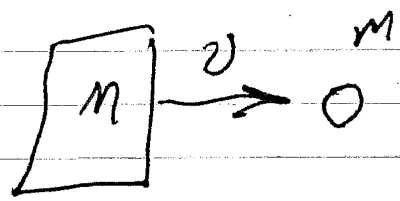
CONSERVE ENERGY $v_f^2 = v_i^2$

CONSERVE MOMENTA?

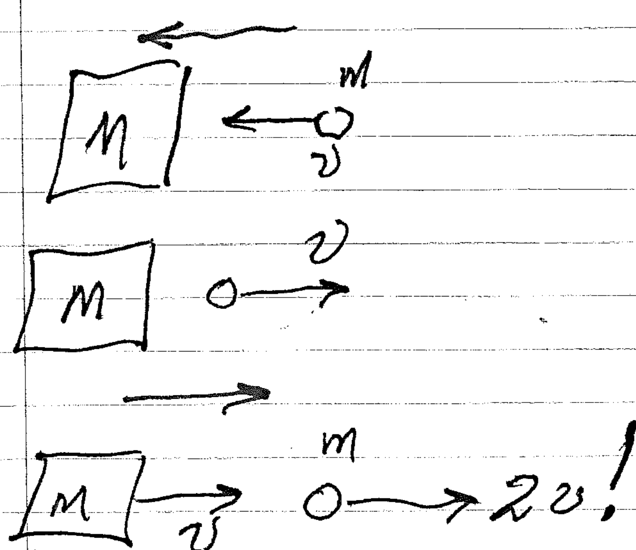


$2mv = MV$ ← RATHER SMALL

NOW SUPPOSE BENCH MOVES, HITS BALL:

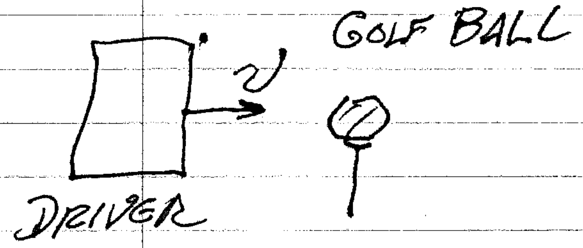


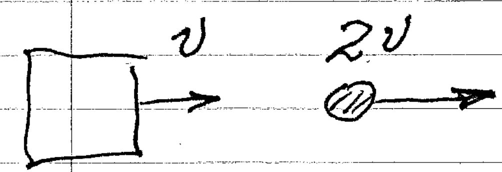
$v_{cm} = v$



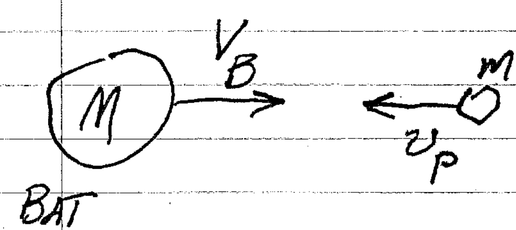
REAL WORLD?

GOOD APPROXIMATION

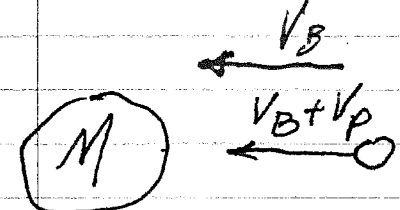


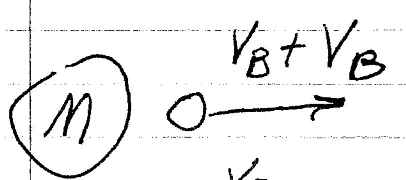


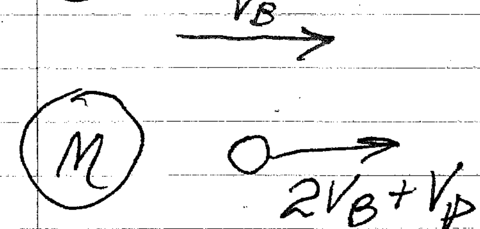
LESS GOOD APPROXIMATION



IF $M \gg m$, $v_{cm} = V_B$







NOTE: FASTER IT'S THROWN
TOO FAST IT COMES OFF THE BALL

(PROB 81)

CHAPTER 7: ALMOST INTUITIVE, EASY

CHAPTER 8: NOT INTUITIVE, HARDER

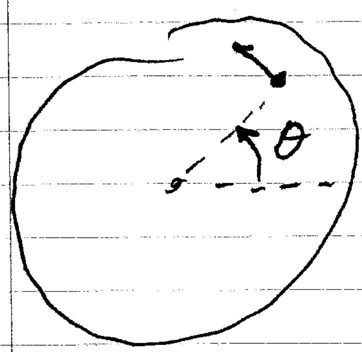
→ WE OPERATE IN LINEAR WORLD,
NOT OBVIOUSLY ROTATING ONE

LINEAR: DEFINITIONS, NEWTON, ENERGY, MOMENTUM

CIRCULAR: DEFINITIONS, ENERGY, "NEWTON", MOMENTUM
→ DEPARTURE FROM ORDER IN TEXT

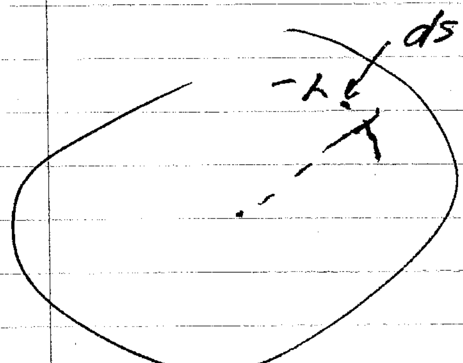
START WITH DEFINITIONS:

WHEEL x, v, a NOT USEFUL CONCEPTS:



θ = ANGLE (WITH RESPECT TO SOME DEFINED ORIGIN

v – NOT USEFUL: VARIES



$$v = \frac{ds}{dt}$$

BUT $ds = r\,d\theta$

$$v = r\frac{d\theta}{dt} \rightarrow \text{VARIES WITH } r$$

$\frac{d\theta}{dt}$ IS SAME ALL PARTS

$$\frac{d\theta}{dt} = \text{ANGULAR VELOCITY} = \omega \quad (\text{RADIANS}/\text{SEC})$$

Name WALES

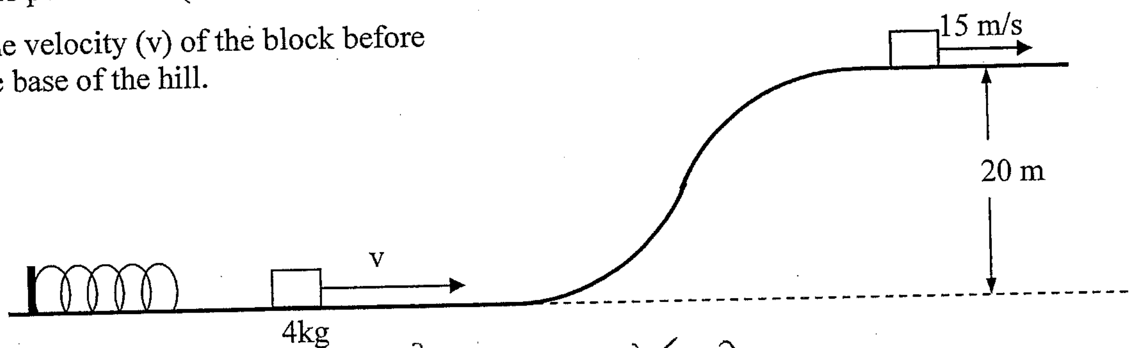
PHYSICS 008 *(Please Print)*

Fourth Quiz
October 21, 2009

Please do all work on this sheet. Your score will depend both on the work you show and on the answers you obtain. You may use a calculator and the information on the reverse side of this sheet.

A block of mass of 4 kilograms is on a horizontal frictionless surface. It is placed against a spring which is compressed by 0.50 meter. When the spring is released the block slides across the surface and up a hill, also frictionless. The top of the hill is 20 meters above its base. At the top of the hill the velocity of the block is 15 meters per second. (Note: You may use "g" = $10 m/s^2$ if you wish.)

a) Determine the velocity (v) of the block before it reaches the base of the hill.



$$\frac{mv^2}{2} + 0 = \frac{m(15)^2}{2} + m(10)(20)$$

$$v^2 = (15)^2 + 400 = 625$$

$$v = 25 \, m/s$$

b) Determine the elastic constant (k) of the spring.

$$\frac{kx^2}{2} + 0 = \frac{mv^2}{2}$$

$$k = \frac{mv^2}{x^2} = \frac{4(625)}{(.5)^2} = 10{,}000 \, N/M$$

Name Wales

PHYSICS 008 *(Please Print)*

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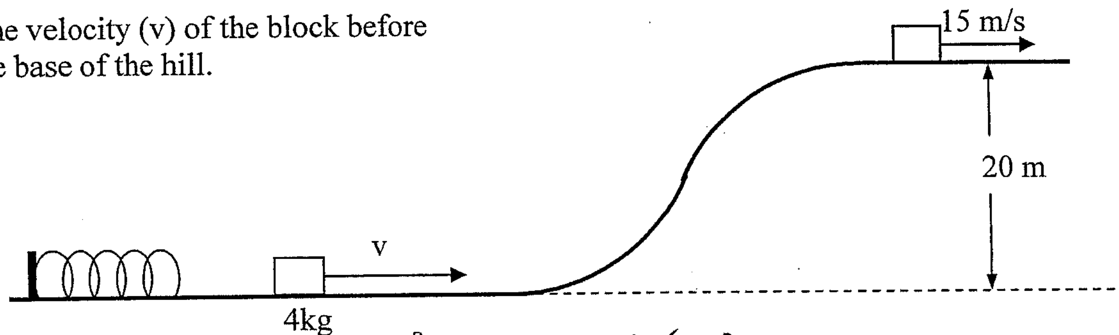

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$$k = \frac{mv^2}{x^2} = \frac{4(625)}{(.5)^2} = 10{,}000 \ N/M$$

Quadratic Formula:

If: $ax^2 + bx + c = 0$, then: $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

Kinematics:

$Velocity = v = \frac{dx}{dt}$ $\quad AverageVelocity = v_{avg} = \frac{(x_f - x_i)}{(t_f - t_i)}$ $\quad Acceleration = a = \frac{dv}{dt}$

If a = constant: $v = v_o + at$

$$x = x_o + v_o t + \frac{at^2}{2}$$

$$v^2 - v_o^2 = 2a(x - x_o)$$

Centripetal Acceleration: $a_c = \frac{v^2}{r}$; directed toward center of circle

Newton's Law and Forces:

$\vec{F} = m\vec{a}$ (or $\vec{a} = \vec{F}/m$) Kinetic Friction: $F_f = \mu_k N$

Static Friction: $F_f \le \mu_s N$

Force of gravity: $F = mg$, where g = 9.8 m/s^2: (Near earth, pointed down)

$F = \frac{GM_1 M_2}{r^2}$, general case (attractive)

Work and Energy:

$Work = W = Fx = \vec{F} \cdot \vec{r} = Fr\cos\theta = \int \vec{F} \cdot d\vec{r}$ $\quad Power = P = dW/dt = \vec{F} \cdot \vec{v}$

$KineticEnergy = KE = mv^2/2$ $\quad PotentialEnergy = PE$ $\quad$ Near earth ΔPE = Δmgh

Spring: $F = -kx$, $PE = kx^2/2$

Work and Conservation of Energy

$$Work_{added} + PE_i + KE_i = Work_{lost} + PE_f + KE_f$$

If no work added or lost then: $PE_i + KE_i = PE_f + KE_f$

Some Useful (?) Constants:

$G = 6.67x10^{-11} \frac{Nm^2}{kg^2}$, $\quad R_e = 6.37x10^6 m$, $\quad M_e = 5.98x10^{24} kg$

OCTOBER 23, 2009

NEXT WEEK: MONDAY - CONTINUE CHAPT 8
WEDNESDAY - QUIZ ON 7 (INC. 6)
FRIDAY - CHAPT 8 PROBLEMS
25, 35, ~~40~~, 49, 50, 55, ~~60~~, 61, 65, 72, 75, 79, 80

OFFICE HOURS: MW 3-5PM
(OR E-MAIL ME!)

QUIZ: MOST FOUND IT EASY

FEW DID NOT → SHOULD SEE ME, GET HELP

SIMPLE CONS. OF ENERGY

PROBLEMS - HAND OUT SOLUTIONS:

NOTE 9/11 BEGIN WITH $\vec{P}_f = \vec{P}_i$

IF NO EXTERNAL FORCE, MOMENTUM OF SYSTEM REMAINS CONSTANT

(KE MAY OR MAY NOT BE CONSERVED)

PHYSICS 008
OCTOBER 23, 2009

CHAPTER 7:

4. $P_i = P_f$

$0 = 6.4(10) + (26+45)V$

$V = -64/71 = -0.90\ m/s$

6. $P_i = P_f$

$(95)4.1 + 85(5.5) = 180V$

$V = 4.76\ m/s$

7. $P_i = P_f$

$12{,}600(18) = (12{,}600 + 5350)V$

$V = \frac{12{,}600(18)}{17{,}950} = 12.6\ m/s$

9. 100 KM/HR = 27.8 m/s

$\frac{\Delta P}{\Delta t} = F = 27.8 \frac{m}{s} \cdot 40 \frac{KG}{s\text{-}m^2} \cdot .75 m^2$

$= 834 \frac{KG\text{-}m}{s^2}$ (= NEWTONS)

FRICTION (MAX) $= \mu mg$

$= 1(70)(9.8) = 686 N$

(BLOWN AWAY!)

12. $P_i = P_f$

$.023(230) = .023(170) + 2.0V$

$V = \frac{.023(230-170)}{2.0} = .69 \frac{m}{s}$

15. a) IMPULSE $= \Delta P$

$= .045(45) = 2.02 \frac{KG\text{-}M}{S}$

b) $F_{AVG} = \frac{\Delta P}{\Delta t} = \frac{2.02}{.0035}$

$= 577 N$

23. $P_i = P_f$

$m(3.0) = mv_1 + 2mv_2$

$v_1 = 3 - 2v_2$

(1) $v_1^2 = 9 - 12v_2 + 4v_2^2$

$KE_i = KE_f$

$\frac{m(3)^2}{2} = \frac{mv_1^2}{2} + \frac{2mv_2^2}{2}$

(2) $3^2 = v_1^2 + 2v_2^2$

SUBSTITUTE (1) IN (2):

$3^2 = 9 - 12v_2 + 4v_2^2 + 2v_2^2$

$0 = 6v_2^2 - 12v_2$

$v_2 = 0,\ 2\ m/s$ (EAST)

$v_1 = 3 - 2(2) = -1\ m/s$

35. $P_i = P_f$

$920v = (920 + 2300)V$

$v = 3.5V$

$KE_i = KE_f + LOSS$

KE_i (OF WRECK) $= MV^2/2$

KE_f (OF WRECK) $= 0$

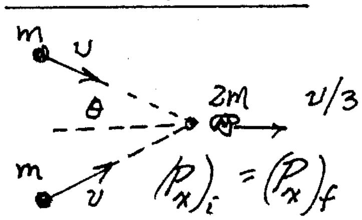
LOSS $= F_f$ (DISTANCE) $= .8(Mg)2.8$

$= 22M = \frac{MV^2}{2}$

$V = 6.63\ m/s$

$v = 23\ m/s$

43.



$(P_x)_i = (P_x)_f$

$2mv\cos\theta = 2m\,v/3$

$\cos\theta = \frac{1}{3}\ ;\ \theta = 70.5^\circ$

67. $P_i = P_f$

$mv = -\frac{mv}{4} + MV$

(1) $V = \frac{5}{4}\frac{mv}{M}$

$KE_i = KE_f$

$\frac{mv^2}{2} = \frac{1}{32}mv^2 + \frac{MV^2}{2}$

(2) $V^2 = \frac{15}{16}\frac{mv^2}{M}$

(1) INTO (2)

$\frac{25}{16}\frac{m^2v^2}{M^2} = \frac{15}{16}\frac{mv^2}{M}$

$M = \frac{25}{15}m = \frac{5}{3}m$

77. $P_i = P_f$

$0 = M_{NUC}v_{NUC} + m_\alpha v_\alpha$

$v_N = \frac{-m_\alpha}{M_H} v_\alpha$

$= \frac{-1}{57}(3.8\times10^5)$

$= 6.7\times10^3\ m/s$

(9) WIND = 27.8 m/s MASS OF WIND $\frac{40\,KG}{5\text{-}m^2}$ AREA = .5×1.5 = .75m

→ MULTIPLY $\frac{KG\text{-}M}{S^2}$ (MA) = FORCE

(RECALL 6-34

IGNORED AIR RESISTANE AT 60 m/s

23, 67 — PE+KE → COMPLICATES SOLUTION

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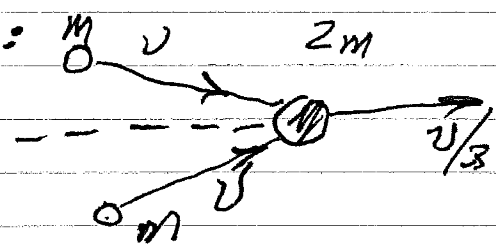
43. 2 (m AT v) COLLIDE, STICK AT v/3

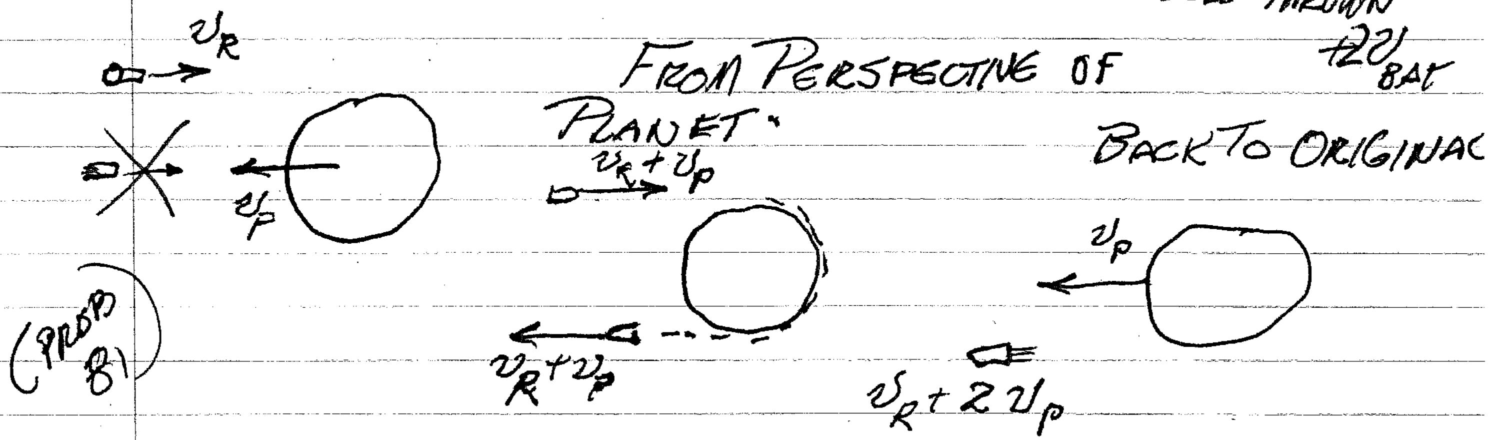
DIAGRAM HELPS:



$\vec{P}$ = CONST

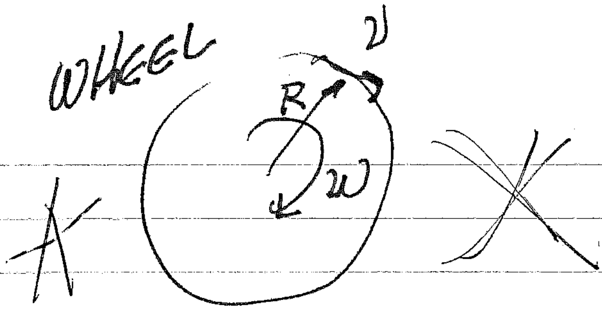
$P_y = 0$ P_x $2(mv\cos\theta) = 2m(v/3)$

SLING-SHOT EFFECT (RECALL BB → $v_{BALL} = v_{THROWN} + 2v_{BAT}$



$\omega = v/R$

IF ω CONSTANT



$$\theta = \theta_0 + \omega t$$

SPINNING WHEEL: $\theta = ?$ ω OBVIOUS

NOW SUPPOSE ω CHANGES:

$$\frac{d\omega}{dt} \equiv \alpha = \text{ANGULAR ACCELERATION}$$

$$\omega = \left\{ \omega_0 + \int \alpha\, dt \right.$$

IF α CONSTANT:

$$\omega = \omega_0 + \alpha t$$

PUT IT ALL TOGETHER (IF α CONSTANT)

$$\theta = \theta_0 + \omega_0 t + \alpha t^2/2$$

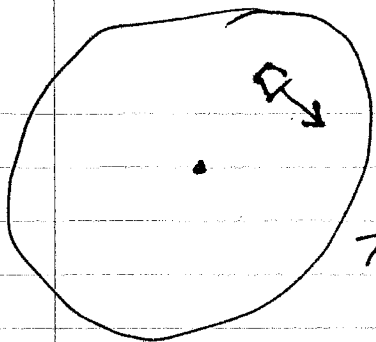
$$\omega = \omega_0 + \alpha t$$

$$\omega^2 - \omega_0^2 = 2\alpha(\theta - \theta_0)$$

FAMILIAR, BUT OF MARGINAL UTILITY

CONSIDER ROTATING WHEEL

$$KE_{TOTAL} = \sum KE \text{ OF ALL PIECES}$$



$$(KE)_m = \frac{mv^2}{2} = \frac{m(\omega r)^2}{2}$$

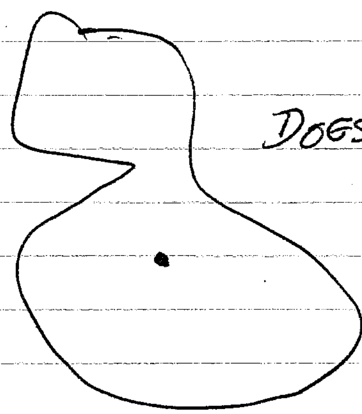
TOTAL: $$\sum \frac{m(\omega r)^2}{2} = \frac{\omega^2}{2} \sum m r^2$$

OR: $$\frac{\omega^2}{2} \int r^2 \, dm \equiv \frac{\omega^2}{2} I$$

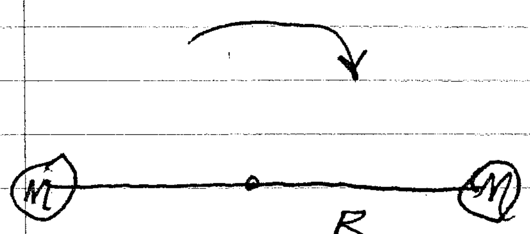
I FUNCTION OF MASS AND DISTRIBUTION OF MASS:
"MOMENT OF INTERIAL" ($KG \cdot M^2$)

FEW SIMPLE ONES, THEN LOOKUP MORE COMPLICATED ~~DISK (CYLINDER) $= \frac{1}{2} MR^2$~~

NOTE ALSO



DOES NOT HAVE CALCULABLE I



DUMBBELL
ROTATING AROUND
MIDDLE:

$$I = MR^2 + MR^2 = 2MR^2$$

OCTOBER 26, 2009

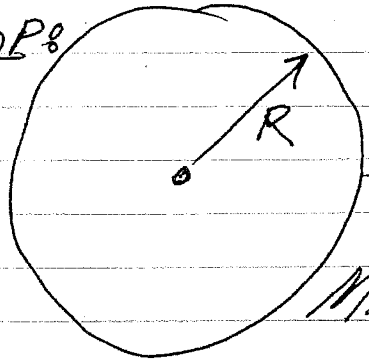
NOTE: OFFICE HOURS MW 3-5

QUIZ WEDNESDAY (7+6)

PROBLEMS FRIDAY (8)

MONDAY, ~~Oc~~ NOVEMBER 9 - EXAM #2
(TWO WEEKS)

HOOP:

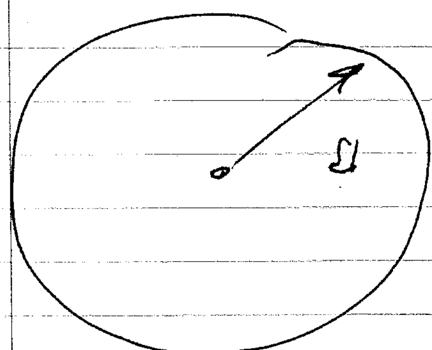


ROTATING AROUND CENTER

(BICYCLE WHEEL)

MASS ALL AT R: $I = MR^2$

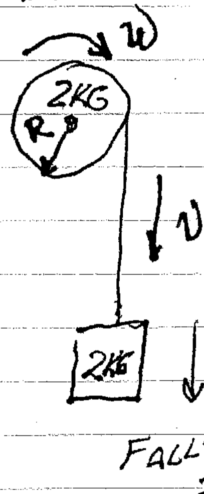
SOLID DISK



SOME OF MASS AT SMALLER RADIUS:

$$I = \int_0^R dm\, r^2 = \frac{MR^2}{2}$$

EXAMPLE:



DO THIS

FALLS BY 3m

$v = ?$

$\cancel{v}\ \omega = v/R$

$$PE + KE = PE + KE$$

$$2(10)(3) + 0 = 0 + \frac{mv^2}{2} + \frac{I\omega^2}{2}$$

$$= \cancel{I = \frac{MR^2}{2}} = \frac{mv^2}{2} + \frac{I}{R^2}\frac{v^2}{2}$$

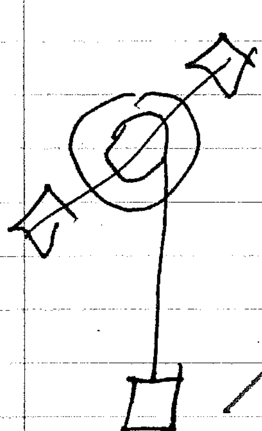
PULLEY IS DISC — $I = mR^2/2$

$$m_1 g h = 0 + \frac{m_1 v^2}{2} + \frac{m_2 R^2/2}{R^2}\,\frac{v^2}{2}$$

$$2(10)(3) = \frac{2v^2}{2} + \frac{1v^2}{2} = \frac{3}{2}v^2$$

$$v^2 = 40, \quad v = 6.3\ m/s$$

CONSIDER SLIGHTLY MORE GENERAL CASE



$$mgh = \frac{mv^2}{2} + \frac{I\omega^2}{2}$$

$$= mv^2 + \frac{I}{2}\frac{v^2}{R^2}$$

IF I BIG, $\frac{mv^2}{2}$ WILL BE SMALL

WATCH FALLING MASS → I LARGE

I SMALL

FOR MOST PROBLEMS INVOLVING ROTATION

ENERGY PROVIDES EASIER APPROACH THAN FORCE

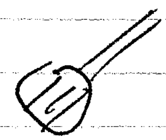
— BUT NOT ALL: NEED TO LOOK AT ANGULAR

ANALOG TO $\vec{F} = m\vec{a}$

ANGULAR ANALOG TO FORCE IS TORQUE

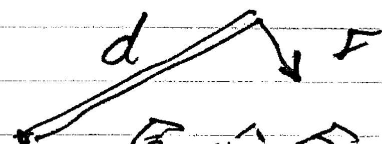
→ MIGHT CALL IT "LEVERAGE"

DEMO



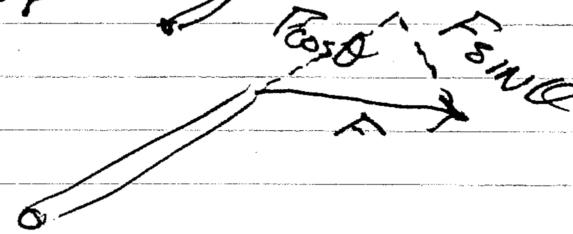
~~NUT~~ SCREW

TURNING SCREW REQUIRES BOTH FORCE AND DISTANCE



$\tau = rF$

BUT AT ANGLE:

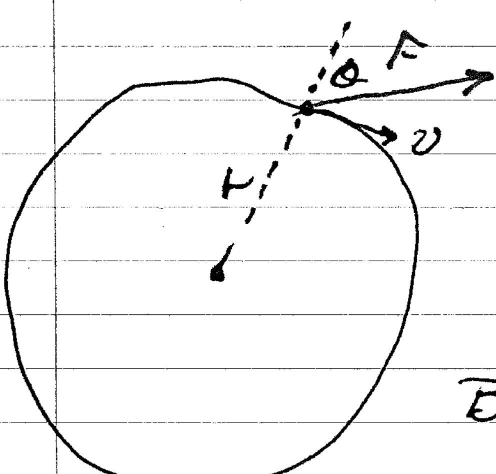


$\tau = rF\sin\theta$

→ BUT WE MULTIPLIED TWO VECTORS:

$\vec{\tau} = \vec{r} \times \vec{F}$ $\quad (\tau = rF\sin\theta)$

(WORRY ABOUT DIRECTION LATER)



$\tau = Fr\sin\theta$

POWER $= \vec{F}\cdot\vec{v} = F\sin\theta\, v$

$= F\sin\theta\, r\omega = \tau\omega$ ~~[illegible]~~ CF

BUT POWER $= \dfrac{\Delta W}{\Delta t} = \dfrac{\Delta KE}{\Delta t}$ ← IN THIS CASE

AND $KE = \dfrac{I\omega^2}{2}$

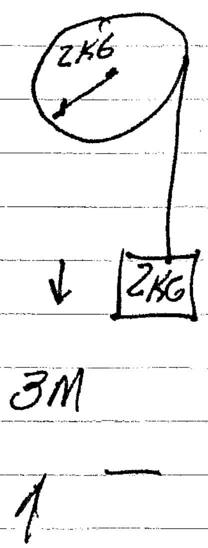
$$\frac{dKE}{dt} = \frac{d}{dt}\frac{I\omega^2}{2} = \frac{I}{2}\,2\omega\frac{d\omega}{dt} = I\omega\alpha$$

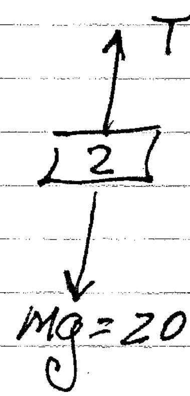
$$\tau\omega = I\omega\alpha$$

$\boxed{\tau = I\alpha}$ ANALOG TO $\vec{F} = m\vec{a}$

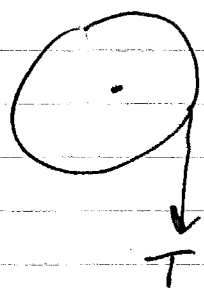
(AGAIN, WORRY ABOUT VECTORS LATER)

GO BACK TO





$20 - T = 2a$



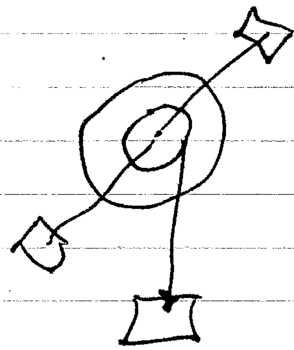
$$TR = I\alpha = \frac{MR^2}{2}\frac{a}{R}$$

$$T = \frac{MR^2}{2R^2}a = \frac{2}{2}a = a$$

$20 - a = 2a \qquad a = \frac{20}{3}$

$$v^2 - v_0^2 = 2\,\frac{20}{3}(3) = 40$$

NOW LOOK AT GIZMO FROM THIS PERSPECTIVE



$$mg - T = ma = m\alpha r$$

$$rT = I\alpha, \quad T = \frac{I\alpha}{r}$$

$$mg = \frac{I\alpha}{\cancel{R}r} + mr\alpha$$

$$\alpha = \frac{g/r}{I/r^2 + m}$$

I BIG $\rightarrow \alpha$ SMALL
SMALL $\rightarrow \alpha$ BIG

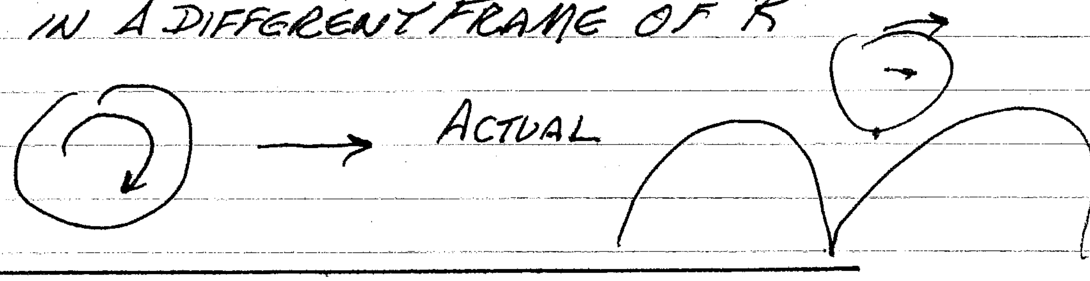
r SMALL $\rightarrow \alpha$ SMALL
r BIG $\rightarrow \alpha$ BIG

~~KINEMATICS: $\omega = \frac{v}{R}$ $\alpha = \frac{a}{r}$~~

ENERGY: $KE = I$

ROLLING (WHEEL)

MOTION IS VERY COMPLEX : YOU SEE IT IN A DIFFERENT FRAME OF R

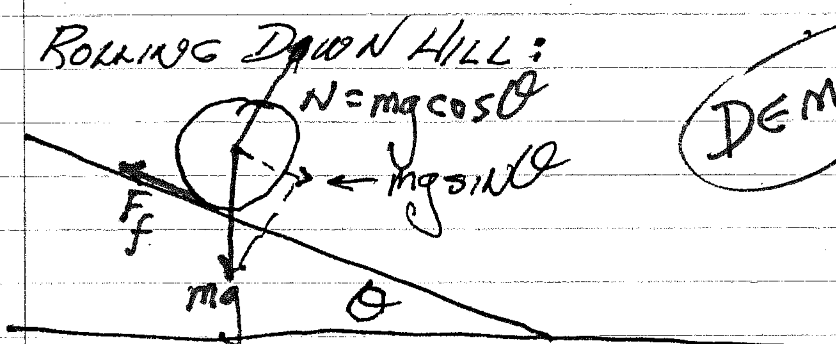


TURNS OUT YOUR PERSPECTIVE IS SENSIBLE

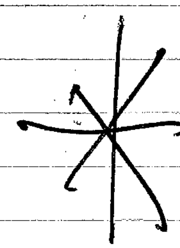
$$\omega = \frac{v_{cm}}{R} \qquad KE = \frac{I\omega^2}{2} + \frac{mv_{cm}^2}{2}$$

79

ROLLING DOWN HILL:



DEMO



SINCE CONTACT POINT IS NOT MOVING

$$F_f \neq \mu N$$

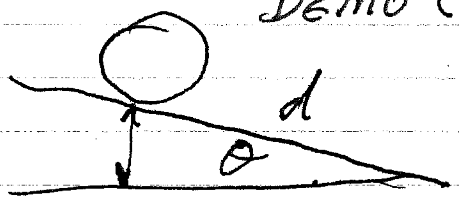
$$mg\sin\theta - F = ma$$

$$F_f R = I\alpha = \frac{Ia}{R}$$

$$F_f = \frac{Ia}{R^2}$$

80

DEMO (RING)



$$mgh = \frac{mv^2}{2} + \frac{I\omega^2}{2}$$

$$= \frac{mv^2}{2}\left[1 + \frac{I\omega^2}{mv^2}\right] = \frac{mv^2}{2}\left[1 + \frac{I}{MR^2}\right]$$

$$v^2 = \frac{2gh}{1 + \frac{I}{MR^2}}$$

HOOP $I = mr^2$; $v^2 = gh$

SOLID DISC $I = \frac{MR^2}{2}$ $v^2 = \frac{4}{3}gh$

SPHERE $I = \frac{2}{5}MR^2$ $v^2 = \frac{10}{7}gh$

SLIDING BLOCK (w/o FRICTION)

$v^2 = 2gh$

LOOK AT ACCELERATION:

SLIDE w/o FRICTION: $a = g\sin\theta$

HOOP: $a = \frac{v^2 - v_0^2}{2h/\sin\theta} = \frac{gh}{2h/\sin\theta} = \frac{g}{2}\sin\theta$!

WHAT SLOWS IT DOWN? FRICTION!

← 78

$$mg\sin\theta = ma + \frac{I}{R^2}a$$

$$a = \frac{g\sin\theta}{1 + I/mR^2}$$

SLIDING: $a = g\sin\theta$

DISK $\left(I = \frac{mR^2}{2}\right)$ $a = \frac{2}{3}g\sin\theta$

RING $(I = mR^2)$ $a = \frac{1}{2}g\sin\theta$

SPHERE $\left(I = \frac{2}{5}mR^2\right)$ $a = \frac{5}{7}g\sin\theta$

KINEMATICS: $\omega = \frac{v}{r}$, $\alpha = \frac{a}{r}$

ENERGY: $KE = \frac{I\omega^2}{2}$ $I = \Sigma mr^2$

DYNAMICS: $\tau = Fr\sin\theta = I\alpha$

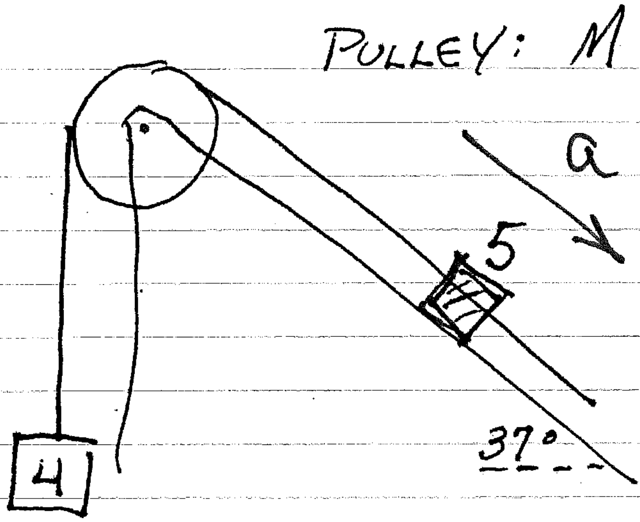
POWER $= \tau\omega$

LAST: MOMENTUM – DEFER TO WEDNESDAY

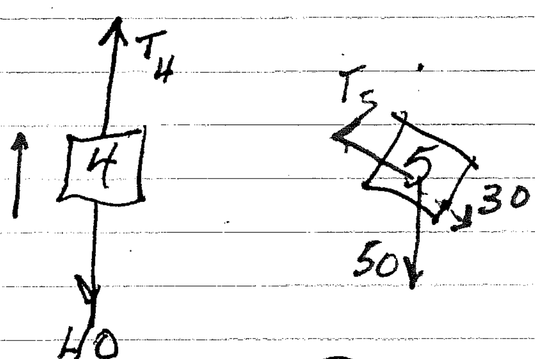
$\rightarrow$ ~~MORE EXAMPLES:~~

$\Longrightarrow$ 82

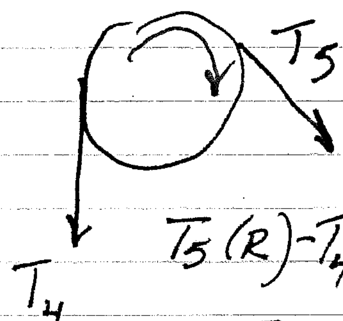
PULLEY: $M = 6\,\text{KG}$, $R = .1\,m$
(DISK)



1. GUESS DIRECTION (WRONG IN THIS EXAMPLE)
2. LOOK AT EACH COMPONENT



$$T_4 - 40 = 4a$$
$$30 - T_5 = 5a$$
$$\cancel{(T_5)R - T_4(R) = I}$$
$$T_5 - T_4 = 3a$$



$$T_5(R) - T_4(R) = I\alpha = \frac{MR^2}{2}\frac{a}{R} = \frac{6}{2}aR$$
$$T_5 - T_4 = 3a$$

$$-40 + 30 = \cancel{10}\,12a$$
$$a = -\frac{10}{12} = -\frac{5}{6}\,m/s^2$$

FRICTION CAN CAUSE PROBLEMS

LINEAR MOMENTUM — MAKES SENSE INTUITIVELY

ANGULAR MOMENTUM — STRANGE CONCEPT, ALMOST COUNTER-INTUITIVE.

LINEAR: $\vec{F} = m\vec{a} = m\frac{d\vec{v}}{dt} = \frac{d}{dt}(m\vec{v})$

$$= \frac{d\vec{p}}{dt}$$

ANGULAR: $\vec{\tau} = I\vec{\alpha} = I\frac{d\vec{\omega}}{dt} = \frac{d}{dt}(I\vec{\omega})$

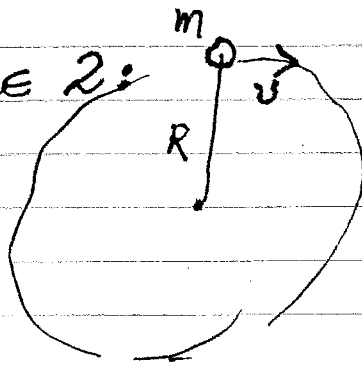
$$\equiv \frac{d}{dt}(\vec{L})$$

L = ANGULAR MOMENTUM

(NOTE VECTOR STILL UNDEFINED — IN MOST CASES WE DON'T NEED TO WORRY)

EXAMPLE 1: SPINNING WHEEL $L = I\omega$

EXAMPLE 2:



$I = mR^2$

$\omega = \frac{v}{R}$

$L = I\omega = mR^2\frac{v}{R} = mvR$

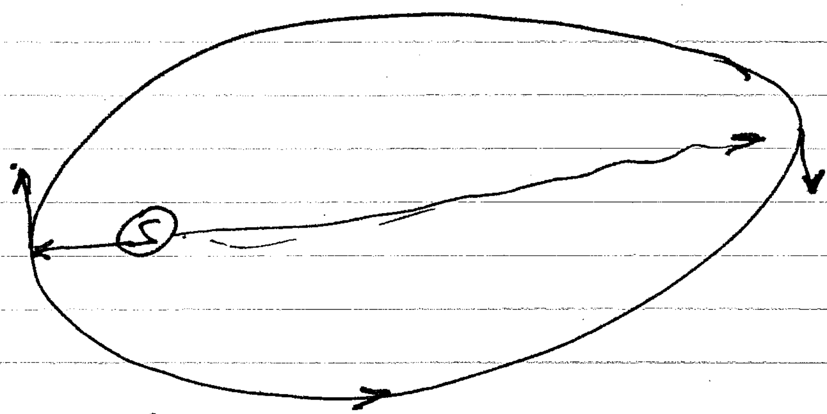
CONS. OF ANGULAR MOMENTUM

IF $\tau = 0$ $\quad L_i = L_f$

DULL & OBVIOUS EXAMPLE - WHEEL KEEP SPINNING

A MORE INTERESTING AND LESS OBVIOUS EXAMPLE:

PLANETARY (OR COMET) ORBITS:

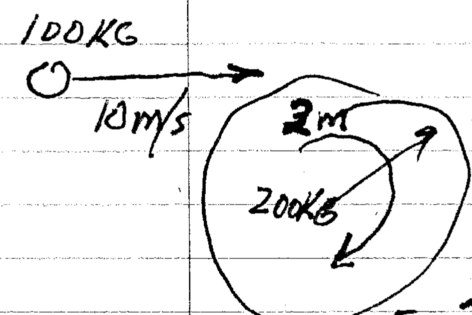


$F = \frac{G M_S m}{R^2}$ PROVIDES NO TORQUE

$m v_1 R_1 = m v_2 R_2$

vR = CONSTANT (FAST WHEN CLOSE, SLOW WHEN FAR AWAY
→ FIRST OBSERVED BY KEPLER)

COLLISIONS? (SOMEWHAT ARTIFICIAL)



CHILD (WITH MASS OF TACKLE) RUNS, JUMPS ON

MGR ~~5RAD~~ ~~2REV/S~~ ~~10RAD/S~~ 2 RAD/S (~ ~~1.5REV/SEC~~ 1 REV/3 SEC

$$L_i = MVR + I\omega = (100)(10)(2) + \frac{200(2)^2}{2}\,2$$

$$= 2000 + \overset{800}{\cancel{4000}} \quad \left(\frac{KG\text{-}M^2}{S}\right)$$

$$L_f = I_f \omega_f = \left[(100)(2)^2 + \frac{200(2)^2}{2}\right]\omega_f$$

$$= 800\,\omega_f = 2800$$

$$\omega_f = 3.5 \text{ RAD/S}$$

WITH ROCKET WE HAD NO COLLISION, BUT
REDISTRIBUTED MASS

$\rightarrow$ $L = I\omega$ IF I CHANGES, ω WILL CHANGE

CAN CHANGE I BY CHANGING <u>DISTRIBUTION</u> OF MASS

DEMONSTRATION $\rightarrow$ KNOWN BY GENERATIONS
OF DISRESPECTFUL STUDENTS
AS THREE DUMBBELL DEMO:

DEMO

NOTE ALTHOUGH $L_i = L_f$,

ENERGY IS <u>NOT</u> CONSERVED

$$KE = \frac{I\omega^2}{2} = I\omega\,\frac{\omega}{2} = L\,\frac{\omega}{2}$$

CLOSE SITUATION HAS HIGHER KE
(FROM WHERE?

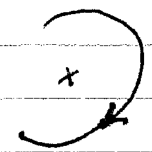
NOW TRY BICYCLE WHEEL

→ WHAT HAPPENED?

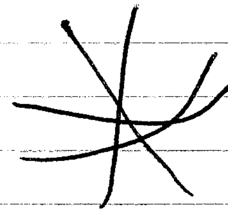
EXPLANATION REQUIRES THAT WE CONSIDER ANGULAR MOMENTUM (AND ANGULAR VELOCITY) AS A VECTOR

PROBLEM – EVERYTHING IS CHANGING (EXCEPT AXIS) → ALONG AXIS

WHICH WAY? <u>DEFINE</u>, THEN REMEMBER:



<u>INTO</u> <u>PAGE</u> FOR CLOCKWISE ROTATION



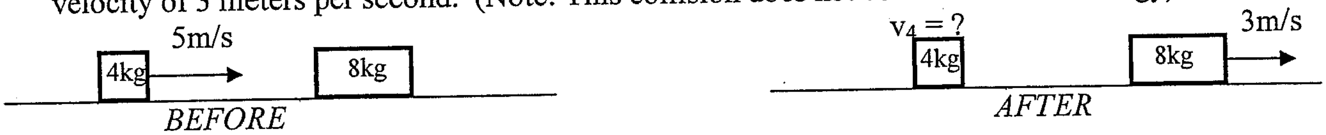
Name *WALES* (Please Print)

PHYSICS 008

Fifth Quiz
October 28, 2009

Please do all work on this sheet. Your score will depend both on the work you show and on the answers you obtain. You may use a calculator and the information on the reverse side of this sheet.

1 A 4-kilogram block moving with a velocity of 5 meters per second on a horizontal frictionless surface strikes an 8-kilogram block that is initially at rest. After the collision the 8-kilogram block has a velocity of 3 meters per second. (Note: This collision does not conserve kinetic energy)



a) Determine the velocity (v_4) of the 4-kilogram block after the collision. *(4pts)*

$4(5) + 0 = 4v + 8(3)$ $4v = -4$

$20 + 0 = 4v + 24$ $v = -1\ m/s$

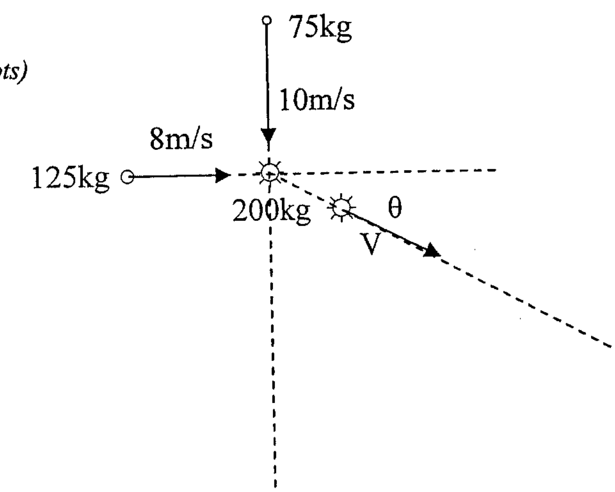
b) Determine the amount of kinetic energy that was lost in the collision. *(2pts)*

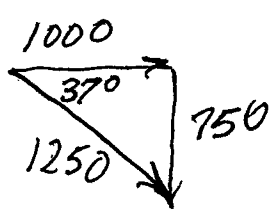
$KE_i = \frac{4(5)^2}{2} = 50\ J$ $KE_f = \frac{8(3)^2}{2} + \frac{4(1)^2}{2} = 38\ J$

$Loss = 12\ J$

2 A 75-kilogram halfback running south with the football with a velocity of 10 meters per second is tackled by 125-kilogram defensive guard running east with a velocity of 8 meters per second.

a) Determine the velocity (magnitude and direction) of the combined players immediately after the tackle is made. *(4pts)*





$V = \frac{1250}{200}$

$= 6.25\ m/s$

Name *WALES*
(Please Print)

PHYSICS 008

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October 28, 2009

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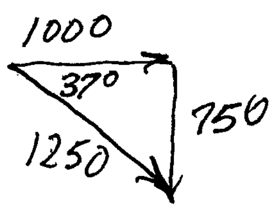
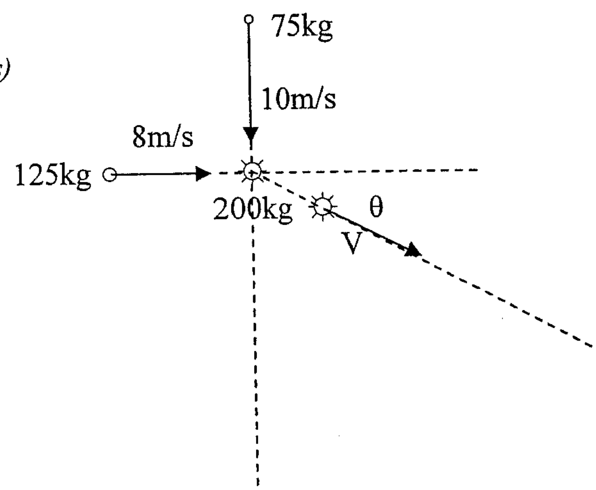


$V = \frac{1250}{200}$

$= 6.25\ m/s$



Quadratic Formula:

If: $ax^2 + bx + c = 0$, then: $x = \dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

Kinematics:

$Velocity = v = \dfrac{dx}{dt}$ $\quad AverageVelocity = v_{avg} = \dfrac{(x_f - x_i)}{(t_f - t_i)}$ $\quad Acceleration = a = \dfrac{dv}{dt}$

If a = constant:
$$v = v_o + at$$
$$x = x_o + v_o t + \frac{at^2}{2}$$
$$v^2 - v_o^2 = 2a(x - x_o)$$

Centripetal Acceleration: $a_c = \dfrac{v^2}{r}$; directed toward center of circle

Newton's Law and Forces:

$\vec{F} = m\vec{a}$ (or $\vec{a} = \vec{F}/m$) Kinetic Friction: $F_f = \mu_k N$

Static Friction: $F_f \le \mu_s N$

Force of gravity: $F = mg$, where g = 9.8 m/s^2: (Near earth, pointed down)

$F = \dfrac{GM_1M_2}{r^2}$, general case (attractive)

Work and Energy:

$Work = W = Fx = \vec{F} \cdot \vec{r} = Fr\cos\theta = \int \vec{F} \cdot d\vec{r}$ $\quad Power = P = dW/dt = \vec{F} \cdot \vec{v}$

$KineticEnergy = KE = mv^2/2$ $\quad PotentialEnergy = PE$ $\quad$ Near earth $\Delta PE = \Delta mgh$

Spring: $F = -kx$, $PE = kx^2/2$

Work and Conservation of Energy

$$Work_{added} + PE_i + KE_i = Work_{lost} + PE_f + KE_f$$

If no work added or lost then: $PE_i + KE_i = PE_f + KE_f$

Momentum:

$\vec{P} = m\vec{v}$ $\quad \vec{F} = d\vec{P}/dt$ $\quad$ If no external forces; $\sum \vec{P}_i = \sum \vec{P}_f$

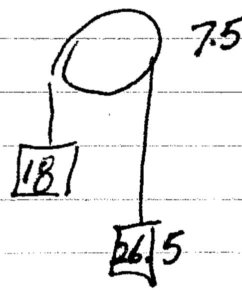
OCTOBER 30, 2009

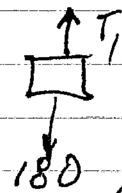
QUIZ: MOMENTUM — 1 D 2D
NEITHER CONSERVE ENERGY

MOST DOING WELL - IF NOT, SEE ME, GET HELP

PROBLEMS 35,

49.





$T_1 - 180 = 18a$

$265 - T_2 = 26.5a$

$(T_2 - T_1)R = \frac{7.5R^2}{2}\alpha$

$= \frac{7.5}{2}Ra$

50.

→ NOTE $v^2 = 2gh = 46$

$265 - 180 = 18 + 26.5 + 3.75a$

$a = \sim \cancel{.78}\ 1.76$

$v^2 = 2ay$

~ 10

55. → SAME AS DUMBBELL

61.

72. YO-YO DEMO $I \rightarrow R^2$ $\cancel{\omega r}$ $\omega = \frac{v}{r}$

75.

79, 80

CHAPTER 8:

PHYSICS 008
OCTOBER 30, 2009

25. $\tau_{cw} = mgL_2 - mgL_1$

35. $\tau = I\alpha$

$I = \frac{mL^2}{3} = \frac{2.2(.95)^2}{3} = 6.62\times10^{-1}$

$\alpha = \frac{\Delta\omega}{\Delta t} = \frac{3(2\pi)}{.2} = 94.2$

$\tau = .662(94.2) = 62.4$ m-N

49. $PE_i = (26.5-18)(9.8)3 = 250\,J$

$KE_f = \frac{mv^2}{2} + \frac{I\omega^2}{2}$

$= \frac{(26.5+18)v^2}{2} + \frac{7.5R^2\, v^2/R^2}{2}$

$= 24.1\,v^2$

$KE_f = PE_i: 24.1v^2 = 250$

$v = 3.22$ m/s

50. $PE_i = mg\frac{L}{2} = 11.3\,m$

$KE_f = \frac{I\omega^2}{2} = \frac{mL^2}{3}\frac{\omega^2}{2}$

$= 0.88\ m\omega^2$

$\omega^2 = \frac{11.3}{.88} = 12.8/s^2$

$v_{END} = \omega L = 8.24$ m/s

55. $(I\omega)_i = (I\omega)_f$

$I_f = \frac{I_i\,\omega_i}{\omega_f} = \frac{4.6(.5)}{3}$

$I_f = 0.77$ kg-m^2

61. a) $(I\omega)_i = (I\omega)_f$

$\omega_f = \frac{I_i\cdot\omega_i}{I_f} = \frac{920(2)}{920+75(3)^2}$

$\omega_f = 1.15$ RAD/SEC

61 b) $KE_i = \frac{I_i\,\omega_i^2}{2}$

$= \frac{920(2)^2}{2} = 1.84\times10^3\,J$

$KE_f = I_f\,\omega_f^2/2$

$= [920+75(3)^2](1.15)^2/2$

$= 1.05\times10^3\,J$

65. "ESTIMATE"

$(I_{EARTH})_i = (I_{EARTH+ASTEROID})_f$

$= \frac{2}{5}\times6\times10^{24}(6.4\times10^6)^2$

$= 9.87\times10^{37}$

$L_{EARTH} = I\omega_0 = \frac{I(2\pi)}{24\times3600}$

$= 7.15\times10^{33}$

$L_{AST} = mvr = 10^5(3\times10^4)\,6.4\times10^6$

$= 1.92\times10^{16}$

$L_i = L_f$

$L_{AST} + I\omega_0 = I\omega$

$\omega = \omega_0 + L_{AST}/I$

$\frac{\omega}{\omega_0} = 1 + \frac{L_{AST}}{I\omega_0} = 1 + \frac{1.92\times10^{16}}{7.15\times10^{33}}$

$= 1 + 2.68\times10^{-18}$

72. $I = I_{FACES} + I_{ROD}$

$= \frac{.1(.075/2)^2}{2} + \frac{.005(.01/2)^2}{2} = 7.04\times10^{-5}$

$mgh = \frac{I\omega^2}{2} + \frac{mv^2}{2}$

$2(.105)9.8(1) = 7.04\times10^{-5}\left(\frac{v}{.005}\right)^2 + .105v^2$

$2.06 = 2.92v^2$

a) $v = 0.84$ m/s

b) $\frac{mgh - mv^2/2}{mgh} = 1 - v^2/2gh$

$= 0.964$

75. a) ENERGY $= F\cdot x + 20\frac{mv^2}{2}$

$= 450(3.5\times10^5) + 20(1400)\frac{(26.4)^2}{2}$

$= 1.67\times10^8\,J$

b) $1.67\times10^8 = \frac{I\omega^2}{2} = \frac{(250)(.75)^2}{2}\frac{\omega^2}{2}$

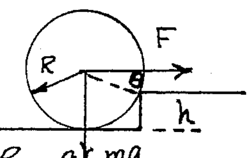
$\omega = 2.18\times10^3$ RAD/S

($\sim$21,000 RPM!)

c) $1.67\times10^8 = 150(746)t$

$t = 1.49\times10^3$ SEC $\simeq$ 25 MIN

79. TAKE TORQUE ABOUT CONTACT POINT:



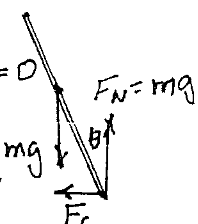
$\tau = FR\sin\theta - mgR\cos\theta \geq 0$

$F \geq mg\cos\theta/\sin\theta$

$F \geq mg\left(\frac{\sqrt{R^2-(R-h)^2}/R}{(R-h)/R}\right)$

$F \geq mg\sqrt{2Rh-h^2}/(R-h)$

80.



a) τ ABOUT CM $= 0$

$(F_f\cos\theta)d = (F_N\sin\theta)d$

$\tan\theta = F_f/F_N$

b) $F_f = mv^2/R \quad F_N = mg$

$\tan\theta = \frac{mv^2}{Rmg} = v^2/Rg$

$= \frac{(4.2)^2}{6.4(9.8)}; \ \theta = 15.7^\circ$

c) $\frac{mv^2}{R} = \mu_s mg$

$R = \frac{v^2}{\mu_s g} = \frac{(4.2)^2}{(.7)(9.8)}$

$= 2.57$ m

86A

OFFICE HOURS MW 2-4

NOVEMBER 2, 2009

1. "PRACTICE EXAM" - SOLUTIONS ON B.B BY THURSDAY

PROBLEM: ALL MULTI-CONCEPT PROBLEM CLEVER, BUT MAYBE NOT GOOD FOR THIS CLASS:

CURRENT PLAN: 5 PROBLEM: FIRST THREE VERY BASIC (NOT INTERESTING, NOT CLEVER)

LAST TWO - MULTI-CONCEPT

REVIEW SESSION - WILL AIM AT BASIC CONCEPTS, NOT COMPLICATIONS

→ HAVING DIFFICULTY: TRY TO COME

→ CRUISING ALONG W/O GREAT EFFORT

- MAY BE A WASTE OF TIME

WEDNESDAY? 5-7 6-8, 7-9 ?

THURSDAY? - 6PM

7:11
8:11
9:01

NEXT WEEK: PRACTICE (FRI) / REVIEW W/TA EV

WED - QUIZ ON CHAPT 8

FRI - PROB ON CHAPT 9
11, 21, 25, 36, 51, 62, 63, 68, 71, 78

EQUILIBRIUM - STATICS - STABILITY
→ MOSTLY APPLICATION OF PREVIOUS MATERIAL

READ - IGNORE 9-3 UNLESS YOU PLAN MEDICAL SCHOOL

EQUILIBRIUM → ACCELERATION = 0

STATIC EQUILIBRIUM → ALSO NOT MOVING

STABILITY → DEFER A BIT

CONDITIONS FOR EQUILIBRIUM ($a = 0, \alpha = 0$)

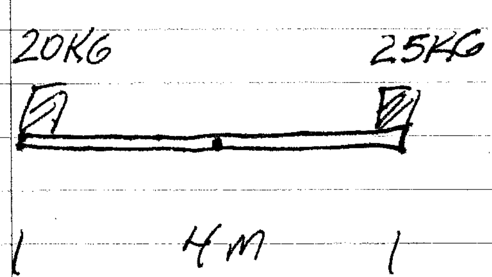
SINCE $\vec{F} = m\vec{a}$ $\quad \vec{F} = 0 \quad (F_x = 0, F_y = 0, F_z = 0)$

SINCE $\vec{\tau} = I\vec{\alpha}$ $\quad \vec{\tau} = 0 \quad (\tau_x = 0, \tau_y = 0, \tau_z = 0)$

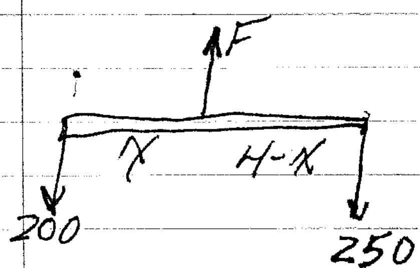
IN TWO DIMENSIONS (MOST SITUATIONS CAN BE REDUCED TO THIS)

$$F_x = 0, \; F_y = 0 \qquad \tau = 0$$

SIMPLE EXAMPLE - SEE-SAW (ADJUSTIBLE)



PIVOT = ? (ASSUME MASS-LESS BAR)



$\sum F_y = 0$ $F = 450$

$\tau = 0$ ABOUT ANY POINT

ABOUT CENTER: $(250)(4-x) - 200x = 0$

$$1000 - 250x - 200x = 0$$

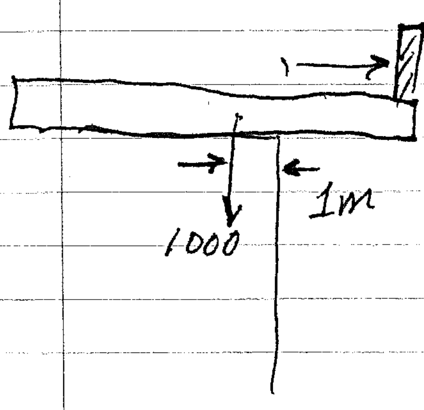
$$450x = 1000 \quad x = 2.22\,m$$

ABOUT NEAR END:

$$(250)(4) - 450(x) = 0$$

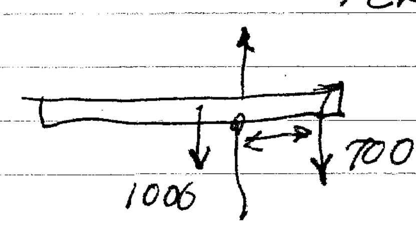
$$x = \frac{1000}{450}$$

NOW LOOK AT HEAVY PLANK



1000 N ~ 220#

HOW FAR OUT CAN ~~150~~ 700 N (~150#) PERSON WALK

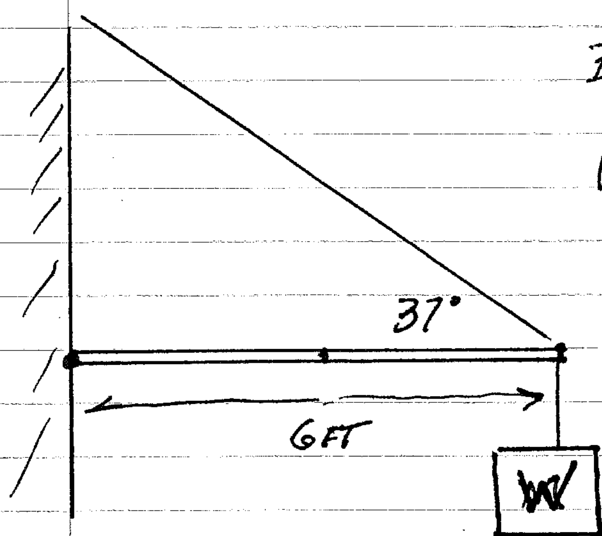


FORCE BY EDGE = 1700

TORQUE ABOUT PIVOT:

$700x - (1000)1 = 0$

$x = \frac{10}{7} = 1.43\,m$



BEAM: 100 POUNDS

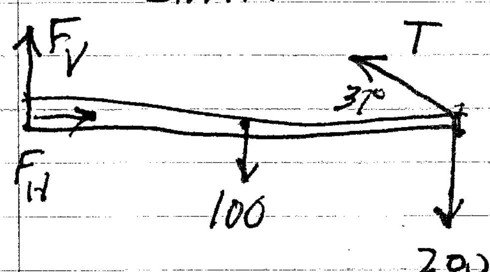
WEIGHT = 200 POUND

? T IN CABLE

? FORCE AT HINGE

NOTE: $\vec{F} = 0$, $\tau = 0$ → ANY UNITS WORK (AS LONG AS CONSISTENT)

TAKE τ ABOUT POINT THAT MAKES PROBLEM SIMPLEST



$(100)(3) + 200(6) - T(6)\sin 37° = 0$

$50 + 200 - .6T = 0$

$T = \frac{250}{.6} = 417\ LBS$

$F_H - T\cos 37° = 0 \qquad F_H = (417)(.8) = 334\ LBS$

$F_y + T\sin 37° - 300 = 0$

$F_y = 300 - T\sin 37 = 50\ LBS$

NOVEMBER 4, 2009

1. REVIEW:

THURSDAY, NOVEMBER 5

6 P.M - AH

(ALSO QUICK & DIRTY ON FRIDAY)

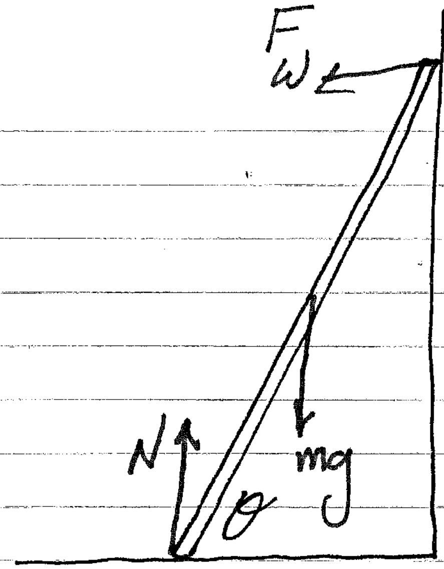
OFFICE HOURS TODAY 2PM → 3:30PM

2. FORMULA SHEET (SAMPLE)

3. MORE STATICS:

$$\sum \vec{\tau} = 0, \quad \sum \vec{F} = 0$$

$$(F_x = 0, F_y = 0, \tau_{cw} - \tau_{ccw} = 0$$



LADDER AGAINST WALL:

NOTHING BUT LADDER

FORCES: mg, N

ASSUME NO FRICTION AGAINST WALL (OR WOULD SCRATCH PAINT)

TORQUE AROUND BASE: $mg\frac{l}{2}\cancel{\sin\theta}\cos\theta$

ROTATES!

BUT HOUSE PUSHES: $\tau = 0$ IF $F_W\, l\, \overset{\sin\theta}{\cancel{\cos\theta}} = mg\frac{l}{2}\overset{\cos\theta}{\cancel{\sin\theta}}$

BUT NOW FORCE TO LEFT:

FRICTION: IF $F_f = F_W$ EQUILIBRIUM:

$$F_f\, l\, \overset{\sin\theta}{\cancel{\cos\theta}} = mg\frac{l}{2}\cancel{\sin\theta}\cos\theta$$

$$\tan\theta = \cancel{\frac{2F_f}{mg}}\ \frac{mg}{2F_f}$$

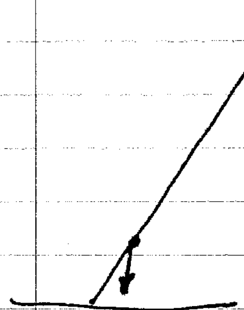
$$\text{BUT } (F_f)_{MAX} = \mu_s F_N = \mu_s mg$$

$$(\tan\theta)_{MIN} = \frac{1}{2\mu_s}$$

TRY $\mu_s = .2$ $\quad \tan\theta_{MIN} = 68°$

(DEMO)

PUT PERSON ON LADDER:



SMALL INCREASE IN TORQUE,
BIG INCREASE IN FRICTION

DEMO

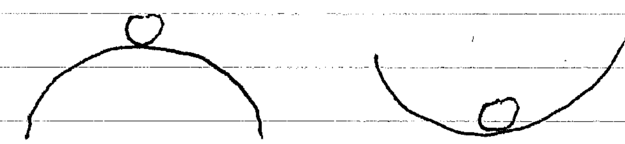
CLIMB HIGHER — BIGGER INCREASE

→ MOST LIKELY PLACE TO SLIP — TOP!

SOLUTION — SEND HEAVY FRIEND UP TO TEST

— USE NEARLY VERTICAL LADDER

STABILITY: STABLE: SLIGHT PUSH WILL DISPLACE



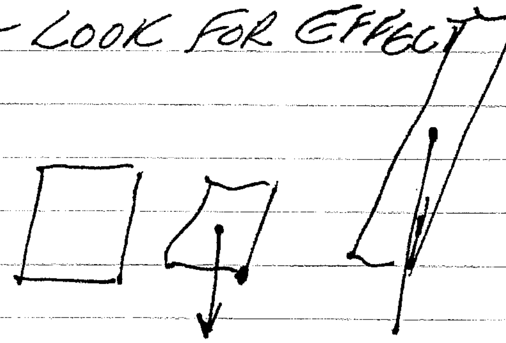
REAL WORLD: UNSTABLE ALREADY FALLEN

PROBLEM: HOW FAR FROM INSTABILITY?

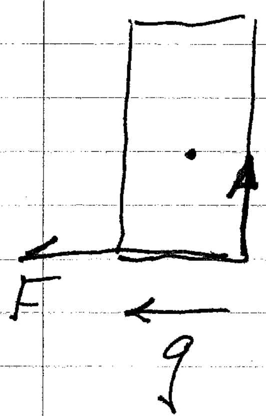
EXAMPLE: WOODEN BLOCK ON EDGES

GENERAL APPROACH — LOOK FOR EFFECT OF SMALL PUSH

LARGE RESTORING FORCE
SMALL RESTORING FORCE



TALL BUILDING: EARTHQUAKE
– LOMA LINDA: $a = .4g \rightarrow$



$$\tau_{cw} = F\frac{h}{2} = ma\frac{h}{2}$$

$$\tau_{ccw} = mg\frac{w}{2}$$

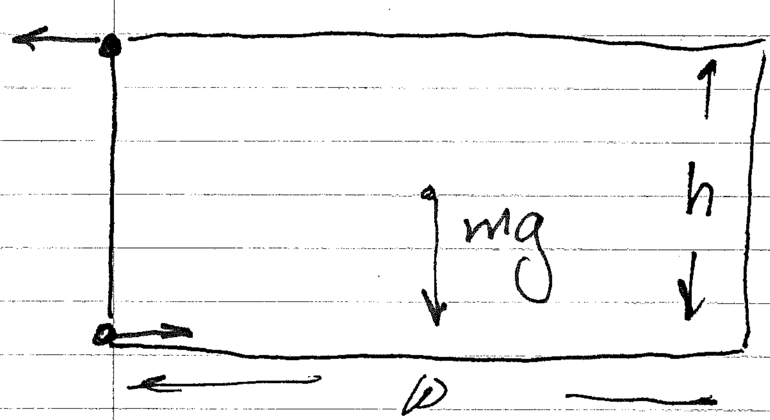
$$ma_{MAX}\frac{h}{2} = mg\frac{w}{2}$$

$$a_{MAX} = \frac{gw}{h}$$

NO HARD + FAST RULES

→ JUDGMENT, EXPERIENCE

GATE



$$\tau_{cw} = mg\frac{w}{2}$$

(ABOUT LOWER HINGE)

$$(F_{\text{upper hinge}})h = \tau_{ccw}$$

$$mg\frac{w}{2} = Fh$$

$$F = \frac{mg}{2}\frac{w}{h}$$

WIDE GATE CAUSES PROBLEMS

VERTICAL FORCES

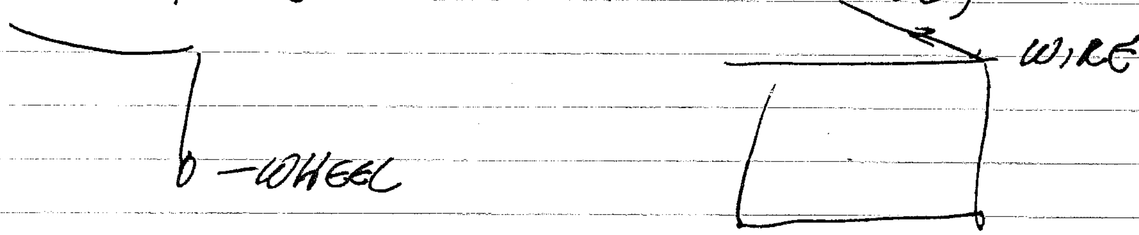
$$F_T + F_B = mg$$

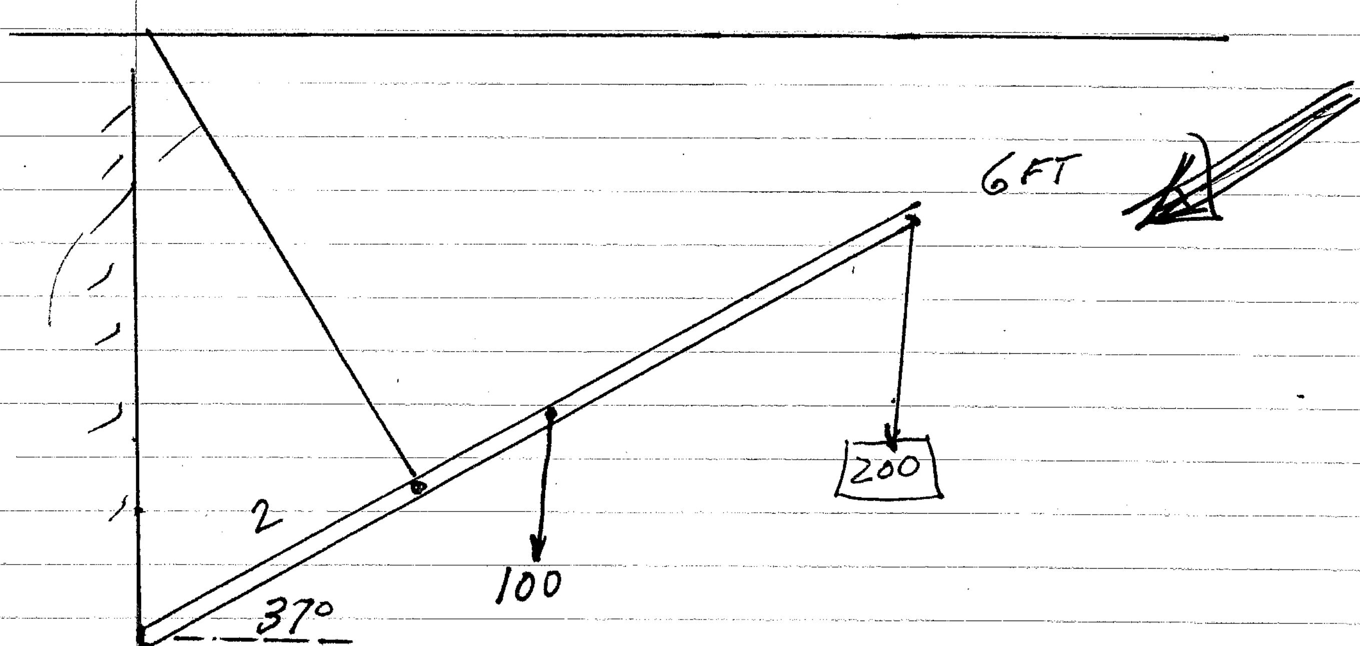
ADD CHILD SWINGING

$$F_H = \frac{mg}{2}\frac{w}{h} + M_C g\frac{w}{h}$$

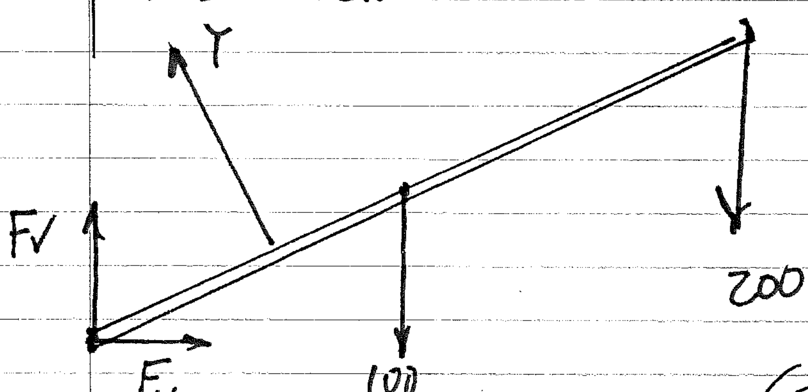
RIPS OUT HINGE:

→ SOLUTION (IF CHILD IS INCORRIGABLE)





FIRST: ISOLATE FORCES



TORQUE ABOUT PIVOT:

~~T(2)~~

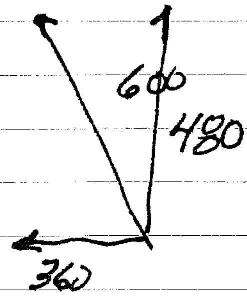
~~(200)(6) + (100)3~~

$$= (200)(6)(.8) + 100(3)(.8)$$

$$= T(2)$$

$$T = \frac{1200}{2} = 600 \text{ POUNDS}$$

(GOOD WAY TO BREAK WIRE)

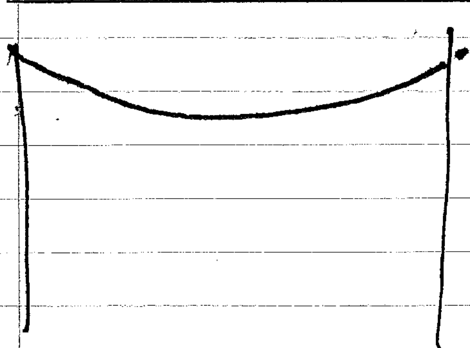


$\sum F_x$: $F_H - 360 = 0 \qquad F_H = 360$

$\sum F_y$ $\quad F_V + 480 = 100 + 200$

$F_V = -180$

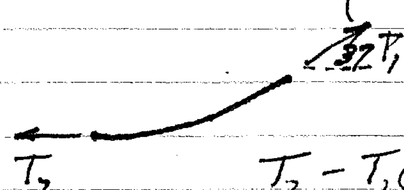
GENERAL APPROACH: ISOLATE FORCES
TORQUE + FORCE



CABLE → mg

T (CENTER)

T (EDGE)



$T_1 \sin 37^\circ = \frac{mg}{2} \qquad T_1 = \frac{mg}{1.2}$

$T_2 - T_1 \cos 37^\circ = 0 \qquad = .83\,mg$

$T_2 = (.83)(.8) \sim .66\,mg$

Name ~~W~~ALES
(Please Print)

PHYSICS 008

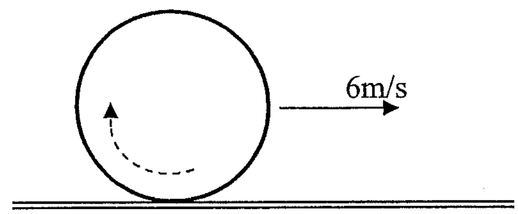
Sixth Quiz
November 4, 2009

Please do all work on this sheet. Your score will depend both on the work you show and on the answers you obtain. You may use a calculator and the information on the reverse side of this sheet.

1. A hoop ($I = MR^2$) is rolling without slipping on a horizontal surface with a linear velocity of 6.0 meters per second. The mass of the hoop is 0.50 kilogram and its radius is 0.15 meter.

   a) Determine the total kinetic energy of the rolling hoop. *(4pts)*

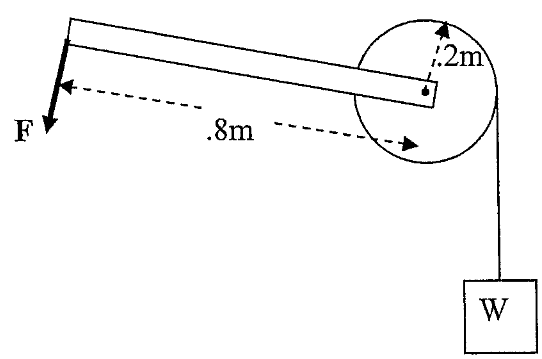
$$KE = \frac{mv^2}{2} + \frac{I\omega^2}{2}$$
$$= \frac{mv^2}{2} + \frac{MR^2}{2}\left(\frac{v}{R}\right)^2 = mv^2$$
$$= (.5)(6)^2 = 18\,J$$



2. A 0.80 meter-long handle is attached to the face of a pulley with a radius of 0.20 meter. When a force **F** is applied at right angles to the handle it provides a torque of 120 m-N about the axis of the cylinder.

   a) Determine the magnitude of the force **F**. *(3pts)*

$$\tau = Fr\sin\theta$$
$$120 = F(.8)$$
$$F = 150\,N$$



A cord is wrapped around the cylinder and then is fastened to a hanging block of weight W. When the handle exerts a torque of 120 m-N the block rises at constant velocity.

   b) Determine the weight of the hanging block. *(3pts)*

$$\tau = 0 \qquad (Wr) - 120 = 0$$
$$W = \frac{120}{r} = \frac{120}{.2} = 600\,N$$

Kinematics:

$Velocity = v = \frac{dx}{dt}$ $\quad AverageVelocity = v_{avg} = \frac{(x_f - x_i)}{(t_f - t_i)}$ $\quad Acceleration = a = \frac{dv}{dt}$

If a = constant: $v = v_o + at$, $\quad x = x_o + v_o t + \frac{at^2}{2}$, $\quad v^2 - v_o^2 = 2a(x - x_o)$

Centripetal Acceleration: $a_c = \frac{v^2}{r}$; directed toward center of circle

Newton's Law and Forces:

$\vec{F} = m\vec{a}$ (or $\vec{a} = \vec{F}/m$) $\quad$ Kinetic Friction: $F_f = \mu_k N$ $\quad$ Static Friction: $F_f \le \mu_s N$

Force of gravity: $F = mg$, where g = 9.8 m/s^2: (Near earth, pointed down)

$F = \frac{GM_1M_2}{r^2}$, general case (attractive)

Work and Energy:

$Work = W = Fx = \vec{F}\cdot\vec{r} = Fr\cos\theta = \int \vec{F}\cdot d\vec{r}$ $\quad Power = P = dW/dt = \vec{F}\cdot\vec{v}$

$KineticEnergy = KE = mv^2/2$ $\quad PotentialEnergy = PE$ $\quad$ Near earth ΔPE = Δmgh

Spring: $F = -kx$, $\quad PE = kx^2/2$

Work and Conservation of Energy

$Work_{added} + PE_i + KE_i = Work_{lost} + PE_f + KE_f$

If no work added or lost then: $PE_i + KE_i = PE_f + KE_f$

Momentum:

$\vec{P} = m\vec{v}$ $\quad \vec{F} = d\vec{P}/dt$ $\quad$ If no external forces; $\sum \vec{P}_i = \sum \vec{P}_f$

Rotational Kinematics:

$\omega = v/r$, $\quad ,\alpha = a/r$

Rotational Dynamics:

$I = \sum mr^2 = \int r^2 dm$, $\quad \tau = rF\sin\theta$, $\quad \tau = I\alpha$,

$KE = I\omega^2/2$, $\quad L = I\omega = mvr$

Conservation of Angular Momentum: If external torque = 0 then $L_i = L_f$

Name WALES
(Please Print)

PHYSICS 008

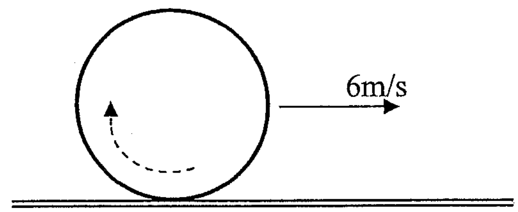
Sixth Quiz
November 4, 2009

Please do all work on this sheet. Your score will depend both on the work you show and on the answers you obtain. You may use a calculator and the information on the reverse side of this sheet.

1. A hoop ($I = MR^2$) is rolling without slipping on a horizontal surface with a linear velocity of 6.0 meters per second. The mass of the hoop is 0.50 kilogram and its radius is 0.15 meter.

   a) Determine the total kinetic energy of the rolling hoop. *(4pts)*

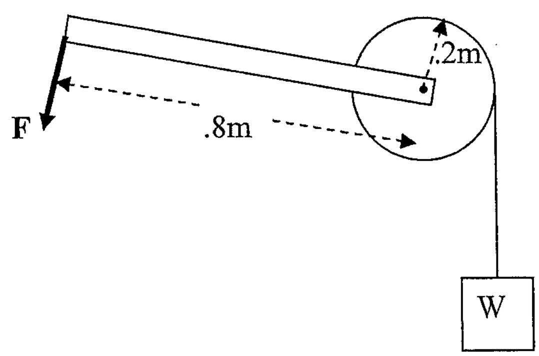
$$KE = \frac{mv^2}{2} + \frac{I\omega^2}{2}$$
$$= \frac{mv^2}{2} + \frac{MR^2}{2}\left(\frac{v}{R}\right)^2 = mv^2$$
$$= (.5)(6)^2 = 18J$$



2. A 0.80 meter-long handle is attached to the face of a pulley with a radius of 0.20 meter. When a force **F** is applied at right angles to the handle it provides a torque of 120 m-N about the axis of the cylinder.

   a) Determine the magnitude of the force **F**. *(3pts)*

$$\tau = Fr\sin\theta$$
$$120 = F(.8)$$
$$F = 150N$$



A cord is wrapped around the cylinder and then is fastened to a hanging block of weight W. When the handle exerts a torque of 120 m-N the block rises at constant velocity.

b) Determine the weight of the hanging block. *(3pts)*

$$\tau = 0 \qquad (Wr) - 120 = 0$$
$$W = \frac{120}{r} = \frac{120}{.2} = 600N$$

NOVEMBER 6, 2009

TODAY:

1. QUIZ
2. CHAPTER 9 PROBLEMS
3. EXAM DETAILS
4. ON WARD

---

1. QUIZ OK
2. 25, 64
3. CHAPTERS

CHAPTERS	BUT NOT SECTIONS
6	
7	3, 9, 10
8	2, 9,
9	3, 5, 6, 7

6 → BACK TO LATER

ENERGY, MOMENTUM, ROTATIONAL ANALOGUES, STATICS

↓

SOLID-BODY MECHANICS

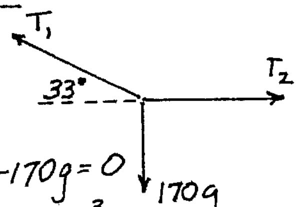
PRACTICE EXAM

PRINCIPLE, THEN GO

Physics 008 — November 6, 2009

Chapter 9:

11.



$F_y = 0$:

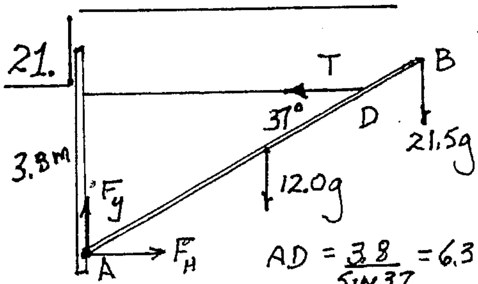
$T_1 \sin 33 - 170g = 0$

$T_1 = 3.06 \times 10^3 N$

$F_x = 0$: $T_2 - T_1 \cos 33 = 0$

$T_2 = T_1 \cos 33 = 2.57 \times 10^3 N$

21.



$AD = \frac{3.8}{\sin 37} = 6.31m$

$AB = 7.5m$

τ about hinge:

$21.5g(7.5)\cos 37 + 12g \frac{7.5}{2}\cos 37 - T(6.31)\sin 37 = 0$

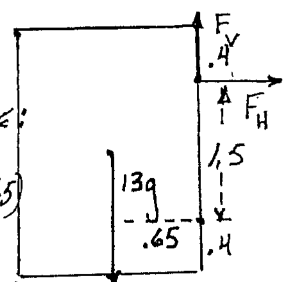
a) $T = 425N$

b) $F_H - T = 0$ $F_H = T = 425N$

$F_V - 12g - 21.5g = 0$ $F_V = 328N$

25.

τ about lower hinge:



$F_H(1.5) - 13g(.65) = 0$

$F_H = 55.2N$

$F_V = \frac{13g}{2} = 63.7N$

36. C.M. is $\frac{4.5}{2} = 2.25m$ off center

C.M. provides restoring torque as long as it is no more than $\frac{D}{2} = \frac{7}{2} = 3.5m$ off center

(Top no more than 7 m off center)

51. a) $\frac{F}{A_{MIN}}$ = Tensile strength

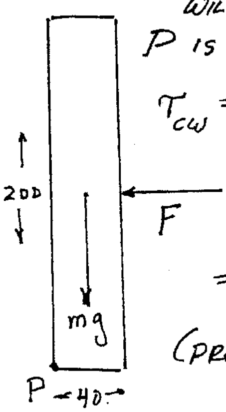
$A_{MIN} = \frac{320(9.8)}{5 \times 10^8} = 6.27 \times 10^{-6} m^2$

Safety factor: $\times 7 = 4.4 \times 10^{-5} m^2$

b) $\frac{\Delta L}{L} = \frac{F}{AE}$

$\Delta L = \frac{320(9.8)(7.5)}{4.4 \times 10^{-5} \cdot 2 \times 10} = 2.7 \times 10^{-3} m$

62.



Will tip if τ about P is CCW:

$\tau_{cw} = mg(20) - F(100)$

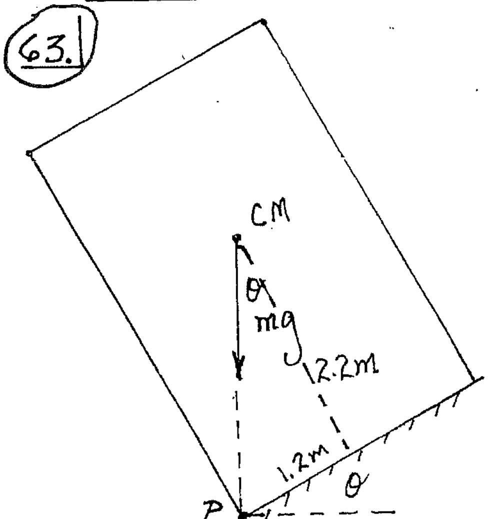
$= 1.8 \times 10^7 (9.8) 20$

$- 950(70 \times 200)100$

$= 2.2 \times 10^9$ m-N

(Pretty safe!)

63.

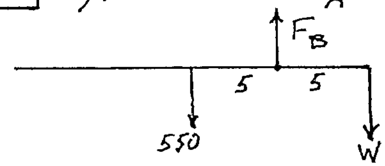


Truck will tip if mg falls to left of P

$\tan\theta = \frac{1.2}{2.2}$

$\theta = 28.6°$

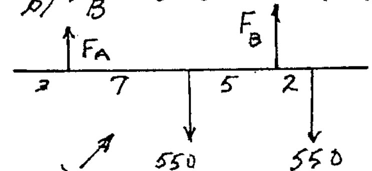
68. a) About to tip: $F_A = 0$



τ about F_B: $W(5) - 550(5) = 0$

$W = 550N$

b) $F_B = 550 + W = 1100N$

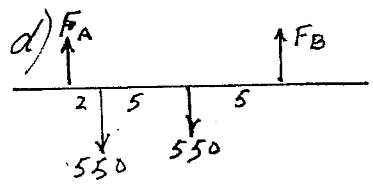


c) τ about B:

$F_A(12) + 550(2) - 550(5) = 0$

$F_A = 137$ $F_B = 1100 - 137 = 963N$

d)

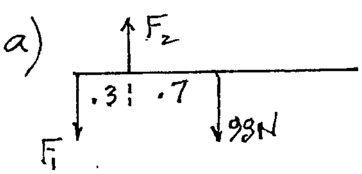


$\tau_{\text{about }A}$: $550(2) + 550(7) - F_B(12) = 0$

$F_B = 413N$

$F_A = 1100 - 413 = 687N$

71. a)

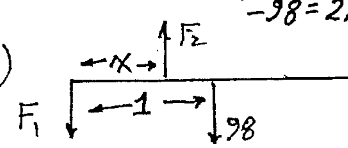


τ around F_1:

$98(1) - F_2(.3) = 0$

$F_2 = 327N$ $F_1 = 327 - 98 = 229N$

(bc)



$98 - F_2 x = 0$

$x = \frac{98}{F_2} = \frac{98}{150}, \frac{98}{85}$

$= .65m, 1.15m$

Horrors! Out of space (see reverse side)

NOVEMBER 11, 2009

1) LOOK AHEAD

2) EXAM

3) CONTINUE

→ NO "REGULAR" OFFICE HOURS THIS WEEK
(BUT SEND E-MAIL FOR APPOINTMENT

9-5, 9-6 → TODAY

CHAPTER 10: 10-9 MOST IMPORTANT
10-11, 12, 13 14 OMIT

CHAPTER 11: COMBINATION OF TWO
DIFFICULT SUBJECT
S.H.M. + WAVES

CHAPTER 12: SOUND
→ QUALITATIVE ONLY (i.e. NO PROBLEMS ON ANY QUIZ OR EXAM

EXAM - AVG = 62/80 (VS 64/80 EXAM 1)

LOWER GRADES GOT HIGHER (GOOD!)

HIGHER GRADES GOT LOWER (NOT SO GOOD)

94C

— NOT A PARTICULARLY GOOD EXAM

1 EASY, 2 LESS EASY, 1 DIFFICULT

1. OBVIOUS WORK CONS. OF ENERGY

a) $\frac{mv^2}{2} = \frac{60(25)^2}{2} = 1.875 \times 10^4\,J$

$h = \frac{1.875 \times 10^4}{(60)(10)} = 31.25\,m$

b) $F_{AVG}\,x = \text{Work} = \cancel{31.25}\ 1.875 \times 10^5$

$F_{AVG} = 1250\,N$

→ ASSUME a = CONST : $\vec{F} = m\vec{a}$

→ ASSUME SPRING: $\frac{1}{2}kx^2 \rightarrow F = kx$

$F_{AVG} = kx/2$

2. EASY:

3.

4. FORCE + TORQUE a) NO BODY

b)

c) $\cancel{F}600\cos 37 - F_f = ma$

$F_f = 600\cos 37 - ma \Rightarrow$

PROPERTIES OF MATERIALS:

REAL SUBSTANCES STRETCH (NOT NECESSARILY BAD) AND MAY BREAK (ALMOST ALWAYS BAD)

SPRING: $F = \cancel{kx}\ k\,\Delta x$

BULK MATERIAL: $\cancel{\Delta x}\ \cancel{A}\ \cancel{\frac{\Delta x}{\text{AREA}}}$

k DEPENDS ON LENGTH $\Delta x \sim L$

CROSS-SECTION AREA $\Delta x \sim \frac{1}{A}$

AND INTRINSIC PROPERTY OF MATERIAL

$$\frac{\Delta L}{L} = \frac{F}{A}\left(\frac{1}{E}\right) \Rightarrow \text{YOUNG'S MODULUS}$$

(RESISTANCE TO STRETCHING / COMPRESSION)

MAT'L	E
STEEL	$200 \times 10^9\ N/m^2$
ALUM	70
CONCRETE	20
WOOD	10 (1) PARALLEL CROSS GRAIN
NYLON	5

STEEL CABLE 10 METERS LONG, AREA $= 4 \times 10^{-6}\ m^2$ (2MM X 2MM)

HUNG 100 KG

— STRETCH $= \frac{10M\,(1000N)}{4 \times 10^{-6} m^2} \frac{1}{200 \times 10^9}$

$= \frac{10^{10}}{4 \cdot 200 \times 10^9} = \frac{1}{80} m$ (~~5cm~~) (1.25 cm)

NYLON: 40X

~~2 METERS~~! .5 m

AND BREAK! TENSILE STRENGTH $\rightarrow \frac{F}{A}$ MAX:

	TENSILE	COMPRESSIVE
STEEL	500×10^6	500×10^6
CONCRETE	2×10^6	20×10^6 ←
NYLON	500×10^6	

→ BACK TO EXAMPLE: 100KG ON 10^{-6}

$$F/A = \cancel{10m(1000)} \frac{(100)(10)}{4\times10^{-6}} = \frac{1}{4}\times10^{9} = 250\times10^{6}$$

HOLDS!

NOTE CONCRETE VS STEEL

STRONG IN COMPRESSION
WEAK IN TENSION

VERY STRONG IN BOTH

NYLON - STRONG AS STEEL, BUT MUCH TOO STRETCHY

SUGGESTION FOR FUTURE ARCHITECTS:

STRUCTURES, OR WHY THINGS DON'T FALL DOWN
J.E. GORDON (1978, 2003)
PAPERBACK, 395 PAGES, \$10.15 ON AMAZON
(~~CHEAPER AND~~ MUCH CHEAPER AND MUCH MORE INTERESTING THAN GIANCOLI)
– COMET AIRLINER LOSSES WORTH PRICE OF BOOK

NOVEMBER 13, 2009

TODAY: FINISH CHAPTER 9, START CHAPTER 10

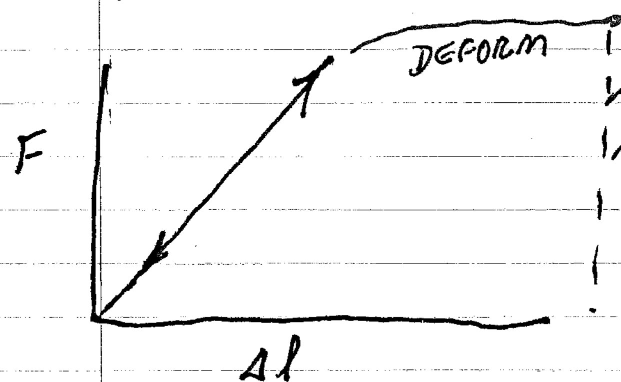
READ: CHAPTER 10: 1-7 (EASY)
8-10 (HARDER)
NOT 11-14

OFFICE HOURS
MON 2-4
THURS 12:30-2:30

FOR WEDNESDAY, NOV 18:

CHAPTER 10: PROBLEMS 20, 25, 33, 43, 49, 65, 69, 85

MOST MATERIALS ARE ELASTIC



APPLY FORCE: STRETCH,
REMOVE: RETURN

LIMIT	TENSILE STRENGTH	COMPRESSIVE ST
STEEL	500×10^6 N/M^2	500×10^6 N/M^2
NYLON	500×10^6 N/M^2	NOT USEFUL
CONCRETE	2×10^6	20×10^6

BIG DIFFERENCE

LOOK AT PROBLEM 9-78

7 m x 10 m $W = 12{,}600\,g$

WOOD: $35\times10^{6}\ N/m^{2}$ (COMPRESSIVE STRENGTH — EXCEED + WILL BUCKLE

DERATE BY 12

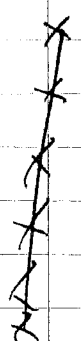
$$\left(\frac{F}{A}\right)_{MAX} = \frac{35\times10^{6}}{12}$$

$$F_{\cancel{MAX}} = A\left(\frac{F}{A}\right)_{MAX}$$

$$A = \frac{F}{\left(\frac{F}{A}\right)_{MAX}} = \frac{12{,}600(\cancel{10}\ 9.8)}{35\times10^{6}}(12) = 4.23\times10^{-2}\,m^{2}$$

$$2\text{"}\times4\text{"} = (9\times4)\,cm^{2} = 36\times10^{-4}\,m^{2}$$

$$\text{NO OF } (2\times4)\text{'s} = \frac{4.23\times10^{-2}}{36\times10^{-4}} = 11.8\ (\sim12)$$



5/SIDE

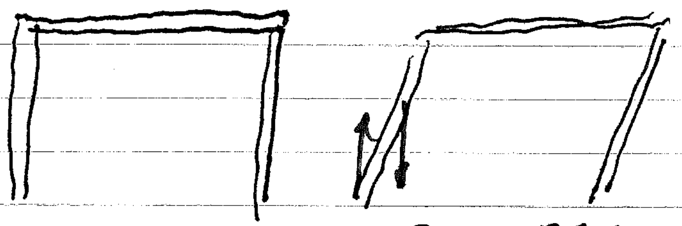
2M SEPARATION:

NEVER HAPPEN!

STANDARD ~ 16" →

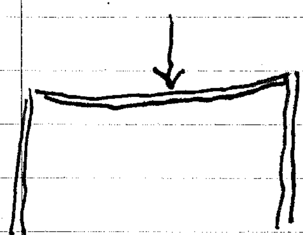
REAL PROBLEM:

1.



COLLAPSE

→ SHEATHING PREVENTS COLLAPSE



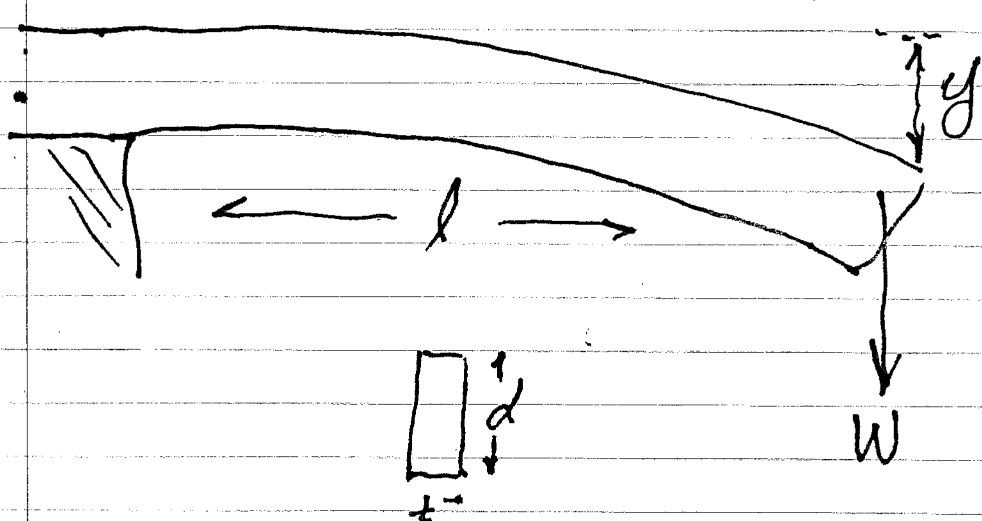
BENDS (BREAKS?)

TYPICAL PROBLEM IS LATERAL FORCES

SERIOUS DERIVATION (LONG + COMPLICATED)

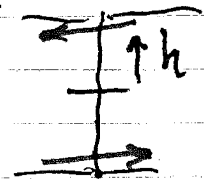
OR ESSENTIAL POINTS)

CONSIDER BEAM FIXED AT ONE END



$$\tau_{cw} \simeq \frac{W}{l}$$

τ_{ccw}



— HOW POSSIBLE?

BEAM IS STRETCHED AT TOP
COMPRESSED AT BOTTOM

$$\frac{F}{A} = E\frac{\Delta l}{l} \qquad \Delta l = (R+h)\theta - R\theta$$

$$= \cancel{R}h\theta$$

$$= \frac{Eh}{R} \qquad l = R\theta$$

$$\frac{\tau}{A} \to \frac{F}{A}h = \frac{Eh^2}{R}$$

INTEGRATE: (+SOME ALGEBRA)

$$y = \frac{6Wl^3}{EAh^2}$$

↳ AREA OF BEAM

OTHER CONFIGURATIONS

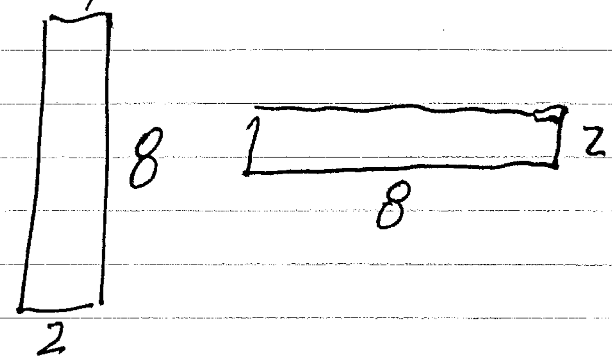
$$\text{DEFL} \sim \frac{Wl^3}{EAh^2}$$

→ 2x4; 4 TIMES AS STIFF

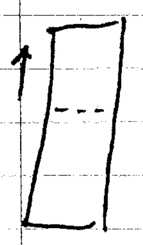
(DEMO)

HOUSE, BRIDGES, I BEAMS

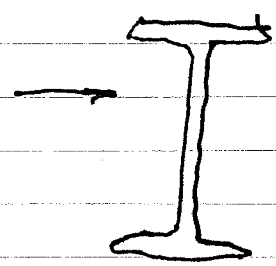
FLOOR JOISTS



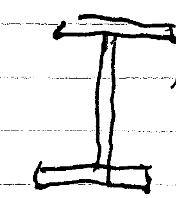
16x AS STIFF



SINCE $\tau \to h^2$, MATERIAL AT TOP & BOTTOM IS MUCH MORE EFFECTIVE THAN MATERIAL IN MIDDLE



"I BEAM



MAT. FLOOR JOINT

CHAPTER 10: FLUIDS (LIQUID, GAS)

DENSITY: $\rho = \dfrac{m}{V}$ $= 1000 \dfrac{kg}{m^3}$ (WATER)

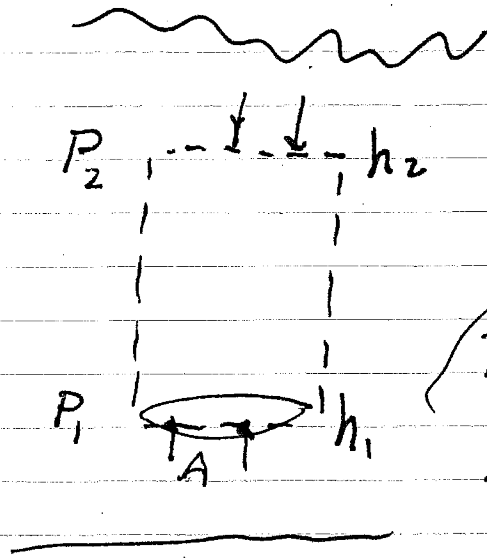
$1.29 \dfrac{kg}{m^3}$ (AIR)

PRESSURE $\equiv \dfrac{F}{A} = P$ (POWER, MOMENTUM)

$\dfrac{N}{m^2}$ = "PASCAL"

UNIT (+ NAME) ALMOST NEVER USED
EXCEPT IN PHYSICS

CONSIDER CONTAINED OF FLUID



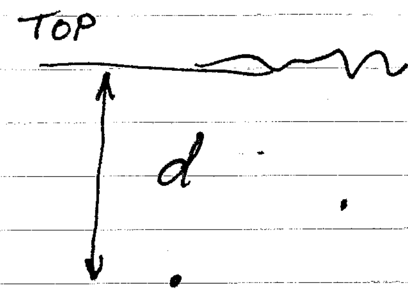
WEIGHT $= (\text{AREA})(h_2 - h_1)\rho g$

PRESSURE MUST SUPPORT WEIGHT

$$(P_1 - P_2)(A) = A(h_2 - h_1)\rho g$$

$$P_1 = P_2 + (h_2 - h_1)\rho g$$

$$\text{OR } P_1 + h_1\rho g = P_2 + h_2\rho g$$



$$P(d) = P_{TOP} + \rho g d$$

WHAT ABOUT TOP? STILL FLUID (AIR) ABOVE

$$P_{ATM} = 0 + \rho_{AIR}\, g\, h$$

ρ_{AIR}: $1.29\frac{N}{M^3}$ → NOT QUITE THAT SIMPLE

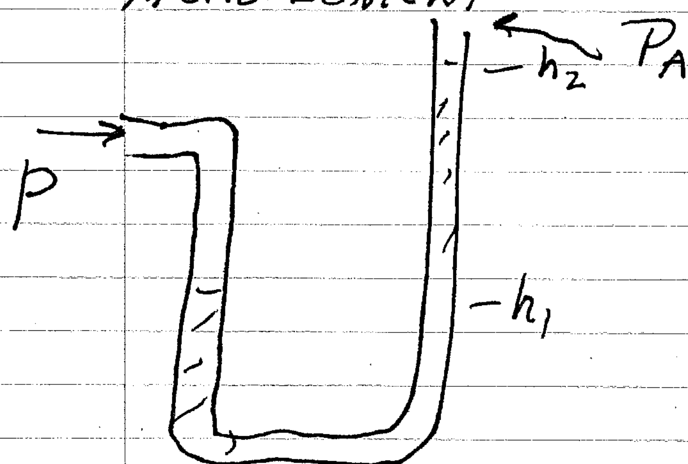
h: HEIGHT OF ATMO

$P_{ATM} \simeq 10^5\, N/M^2 = (1.29)(9.8)\, h$

$$h = \frac{10^5}{\cancel{13}\, 12.5} \simeq 8 \times 10^3 \simeq 8\,KM \sim 5\, MILES$$

IN REALITY: ρ DECREASES WITH HEIGHT, (AIR IS THINNER, BUT HIGHER)

MEASUREMENT:



$$(P_A)(A) + (h_2 - h_1)\rho g (A) = P,$$

$$P = P_A + (h_2 - h_1)\rho g$$

USUAL LIQUID (BEFORE GENERAL AWARENESS OF TOXICITY) MERCURY (Hg)

SUPPOSE $h_2 - h_1 = 20\,cm$

$\rho = 13.6 \times 10^3$

$$P = \cancel{P_A + \rho}$$
$$= 1.01 \times 10^5 + .2(9.8)(13.6 \times 10^3)$$
$$= 1.28 \times 10^5\, N/M^2$$

EASIER TO (1) DEFINE NEW UNIT

(2) LEAVE OFF P_A

NOVEMBER 16, 2009

TODAY: FINISH CHAPT 10, START CHAPT 11

WEDNESDAY: DEMONSTRATION OF EFFECTS FROM CHAPT 10, CHAPT 10 PROBLEMS

FRIDAY: CONTINUE CHAPT. 11
QUIZ ON CHAPT 9 & 10
(ONE SHORT PROBLEM FROM EACH)

$$\frac{F}{\cancel{A}} = \rho g h A$$

$$\frac{F}{A} = P = \rho g h$$

$$h = \frac{P}{\rho g} = \frac{10^5}{1.3 \times 10} = 7.7 \times 10^3 = 7.7\,KM$$

$\simeq$ 5 MILES

$\simeq$ 25,000 FT

OBVIOUS WRONG IN DETAIL

(SINCE $\rho \neq$ CONSTANT)

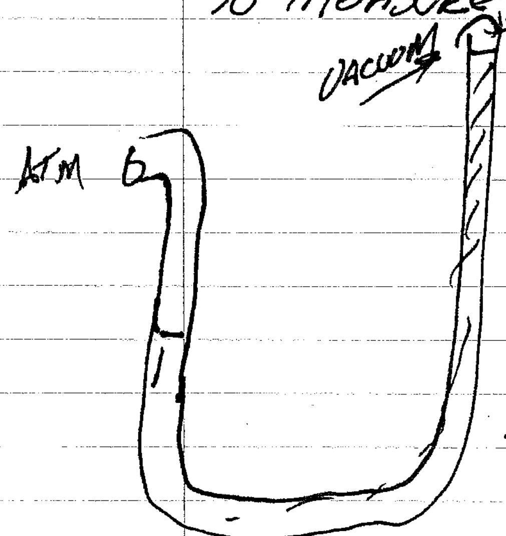
P (MODIFIED) = 20 cm Hg = 200 mm Hg

OR 200 mm Hg ABOVE ATMOSPHERIC

P → "GAUGE" PRESSURE = PRESSURE ABOVE ATMOSPHERIC

*

TO MEASURE ATMOSPHERIC:



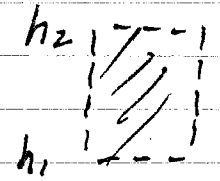
$h_2 - h_1 \sim 760$ mm Hg → BLOOD PRESSURE (GAUGE)

$\sim$ 30 INCHES Hg → WEATHER ABS

OTHER UNITS POUNDS/IN^2 → TIRE PRESSURE GAUGE

HEIGHT OF ATM

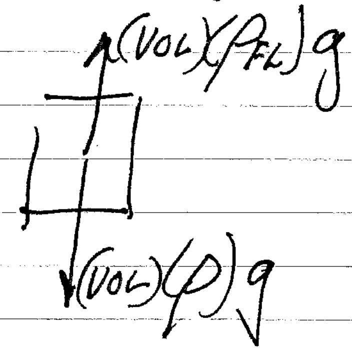
BUOYANCY:



$\text{FORCE} = A(h_2 - h_1)\rho_{LIQ}\, g = (\text{VOL})\rho_{FL}\, g$

(DUE TO SURROUNDING FLUID)

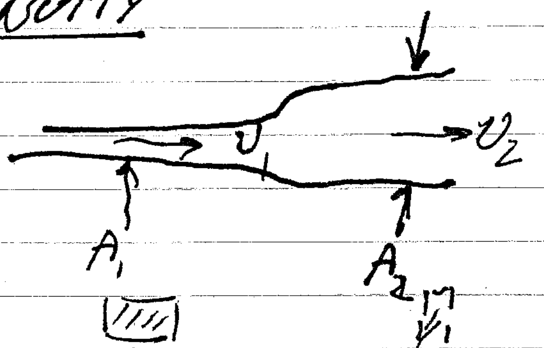
REPLACE IT WITH SOMETHING ELSE



IF $\rho < \rho_{FL}$ → NET UPWARD FORCE (TOWARD SURFACE)

IF $\rho > \rho_{FL}$ → NET DOWNW F (SINKS)

CONTINUITY



$\Delta V_1 = A_1 v_1$

$\Delta V_2 = A_2 v_2$

IF FLUID IS INCOMPRESSIBLE:

$\Delta V_1 = \Delta V_2 \qquad A_1 v_1 = A_2 v_2$

$$\frac{v_2}{v_1} = \frac{A_1}{A_2}$$

"INCOMPRESSIBLE" → NOTHING TRULY INCOMPRESSIBLE

WATER – ALMOST INCOMPRESSIBLE

AIR – EQUATIONS WORK SURPRISINGLY WELL.

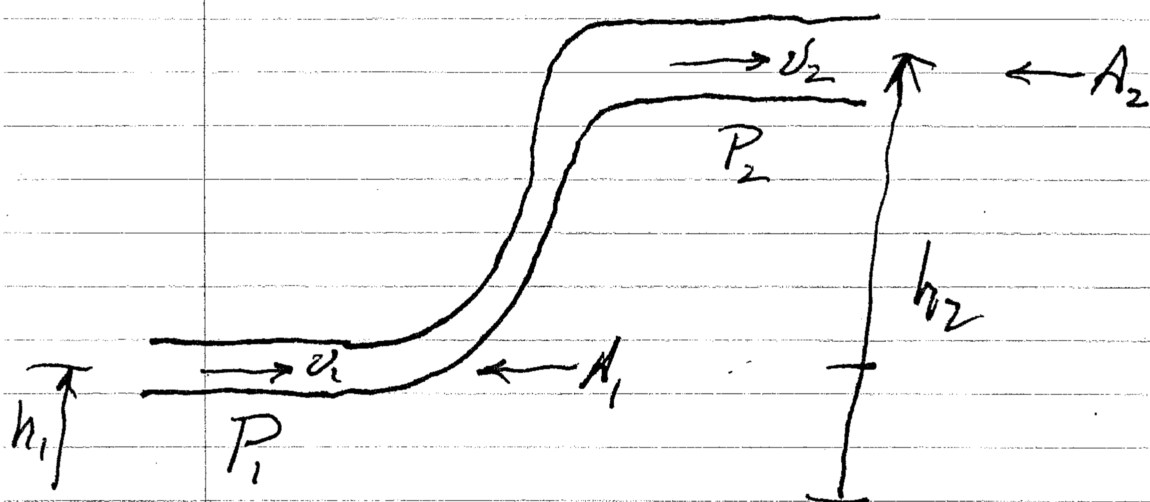
~~BERNOULLI'S EQUATION:~~

WORK DONE BY PRESSURE

$dW = F\,dx$

$= P \Delta A\, dx = P\,dV$

BERNOULLI'S EQUATION:



$$W_1 = P_1 dV_1 = \cancel{P_1 A_1 dx} = \cancel{P_1 A_1 v_1 dt}$$

$$W_2 = -P_2 dV_2 = L$$

$$W_1 - W_2 = \text{TOTAL WORK} = \text{INC KE} + \text{INC PE}$$

$$= \rho \frac{dV_2 v_2^2}{2} - \rho \frac{dV_1 v_1^2}{2} + \rho g h_2 dV_2 - \rho g h_1 dV_1$$

BUT IF INCOMPRESSIBLE, $dV_1 = dV_2$

$$P_1 - P_2 = \frac{\rho v_2^2}{2} - \frac{\rho v_1^2}{2} + \rho g h_2 - \rho g h_1$$

REARRANGE:

$$P_1 + \frac{\rho v_1^2}{2} + \rho g h_1 = P_2 + \frac{\rho v_2^2}{2} + \rho g h_2$$

—OR—

$$P + \frac{\rho v^2}{2} + \rho g h = \text{CONSTANT}$$ (FOR GIVEN SAMPLE OF GAS)

LOOKS A BIT LIKE CONS. OF ENERGY WITH AN EXTRA TERM

SUPPOSE v = CONST

$$P + \rho g h = \text{CONSTANT}$$ → ALREADY KNEW THAT

SUPPOSE P = CONST

$$\frac{\rho v^2}{2} + \rho g h = \text{CONST}$$

$$\frac{v^2}{2} + g h = \text{CONST}$$ → ALREADY KNEW THAT TOO

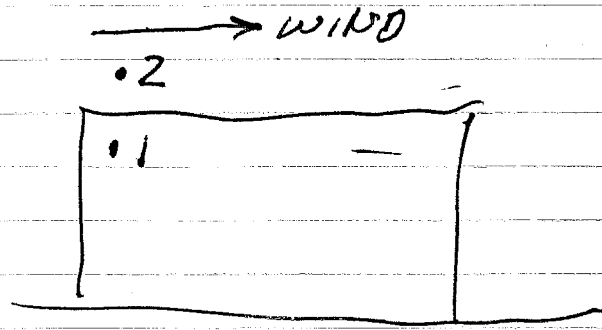
SUPPOSE h = CONSTANT

$$P + \frac{\rho v^2}{2} = \text{CONSTANT}$$ → THAT'S NEW!

~~THAT~~

LOOK AT HOUSE OF PROBLEM 9-78

AREA = 7X10 = 70 METERS



$$P_1 = P_2 + \frac{\rho v_2^2}{2}$$

$$P_1 - P_2 = \frac{\rho v_2^2}{2}$$

$$\rho \doteq 1.3 \qquad \frac{\rho}{2} = .65$$

$$P_1 - P_2 = .65 v_2^2$$

HURRICANE - CAT 4/5

v_2 = 60 m/s (130 mph)

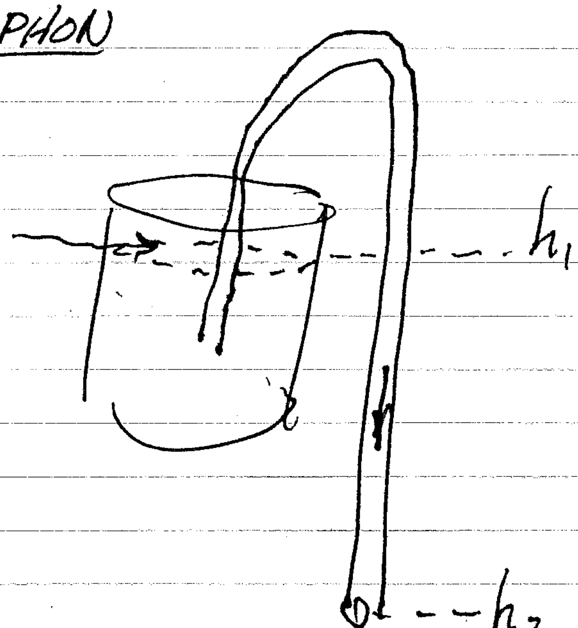
$P_1 - P_2 = .65(60)^2 = 2340\ N/m^2$

FORCE $= (P_1 - P_2)$ AREA $= 1.6 \times 10^5\ N$

WEIGHT $= (12{,}600)g = 1.23 \times 10^5\ N$

ROOF BLOWS UP & AWAY → UNLESS SOMEONE FASTENED IT DOWN

SIPHON



FILL TUBE WITH LIQUID

A = CONST, v = CONSTANT IN TUBE

$v_1 = 0 \quad P_1 = P_2$

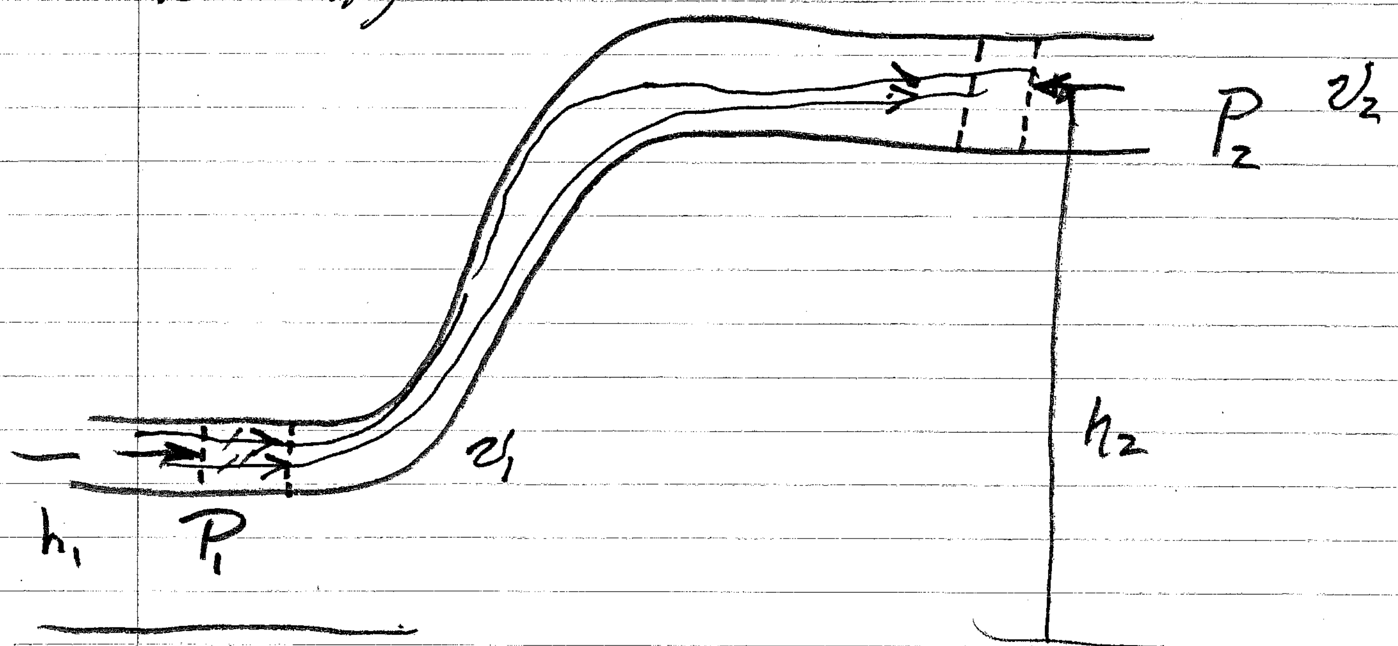
$$P + \rho g h_1 + 0 = P + \rho g h_2 + \frac{\rho v_2^2}{2}$$

$$v_2^2 = 2g(h_1 - h_2)$$

(STEAL GAS, EMPTY SINKS, ETC)

NOVEMBER 18, 2009

(1) REVISIT BERNOULLI (WITH MORE COLORS FOR CLARITY)



WORK DONE ON GAS:

$P_1 \Delta V_1 - P_2 \Delta V_2$ ← OPPOSED TO MOTION

↑ IN DIRECTION OF ~~PRESSURE~~ MOTION

IF INCOMPRESSIBLE, $\Delta V_1 = \Delta V_2$

NET WORK = $\Delta KE + \Delta PE$ $= \rho \frac{\Delta V}{2} v_2^2 - \rho \frac{\Delta V}{2} v_1^2 + \rho g h_2 \Delta V - \rho g h_1 \Delta V$

ΔV DROPS OUT →

$$P + \frac{\rho v^2}{2} + \rho g h = \text{CONSTANT}$$

107B

PROBLEMS: (25)

(43) $P_{IN} - P_{OUT} = \frac{\rho v^2}{2}$ DEMO 1

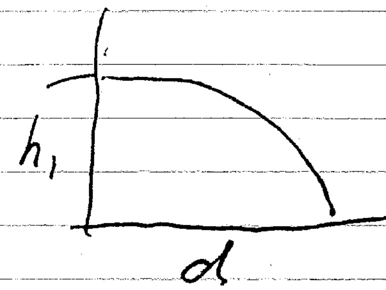
(49) $\rho g h_2 = \rho g h_1 + \frac{\rho v_1^2}{2}$ $(P_1 = P_2)$

$v_1^2 = 2g(h_2 - h_1)$

$h_1 = \frac{g t^2}{2}$

$t^2 = \frac{2h_1}{g}$

$D^2 = (v_1 t)^2 = 4[h_1(h_2 - h_1)]$



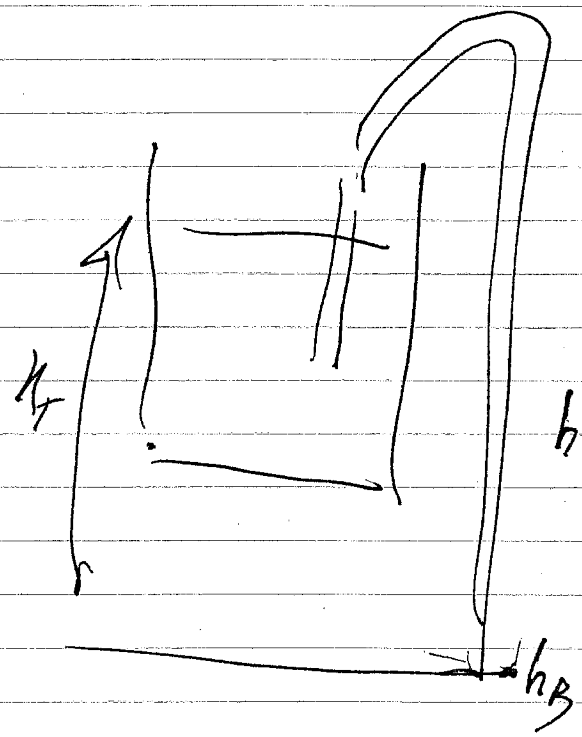
→ TWO ANSWERS.

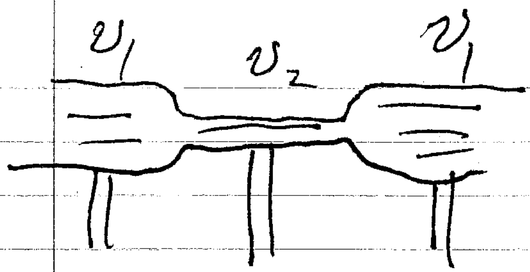
DEMO 2

(85) $\frac{\rho v^2}{2} = \rho g h_T - \rho g h_B$

$v^2 = 2g(h_T - h_B)$

DEMO 3





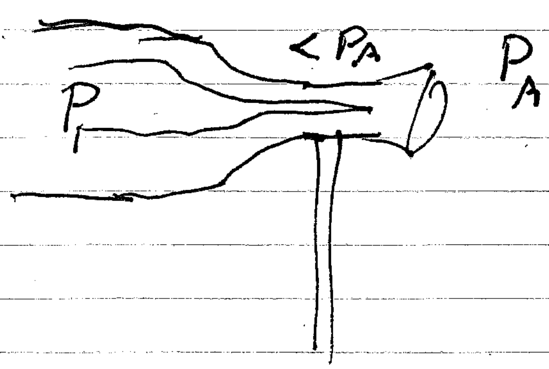
$v_1 A_1 = v_2 A_2 \qquad v_2 > v_1$

BUT $P_1 + \frac{\rho v_1^2}{2} = P_2 + \frac{\rho v_2^2}{2}$

$P_1 - P_2 = \frac{\rho}{2}\left(v_2^2 - v_1^2\right)$ DEMO # 4

$P_1 > P_2 \rightarrow$ PUSHES LIQUID UP

CASPIRATOR $\rightarrow$ HOSE END SPRAYER



PHYSICS 008
NOVEMBER 18, 2009

CHAPTER 10:

20. a) $M = \rho V = \rho h \pi r^2$

$= 10^3 (12) \pi (3\times10^{-3})^2 = 0.34\,KG$

$W = mg = 3.4\,N$

b) $P = \rho g h = 10^3 (9.8) 12$

$= 1.18\times10^5\,N/M^2$

$F = PA = 1.18\times10^5 \pi (.21)^2$

$= 1.63\times10^4\,N$

$(\sim 1.5\,\text{TONS!})$

25. $B.F. = \rho V g = 1.29 \times \frac{4}{3}\pi (7.35)^3 (9.8)$

$= 2.10\times10^4\,N$

$W_{HE} = \rho_H V g = .179 V g = 2.9\times10^3\,N$

LIFT $W_t = B.F. - W_{HE} - 930g$

$= 8.99\times10^3\,N \ (= 917\,Kg)$

33. f = FRACTION ABOVE SURFACE

WEIGHT = BUOYANT FORCE

$\rho_{ICE}(Vol)g = \rho_{H_2O}(1-f)(Vol)g$

$1 - f = \frac{\rho_{ICE}}{\rho_{H_2O}} = 0.896$

$f = 1 - .896 = .104$

43. $P_{IN} - P_{OUT} = \rho v^2/2$

$= \frac{1.29\times(35)^2}{2} = 790\,N/m^2$

$\text{FORCE(UP)} = (P_{IN} - P_{OUT})\,\text{AREA}$

$= 790 (240) = 1.90\times10^5\,N$

49. a) $v_2 \simeq 0$

$\rho g h_2 = \rho g h_1 + \frac{\rho v_1^2}{2}$

$v_1^2 = 2g(h_2 - h_1)$

DISTANCE $= v_1 t$; $t^2 = 2h_1/g$

$(v_1 t)^2 = 4(h_1)(h_2 - h_1)$

$D = 2\sqrt{h_1(h_2 - h_1)}$

49 b) $h_1'(h_2 - h_1') = h_1(h_2 - h_1)$

$h_1'^2 - h_2 h_1' + h_1(h_2 - h_1) = 0$

SOLVE QUADRATIC EQ'N:

$h_1' = \frac{h_2}{2} \pm \frac{\sqrt{h_2^2 - 4h_1h_2 + 4h_1^2}}{2}$

$= \frac{h_2}{2} \pm \frac{h_2 - 2h_1}{2}$

$= h_1,\ h_2 - h_1$

HORRORS! (TOO FEW PROBLEMS)

65. $F_{30PSI} = PA$

$= 2.1\times10^5 \pi (.03)^2/4$

$= 148\,N$

$F_{45PSI} = 3.1\times10^5 \pi (.03)^2/4$

$= 219\,N$

69. $\Delta P = \rho g h$

$= 1000(9.8)6$

$= 5.88\times10^4\,\frac{N}{m^2} = 0.58\,ATM$

85. $\frac{\rho v^2}{2} = \rho g h_T - \rho g h_B$

$= \rho g (h_T - h_B)$

$v^2 = 2g(.64)$

$v = 3.54\,m/s$

RATE (= VOLUME/SEC)

$R_V = vA = 3.54\left(\frac{\pi}{4}\right)(1.2\times10^{-2})^2$

$= 4.0\times10^{-4}\,m^3/sec = 400\,cm^3/sec$

RATE (= MASS/SEC)

$R_m = \rho R_V = 0.40\,Kg/sec$

CHANGE GEARS

CHAPTER 11: VIBRATION + WAVES

BEFORE CH 9 AFTER CHAPTER 10

TOO BAD!

– PERIODIC MOTION

DEMO

MANY CASES: MAY BE MOST COMMON TYPES OF MOTION

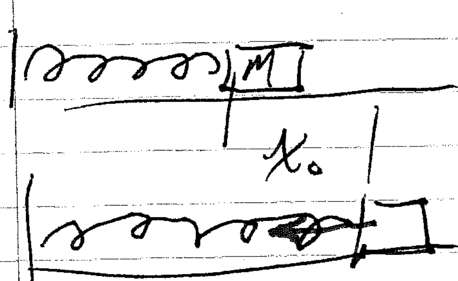
→ STABILITY → OFF EQUILIBRIUM ← BOTTOM OF BOWL

→ COMES BACK

(RATTLES, ETC)

PUREST CASE: MASS ON AN IDEAL SPRING

→ RESTORING FORCE $= -kx$)



$$F = -kx = ma$$

$$a = -\frac{k}{m} x$$

$$\frac{d^2x}{dt^2} = -\frac{k}{m} x$$

ONE OF ~~TWO~~ THREE IMPORTANT DIFFERENTIAL EQUATIONS IN COURSE

OTHER ONE IS $\frac{dx}{dt} = (\text{CONST})x$

CONST = +, −

ONE EXAMPLE $\frac{d\$}{dt} = R\$$

(INTEREST = RATE × CAPITAL)

OR $\frac{dR}{dt} = (B.R.)R$

(RABBITS)

WAVE EQUATION +

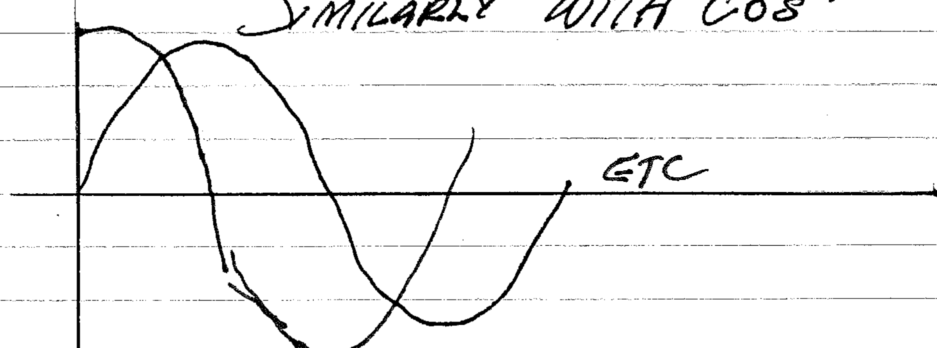
LOTS OF FUN EXAMPLES — BUT NO TIME ~~THA~~ THIS SEMESTER

SOLUTION TO $a = -\frac{k}{m}x$:

$x = \sin \omega t \qquad \frac{dx}{dt} = \omega \cos \omega t$

$\frac{d^2x}{dt^2} = -\omega^2 \sin \omega t$

SIMILARLY WITH COS:



NOVEMBER 20, 2009

FOR MONDAY: READ 11-1 → 11-6

FEW SEMI-INTERESTING PROBLEMS

CHAPT 11: 25, 27, 31, 45, 71, 83

TODAY: OSCILLATIONS

MONDAY: WAVES

(NO REG. OFFICE HOURS – BUT E-MAIL ME)

WEDNESDAY: NO CLASS

MONDAY NOV 30 – SOUND (APPLIED WAVES)

CLEAR WE WON'T FINISH TEXT

BY END OF SEMESTER

PHYS 009 – START WHERE WE STOP

(LONG SEMESTER – MORE TIME, LESS INTERUPTION)

$x = A \sin \omega t \qquad \omega = \frac{1}{\text{TIME}}$

$v = \frac{dx}{dt} = \omega A \cos \omega t$

$a = \frac{d^2x}{dt^2} = -\omega^2 A \sin \omega t$

*

THUS ~~X_0~~ $x = A\sin\sqrt{\frac{k}{m}}\,t + B\cos\sqrt{\frac{k}{m}}\,t$

$A, B = ?$ DEPENDS ON HOW YOU START CLOCK

X_0 AT $t=0$ $\quad v_0 = 0$

$X_0 = B\cos\sqrt{\frac{k}{m}}\,t$

$\frac{dx}{dt} = \cancel{A\omega}\cdot\sqrt{\frac{k}{m}}\,A\cos\sqrt{\frac{k}{m}}\,t - \sqrt{\frac{k}{m}}\,B\sin\sqrt{\frac{k}{m}}\,t$

$\cancel{B}\ B = X_0 \quad A = 0$

$x = X_0\cos\sqrt{\frac{k}{m}}\,t$

PERIOD: TIME FOR ONE OSCILLATION $= T$

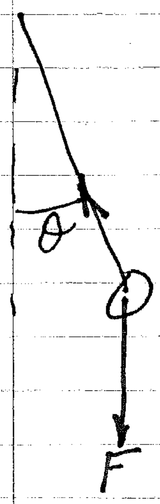
$\sqrt{\frac{k}{m}}\,T = 2\pi \qquad T = 2\pi\sqrt{\frac{m}{k}}$

f = FREQUENCY = OSC/SEC

$= \frac{1}{T} = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$

(DEMO) - VARIABLE MASS

ALL EXAMPLES THE SAME:



PENDULUM:

$$\tau = mgL\sin\theta = I\alpha \quad (\text{OPP. TO } \theta)$$

$$I = mL^2$$

$$\alpha = -\frac{\cancel{M}gL\sin\theta}{\cancel{M}L^2} = -\frac{g}{L}\sin\theta$$

IF θ IS SMALL: $\sin\theta \approx \theta$

$$\alpha = -\frac{g}{L}\cancel{\sin\theta}\,\theta$$

$$\theta = \theta_0 \cos\sqrt{\frac{g}{L}}\,t$$

$$\sqrt{\frac{g}{L}}\,T = 2\pi$$

$$T = 2\pi\sqrt{\frac{g}{L}}$$

DEMO WITH L

ON MOON?

NOTE: IF θ IS LARGE, DOESN'T QUITE WORK

ENERGY

$$KE + PE = (\text{SPRING})\ \frac{mv^2}{2} + \frac{kx^2}{2}$$

$$x = A\sin\omega t = A\sin\sqrt{\frac{k}{m}}\,t$$

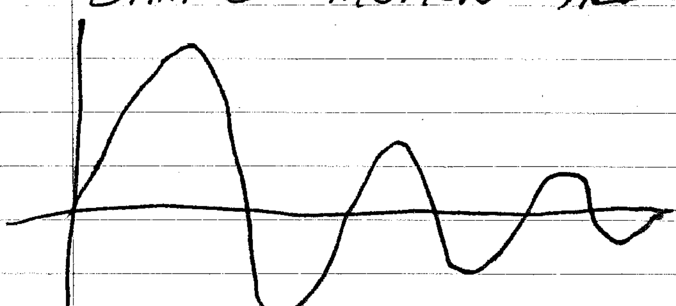
$$v = \omega A\cos\omega t = \sqrt{\frac{k}{m}}\,A\cos\sqrt{\frac{k}{m}}\,t$$

$$\frac{mv^2}{2} = \frac{m}{2}\frac{k}{m}A^2\cos^2\sqrt{\frac{k}{m}}\,t = \frac{kA^2}{2}\cos^2$$

$$\frac{kx^2}{2} = \frac{kA^2}{2}\sin^2$$

$$KE + PE = \frac{kA^2}{2}(\sin^2 + \cos^2) = \frac{kA^2}{2}$$

"DAMPED" MOTION: ALL WAYS STOPS

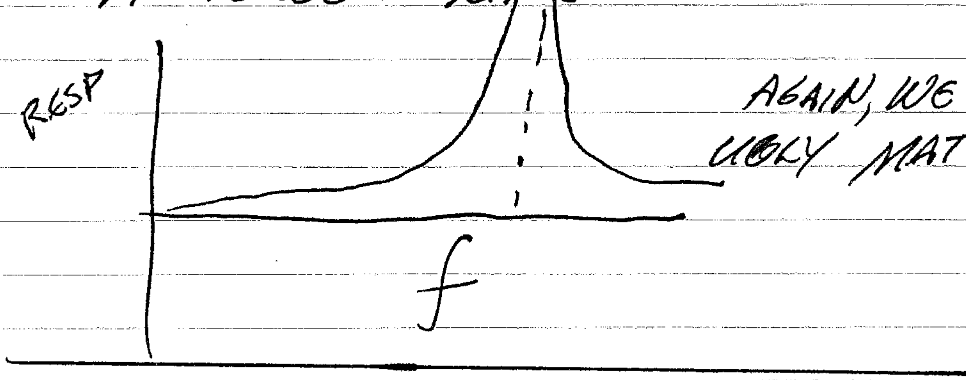


MORE ADVANCED COURSES

↳ PUNISH STUDENTS WITH SOLUTIONS

↳ LUCKY YOU!

FORCED OSCILLATIONS - APPLY FORCE TO SYSTEM AT PARTICULAR FREQUENCY
→ IF CLOSE TO NATURAL FREQUENCY RESPONSE IS LARGE



AGAIN, WE MISS UGLY MATH

EXAMPLE: SWING → TO PUSH HIGH, PUSH EXACTLY AT FREQUENCY OF SPRING

EXAMPLE: SPRING

EXAMPLE: TALL BUILDING

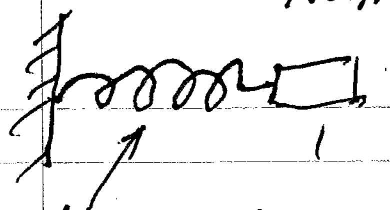
BLOW - SWAYS

BLOW AT RIGHT FREQUENCY

GROUND MOVES

(114)

$M = 4\,Kg$



$.1\,M$ | RELEASE:

$k = 100\,N/M$

a) $V_{MAX} = ?$

b) TIME TO RETURN TO ORIGINAL POSITION?

a) $x = A\cos\omega t = .1\cos\sqrt{\frac{k}{m}}\,t = .1\cos 5t$

$v = -\omega A\sin\omega t$

$= -.5\sin 5t$

$v_{MAX} = 0.5\,m/s$

—OR—

CONS. OF ENERGY:

$PE + KE = PE + KE$

$\frac{kx_0^2}{2} + 0 = 0 + \frac{mv_{max}^2}{2}$

$v_{MAX}^2 = \frac{k}{m}x_0^2 = 25(.1)^2$

$v_{MAX} = 0.5\,m/s$

b) TIME TO GET BACK:

$\frac{T}{4} = \frac{2\pi\sqrt{\frac{m}{k}}}{4} = \cancel{\frac{\pi}{5}} \approx$ ~~.63 SEC~~ ~~.628~~ SEC

$\frac{\pi}{10} = .314\,SEC$

WRONG WAYS:

$$v_{AVG} = \frac{.5}{2}$$

$$t = \frac{.1}{.5/2} = .4\,\text{SEC}$$

OR: $$.1 = \frac{at^2}{2}$$

$$t^2 = \frac{.2}{a}$$

$$a = \frac{k}{m}x = (25)(.1) = 2.5$$

$$t^2 = \frac{.2}{2.5} = .08$$

$$t = 0.28\,\text{SEC}$$

$v = v_{MAX} \sin \omega t$

$= v_{MAX} \sin_{AVE}$

$v_{AVG} = \frac{v_{MAX}}{\sqrt{2}}$

Name WALES
(Please Print)

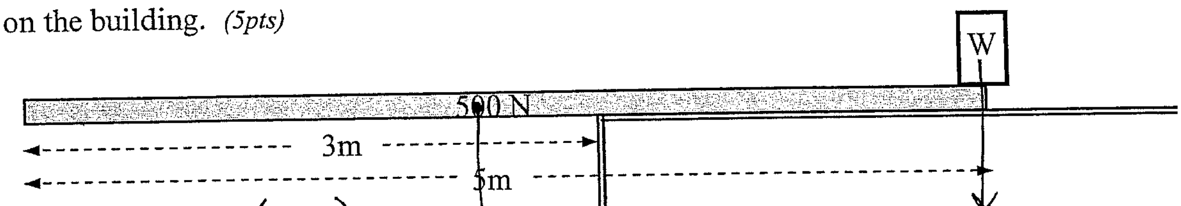
PHYSICS 008

Seventh Quiz
November 20, 2009

Please do all work on this sheet. Your score will depend both on the work you show and on the answers you obtain. You may use a calculator and the information on the reverse side of this sheet.

1. One end of a uniform beam of length 5.0 meters and weight 500 Newtons projects 3.0 meters beyond the edge of a building.

   Determine the minimum weight (W) of the object that must be placed on the other end of the beam to keep it on the building. *(5pts)*



$W(2) - 500(.5) = 0$ 500   Building   W

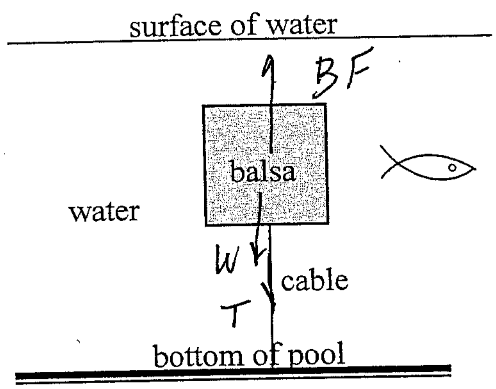
T +2

SOME RIGHT +1

$W = \frac{250}{2} = 125N$

2. A 0.20 meter by 0.20 meter by 0.20 meter cube of balsa wood (density = 200 kg/m^3) is held beneath the surface of a pool (water; density = 1000 kg/m^3) by a cable fastened to the bottom of the pool.

   Determine the tension in the cable. *(5pts)*



$BF - W - T = 0$

$T = BF - W$

$BF = (.2)^3 \rho_w g = 78.4N$

$W = (.2)^3 \rho_B g = 15.7N$

$T = \cancel{67}\ 62.7N$

W +2

BF +2

$$\left\{ \begin{aligned} P_B - P_T &= \rho g(h_T - h_B) \\ &= 1000(9.8)(.2) = 1960 \\ F_B &= (P_B - P_T)(.04) = 78.4N \end{aligned} \right.$$

Torque: $\tau = rF\sin\theta$

Statics: $\vec{F} = 0$, $\vec{\tau} = 0$ In practice (2-D) $F_x = 0$, $F_y = 0$, $\tau_{cw} = \tau_{ccw}$

Fluids:

Density (ρ) = Mass/Volume

Pressure (P) = Force/Area

Buoyant Force = Weight of displaced fluid

Continuity: $A_1 v_1 = A_2 v_2$

Bernoulli's Equation: $P + \frac{\rho v^2}{2} + \rho g h = constant$

NOVEMBER 23, 2009

1. QUIZ → #8 NEXT WEEK 5/8 (DROP 3 LOWEST)

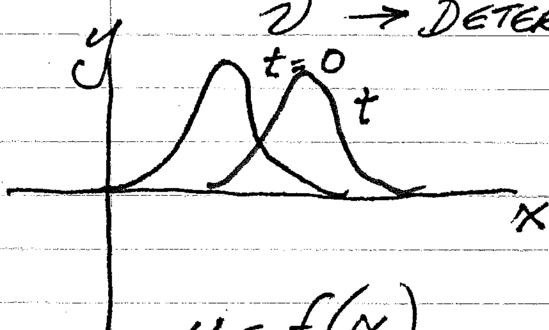
2. PROBLEMS 27, 31, 83

3. READ 11: 7, 8, 11, 12, 13
NO PROBLEMS

WHAT IS A WAVE?

≡ TRAVELLING DISTURBANCE DEMO

v → DETERMINED BY MEDIUM



$y = f(x)$

MOVED BY vt

$y = f(x - vt)$ → WAVE MOVING IN ONE DIMENSION WITH VELOCITY v

TRANSVERSE WAVES - DISPLACEMENT ⊥ TO DIRECTION

— THIS DEVICE, LIGHT WAVES, WAVES ON STRINGS
↳ $v = 3 \times 10^8 m/s$

LONGITUDICAL WAVES - SOUND $v \approx 330 m/s$

REFLECTION DEMO

SUPERPOSITION DEMO

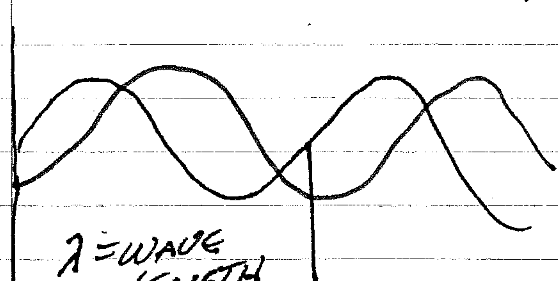
(INTERFERENCE - WAVES CAN ADD OR SUBTRACT
MASSES CAN ONLY ADD

ENERGY: OBVIOUSLY ENERGY BEING TRANSPORTED

SUPPOSE INSTEAD OF PULSE I MOVE END UP + DOWN: AT SOME FREQUENCY f

AT $x = 0$ $y = A \sin 2\pi f t$

→ THIS MOVES ALONG:



λ = WAVE LENGTH

$$\lambda = vT = \frac{v}{f}$$

$v = f\lambda$ ← GENERALLY TRUE FOR SINUSOIDAL WAVES

NOTE f VS λ

~~REFLECT SINUSOIDAL~~:

~~y~~ FORMULA (UGLY THOUGHT!)

$t = 0$ $y = A \sin \cancel{x}\, 2\pi \frac{x}{\lambda}$

$t > 0$

$y_1 = A \sin \frac{2\pi}{\lambda}(x - vt)$ $\longrightarrow$ TO RIGHT

~~$y_2 = A \sin \frac{2\pi}{\lambda}(x + vt)$ $\longrightarrow$ TO LEFT~~

~~REFLECTION:~~

~~$Y = y_1 + y_2 = A \sin \frac{2\pi x}{\lambda} \cos$~~

$= A \sin\left(2\pi\left(\frac{x}{\lambda} - ft\right)\right)$

NOW REFLECT $y_2 = A \sin 2\pi\left(\frac{x}{\lambda} + ft\right)$ TO RIGHT

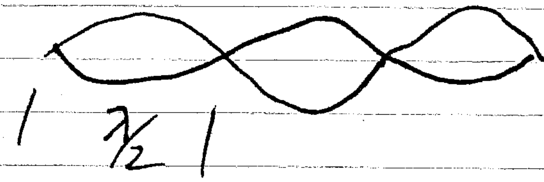
ADD: $Y = y_1 + y_2 = A \sin \frac{2\pi x}{\lambda} \cos 2\pi f t + A \cos \frac{2\pi x}{\lambda} \sin 2\pi f t$

$+ A \sin \frac{2\pi x}{\lambda} \cos 2\pi f t - A \cos \frac{2\pi x}{\lambda} \sin 2\pi f t$

$= 2A \sin \frac{2\pi x}{\lambda} \cos 2\pi f t$

DEMO "STANDING" WAVES

<u>NODE</u>: $y = 0$



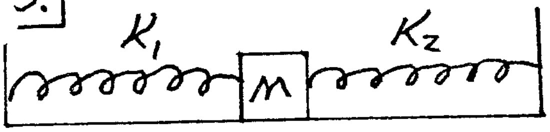
RESONANCE $\rightarrow$ IF $L = \underset{\text{INTEGER}}{m} \frac{\lambda}{2}$

THEN REFL FROM LEFT EXACTLY IN PHASE WITH OUTGOING

CHAPTER 11:

PHYSICS 008
NOVEMBER 23, 2009

25.



MOVE MASS DISTANCE X TO RIGHT:
K_1 (STRETCHED) EXERTS $K_1 x$ TO LEFT
K_2 (COMPRESSED) EXERTS $K_2 x$ TO LEFT

TOTAL FORCE $F = -(k_1 + k_2)x = ma$

$$a = -\frac{(k_1 + k_2)}{m} x$$

$$\rightarrow T = 2\pi\sqrt{\frac{m}{k_1 + k_2}}$$

27. $T = \frac{38}{8} = 2\pi\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{65}{k}}$

$$k = (65)4\pi^2\left(\frac{8}{38}\right)^2 = 114\ N/m$$

$$kx = mg : x = \frac{65(9.8)}{114} = 5.6\ m$$

ORG. LENGTH $= 25 - 5.6 = 19.4\ m$

31. a) $T = 2\pi\sqrt{\frac{L}{g}} = 2\pi\sqrt{\frac{.8}{9.8}}$

$T = 1.79$ SEC

b) "WEIGHTLESS"

$g_{EFFECTIVE} = 0$

$T = \infty$

45. $x = A \sin 2\pi f t$

$$a = -(2\pi f)^2 A \sin 2\pi f t$$

$$a_{MAX} = (2\pi f)^2 A = g$$

$$A = g/(2\pi f)^2$$

$$= \frac{9.8}{(2\pi(.5))^2} = 0.99\ m$$

71. $KE_i = PE_f$

a) $\frac{1}{2} 950(22)^2 = \frac{1}{2} k(5)^2$

$$k = \frac{950(22)^2}{5^2} = 1.84 \times 10^4\ N/m$$

b) $\text{TIME} = \frac{T}{2} = \frac{2\pi\sqrt{m/k}}{2}$

$$= \pi\sqrt{\frac{950}{1.84 \times 10^4}} = 0.71$$

83. $T_p = 2\pi\sqrt{\frac{L}{g}}$

$T_s = 2\pi\sqrt{\frac{m}{k}}$; BUT $mg = k(L - l_0)$

$k = \frac{mg}{L - l_0}$; $T_s = 2\pi\sqrt{\frac{L - l_0}{g}}$

$$\frac{T_p}{T_s} = \sqrt{\frac{L}{L - l_0}}$$

OFFICE HOURS: MW 2-4
- OR BY APP'T

NOVEMBER 30, 2009

CHAPTER 11: READ SEC. 7, 8, 11, 12, 13
(NO PROBLEMS)

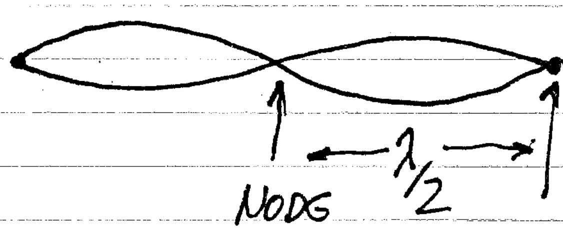
WEDNESDAY - LAST QUIZ: OSCILLATORY MOTION, ENERGY, MOMENTUM

BACK TO MODEL:

IF LENGTH $\xrightarrow{\quad}$ OUT
$\xleftarrow{\quad}$
$\xrightarrow{\quad}$ REFL

OUT & REFLECTED ADD, MAXIMA RESPONSE
(RESONANT AT THAT FREQUENCY)

NOTE: TO BE IN PHASE, $2L = n\lambda$

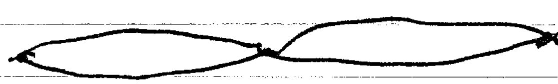


ANY RELEVANCE TO REAL WORLD?

TACOMA NARROWS BRIDGE

WAVE MACHINE IS A BIT ARTIFICIANT

→ TRY VIBRATION STRING



SWITCH GEARS SLIGHTLY:

SOUND: → TUNING FORM (OSCILLATES AT 440 HZ)
↳ w/o WOOD

NOISE

→ W WOOD

SOUND: LONGITUDINAL WAVE THROUGH AIR (OR OTHER MATERIAL)

→ NEED TO COUPLE OSCILLATIONS TO AIR:

COMPUTER – PICKS OUT FREQUENCY

EAR: EARDRUM COUPLES VIBRATIONS TO INNER EAR, WHERE HAIRS IN COCHLEA ARE SENSITIVE (RESONANT) TO DIFFERENT FREQUENCIES, SEND MESSAGE TO BRAIN

"NORMAL" EAR ~ 30 Hz → 15,000 OR SO

LOWER AS AGING OCCURS

RESONANCE DEMO (TWO FORKS)

→ (BEATS)

DECEMBER 2, 2009

CHAPTER 12: READ 1, $\boxed{2}$, 4

PROBLEMS: ALL DULL (WILL WORK ONE IN CLASS)

TODAY: FINISH SOUND
QUIZ

FRIDAY: CHAPTER 13 (FIRST LECTURE OF PH 009)

MONDAY & WEDNESDAY: REVIEW

THURSDAY, DECEMBER 17 – NOON IN A1

– FINAL EXAMINATION –

---

1) OLD EXAM

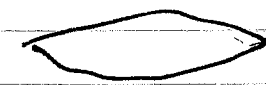
2) LIST OF SECTIONS

PLUNKED (BOWED) STRING:

→ PUTS IN COMBINATION OF MANY FREQUENCIES

↳ THOSE RESONANT SURVIVE

"FUNDAMENTAL": $2L = \lambda$



OVERTONE $2L = n\lambda \quad n = 2, 3, 4$

$f = \frac{v}{\lambda} = \frac{nv}{2L} = \frac{v}{2L}, \frac{2v}{2L}, \frac{3v}{2L}, \frac{4v}{2L} \quad \boxed{f = nf_1} \quad f_1 = \frac{v}{2L}$

~~S~~ VIBRATING STRING MOVES VERY LITTLE AIR

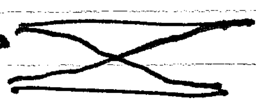
→ BODY OF GUITAR ~~WHEN~~ IS FORCED INTO VIBRATION BY STRINGS, IT MOVES AIR

PIPES: VIBRATION IS ACTUAL SOUND WAVE

→ BLOW: (OVEREDGE, ON REED, ETC)

AGAIN, PICKS UP RESONANT FREQUENCIES

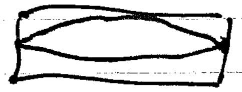
ANTI NODE → DISP



OPEN-OPEN $2L = n\lambda \quad \lambda_0 = 2L$

$f_1 = \frac{v}{2L} \quad f = \frac{v}{\lambda} = \frac{nv}{2L} = nf_1$

DEMO



CLOSED CLOSED $2L = n\lambda \quad \lambda_0 = 2L$

OPEN CLOSED $\cancel{\lambda_0} = \lambda = 4L$

$\lambda/4 = L$

$3\lambda/4 = L$

NO CONTROL OR WORSE! $\lambda = \frac{4L}{3}$

$f_1 = \frac{v}{4L}$

$\rightarrow \lambda = \frac{4L}{2n+1}$

$f = \frac{v}{\lambda} = \frac{v}{4L}(2n+1) = f_1(2n+1)$

$\cancel{f = v/\lambda}$

TROMBONE
ORGAN

VARY PITCH → ν OF SOUND, ETC

CLOSED-CLOSED → SOUND CAN'T GET OUT

CONSIDER SMALL ROOM: $L = 2$ m

$f = \frac{330}{4}$, ETC

→ "SINGING IN THE BATHTUB"

→ REALLY DOES SOUND BETTER (TRY IT!)

SOUND INTENSITY: $I = \frac{\text{POWER}}{m^2}$

PROBLEM: EAR IS EXTREMELY NON-LINEAR!

SOUND LEVEL $\equiv 10 \log \frac{I}{I_0}$

I_0 = THRESHOLD OF HEARING $= 1 \times 10^{-12}$ w/m^2

10 dB → BARELY HEAR
120 dB → RISKING INJURY

$\Big\}$ $I_{MAX} = 1$ w/m^2

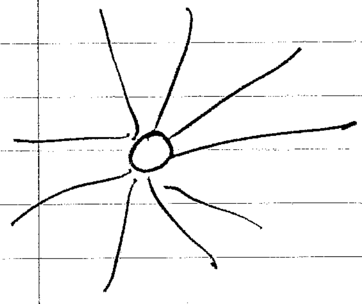
ROOMS: → A-2 REFURBISHED THIS SUMMER

→ SEATS, WALLS, VIDEO EQUIPMENT, ETC

→ DESIGN ELECTRONIC ENGINEER, ARCHITECT, ETC

→ WALKED IN: DIFFERENT SOUND

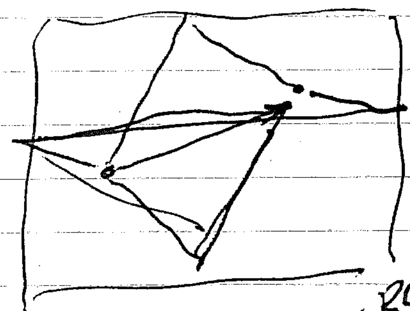
(MAYBE DUE TO ARCHITECT, MAYBE JUST LUCKY)



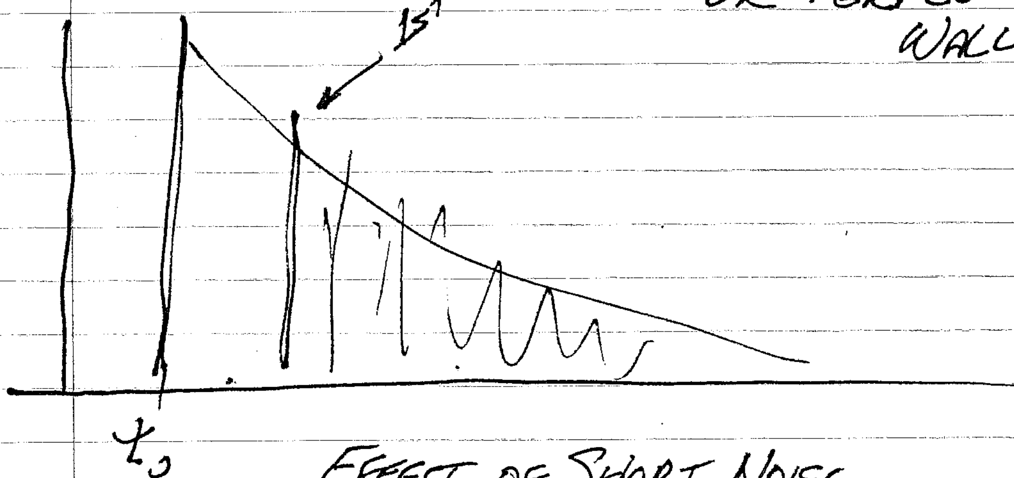
ENERGY RADIATES

$\to \frac{1}{r^2}$

ONLY IF TALKING IN ~~OB~~ OPEN FIELD:



OR PERFECT ABSORBING WALL



EFFECT OF SHORT NOISE

REVERBERATION TIME $\to$ 60db REDUCTION

DOES IT MATTER? $t_R = 0$ BRITTLE

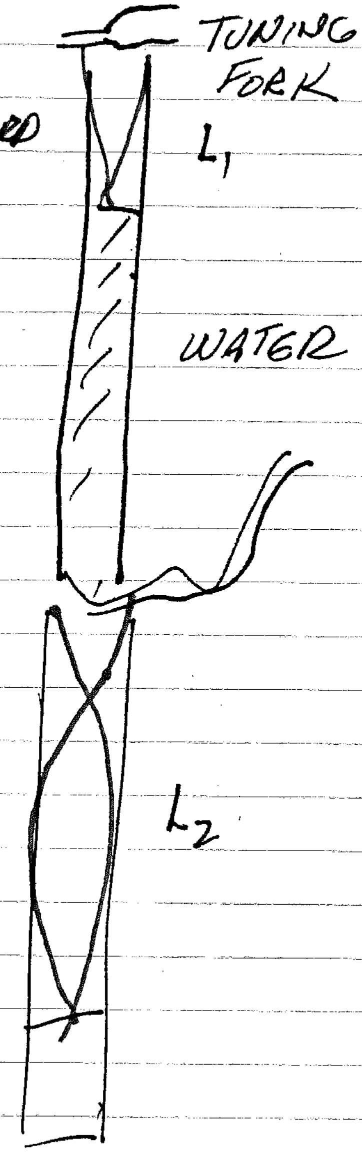
$t_R \sim 5$ SEC $\to$ EVERYTHIN RUNS TOGETHER

SPEECH $\sim$ .5 SEC

MUSIC $\sim$ 1.2 SEC $\to$ 2 SEC

PALESTRA $\sim$ 5 SEC

INTERESTING PROBLEM / MEASURE v OF SOUND (OLD LABORATORY)



IF LENGTH OF AIR COLUMN IS RIGHT LENGTH, RESONANCE IS HEARD

— FIRST AT $L_1 = \frac{\lambda}{4}$

PROBLEM: DISPLACEMENT NODE ISN'T EXACTLY AT END, BUT A BIT BEYOND, DEPENDING ON DIAMETER OF TUBE

LOWER WATER TO FIND $L_2 = \frac{3\lambda}{4}$

SAME PROBLEM WITH END
- BUT NOT WITH

$$L_2 - L_1 = \frac{\lambda}{2}$$

TAKE DATA: $L_1 = 20\text{cm}$

$$L_2 = 57\text{cm}$$

$$L_2 - L_1 = 57 - 20 = 37\text{cm}; = \frac{\lambda}{2} \qquad \lambda = 74\text{cm}$$

$$v = f\lambda = (440)(.74) = 326\text{ m/s}$$

UNCERTAINTY → NOT EXTREMELY PRECISE:

$\pm \frac{1}{2}\text{cm} \rightarrow 1\%$

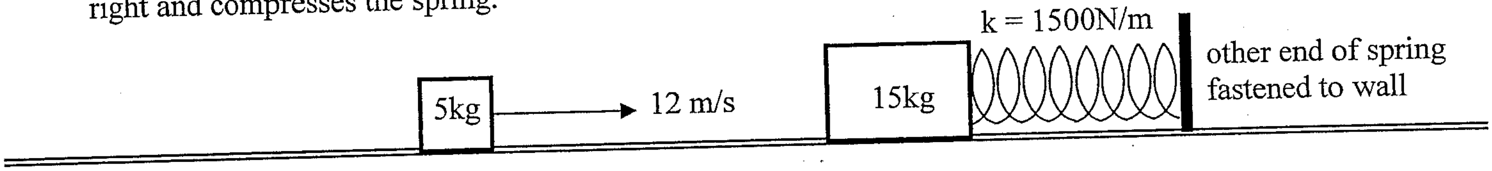
Name WALES
(Please Print)

PHYSICS 008

Eighth *(Last!)* Quiz
December 2, 2009

Please do all work on this sheet. Your score will depend both on the work you show and on the answers you obtain. You may use a calculator and the information on the formula sheet.

A 5-kilogram block, moving with a velocity of 12 meters per second on a horizontal frictionless surface, strikes a second block, of mass 15 kilograms, which is at rest. The second block is fastened to one end of a spring, with elastic constant k = 1500 Newtons per meter, that is initially neither stretched nor compressed. After the collision the 5-kilogram block is at rest, while the 15-kilogram block moves to the right and compresses the spring.



a) Determine the velocity of the 15-kilogram block immediately after the collision. *(3pts)*

$P_i = P_f$

$5(12) = (15)v$

$v = 4\,m/s$

ENERGY −2
MOMENTUM BY WRONG −1

$a \neq$ CONST
$v = v_0 + at$
$v^2 - v_0^2 = 2a(x - x_0)$
ETC

b) Determine the maximum compression of the spring *(4pts)*

$KE_i = PE_f$

$\frac{15(4)^2}{2} = \frac{(1500)x^2}{2}$

$x^2 = \frac{1}{100}(4)^2 \quad x = \frac{4}{10} = 0.4\,M$

After compressing the spring the 15-kilogram block returns to its original position and strikes the 5-kilogram block.

c) Determine the time between the first and second collisions. *(3pts)*

$T = 2\pi\sqrt{\frac{m}{k}} = (2\pi)(.1) = .2\pi$

$t = \frac{T}{2} = .1\pi = .314\ SEC$

−1

DECEMBER 4, 2009

QUIZ - STEP THROUGH ANY COMPLICATED PROBLEM:

a) MOMENTUM

b) ENERGY

c) OSCILLATORY MOTION

GRADING ALGORITHMS

QUIZ GRADE = SUM OF BEST 5

$$\text{COURSE GRADE} = \underset{10\%}{Q} + \underset{20\%}{E_1} + \underset{20\%}{E_2} + \underset{50\%}{F}$$

THEN SET SCALE (ABC)

THEN ADJUST COURSE GRADE (CHECK ALL COMBINATIONS)

E_1	E_2	F
20	20	50
10	30	50
10	10	70
30	30	30

→ SAME SCALE: ALMOST EVERY NUMBER GRADE WILL INCREASE

SOME LETTER GRADES WILL INCREASE

REVIEW FOR EXAM

SECTIONS FROM WHICH PROBLEMS

MIGHT USE MATERIAL:

	CHAPTER	SECTIONS	
1D KIN	2	1-7	
2D KIN	3	1-6, 8	
FORCE	4	1→9	←
CIRCULAR	5	1-3, 6-8	
ENERGY	6	1-10	←
MOMENTUM	7	1-8	←
ANGULAR	8	1-8	
STATICS	9	1-2, 4-6	
FLUIDS	10	1→10	
VIBRATIONS	11	1→4	

PRACTICE EXAM - HAND OUT

NOT A PARTICULAR GOOD EXAMINATION

→ LOOK IT OVER: FOR EACH SECTION
ASK WHAT PRINCIPLES

PLAN: 5 REASONABLE PROBLEMS

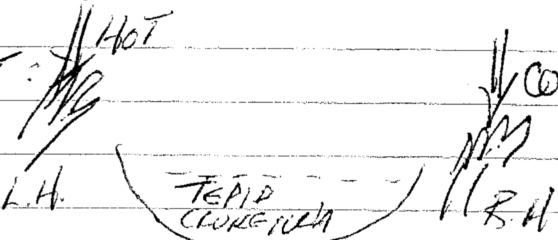
3 LESS REASONABLE PROBLEMS

TEMPERATURE → SUBJECTIVE SENSATION

→ QUITE UNRELIABLE

70° → WARM FOR PERSON A
COOL FOR PERSON B

WORSE THAN THAT:



PLUNGE BOTH HANDS INTO WATER SIMULTANEOUSLY

L.H → WATER IS COOL

RH → WATER IS WARM

NEED MORE OBJECTIVE BASIS:

OBSERVATION: OBJECTS (& LIQUIDS) EXPAND
WHEN THEY GET HOT
CAN USE COLUMN OF MERCURY IN GLASS TUBE
DEFINE: 0° = FREEZING POINT OF WATER
100° = BOILING POINT OF WATER

CENTIGRADE OR CELSIUS

PROBLEM: EXPANSION RATE + LINEARITY
DIFFERENT FOR DIFFERENT MATERIALS
LIQUIDS TEND TO SOLIDIFY WHEN THEY
GET COLD:

SOLUTION ↔ USE DILUTE GAS

SIDE BAR ON DILUTE GAS:

OBSERVATION: FOR GIVEN SAMPLE AT GIVEN
TEMPERATURE:

$$(\text{PRESSURE})(\text{VOLUME}) = \text{CONSTANT}$$

AT CONSTANT VOLUME:

$$V(\Delta P) = \text{CONST}(\Delta T)$$

CONST ⟶ HOW MUCH GAS, WHAT KIND OF GAS

~~ATOMIC THEORY: MATERIALS CONSIST OF ATOMS
WITH MASS ≃ INTEGER × MASS OF SIMPLEST~~

~~DILUTE GAS = POINT-LIKE ATOMS BOUNCING
AROUND~~

~~OBSERVATION: SAME CONSTANT FOR 1 GM HYDROGEN
4 GM HELIUM
ETC~~

$$V(\Delta P) = \underbrace{\frac{\text{MASS}}{\text{ATOMIC WEIGHT}}}_{\text{NO. OF "MOLES"}}(\text{CONST}')\Delta T = nR\Delta T$$

~~126~~ 126

~~R = EMPIRICALLY DETERMINED CONSTANT~~

USE PRESSURE AS MEASURE OF TEMPERATURE

$$\Delta P = \frac{1}{V} \text{CONST} (\Delta T)$$

OR $$P = \frac{1}{V} \text{CONST}\, T + \text{CONST.}$$

CALIBRATE AT $T = 0°$ (ICE)

$T = 100°$ (STEAM)

TRY IT:

→ NEW SCALE: KELVIN:

$0°C = 273K$

$100°C = 373K$

→ "ABSOLUTE ZERO"

→ $P \to 0$

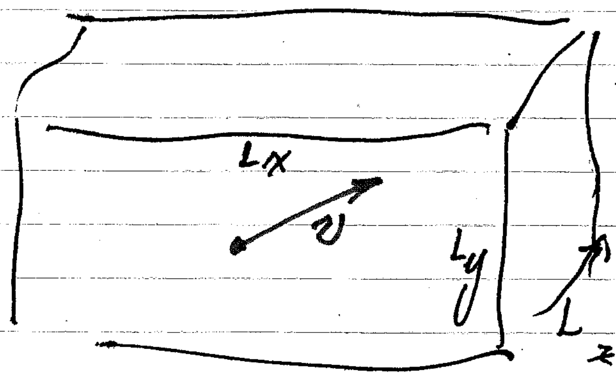
$PV = (\text{CONST})\, T$

→ TWO APPROACHES: EARLIEST HISTORICAL

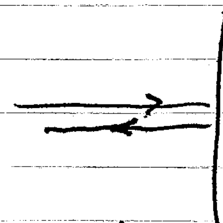
→ EXPERIMENTAL

SECOND: MECHANICS & KINETIC THEORY

ASSUMPTIONS: DILUTE GAS = VACUUM + ATOMS OR MOLECULES MOVING WITHIN CONTAINER MAKING ELASTIC COLLISIONS WITH WALLS:



LOOK AT v_x



(MOM)

$$\Delta P_x = 2P_x = 2mv_x$$

$$F_{AVG} = \frac{\Delta P_x}{\Delta t}$$

$$\Delta t = \frac{2L_x}{v_x}$$

$$F_{AVG} = \frac{2mv_x}{2L_x/v_x} = \frac{mv_x^2}{L_x}$$

$$(\text{PRESSURE})_{AVG} = \frac{F}{A} = \frac{mv_x^2}{L_x L_y L_z} = \frac{mv_x^2}{\text{VOL}}$$

OTHER DIMENSIONS:

SAME ANSWER: $P = \frac{mv_y^2}{\text{VOL}} = \frac{mv_z^2}{\text{VOL}}$

NOW ADD:

$$\cancel{F}\ 3P = \frac{mu^2}{Vol}$$

NOW ADD EFFECT OF N ATOMS

$$3P = \frac{N(mu^2)_{AVG}}{Vol} = \frac{N}{Vol}\,2\left(\frac{mu^2}{2}\right)_{AVG} = \frac{2N}{Vol}(KE)_{AVG}$$

OR

$$PV = \frac{2}{3}N(KE)_{AVG}$$

T IS MEASURE OF AVERAGE TRANSLATIONAL KINETIC ENERGY

NOW WE HAVE A PROBLEM:

$$PV = (CONST)\,T \equiv NkT$$

$$PV = \frac{2}{3}N(KE_{AVG})$$

$$\cancel{T} = \quad kT = \frac{2}{3}KE_{AVG}$$

$$T = \frac{2}{3k}KE_{AVG} \quad \text{OR} \quad KE_{AVG} = \frac{3}{2}kT$$

k = BOLTZMAN CONSTANT $= 1.38 \times 10^{-23}$ J/K

Name WALES (please print)

1 *20pts*	
2 *20pts*	
3 *20pts*	
4 *20pts*	
TOTAL ***80pts***	

Physics 008

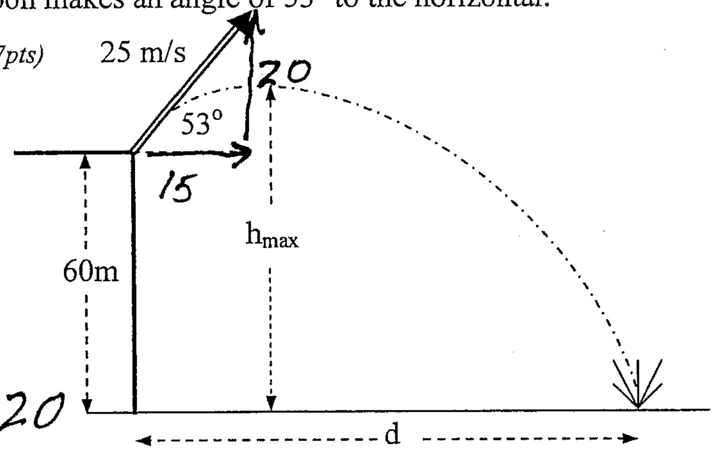
First Examination
October 7, 2009

Please show all work on these sheets. Your grade will depend both on your answers and on the work you do to get those answers. If you need more space use the back of these sheets. You may use a calculator and the information on the "formula" sheet. NOTE: You may use "g" = 10.0 m/s^2 (instead of 9.8 m/s^2) in any case where it is convenient for you.

* Problem 4 (c) may present a challenge. You should not devote a great deal of time to it until you are satisfied with your work on the rest of the examination.

1. A water balloon is launched from the edge of a building that is 60 meters high. The initial velocity of the balloon is 25 m/s. The initial velocity of the balloon makes an angle of 53° to the horizontal.

a) Determine the maximum height of the balloon. *(7pts)*



Note: Not to scale

$(h-60)2(-10) = 0-(20)^2$

$h-60 = 20 : h = 80$

25 -2

-OR-

$0 = 20 - 10t$ $t = 2$

$V_{AVG} = \frac{20-0}{2} = 10$ $h-60 = 20$

b) Determine the total time the balloon spends in the air. *(8pts)*

$0 = 60 + 20t - 5t^2$; $t^2 - 4t - 12 = 0$

-OR- $(t-6)(t+2) = 0$

TO FALL: $0 = 80 + 0(t) - 5t^2$ $t = 6$ SEC

$t_{DOWN} = 4$ SEC $t = 2$

-5

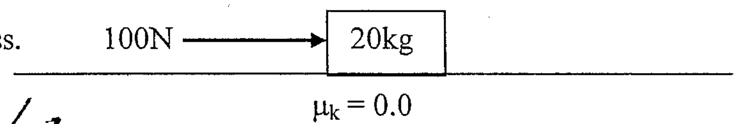
TOTAL $= 4+2 = 6$ s

c) Determine the horizontal distance between the base of the building and the spot at which the balloon lands. *(5pts)*

$(15)(6) = 90$ M $a \neq 0$ -3

2. A 20 kilogram block rests on a horizontal plane. The block is pushed by a force of 100 Newtons. Determine the acceleration of the block when:

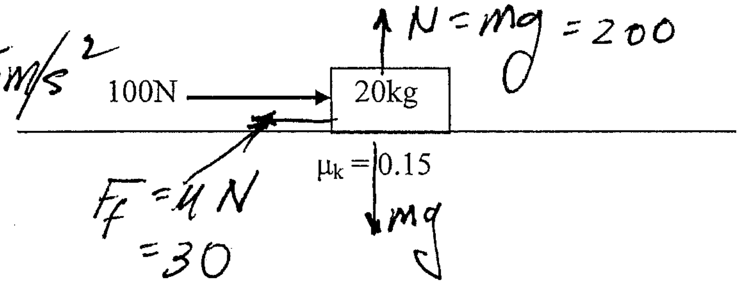
a) The force is horizontal and the surface is frictionless. *(3pts)*



$a = \frac{100}{20} = 5.0\ m/s^2$

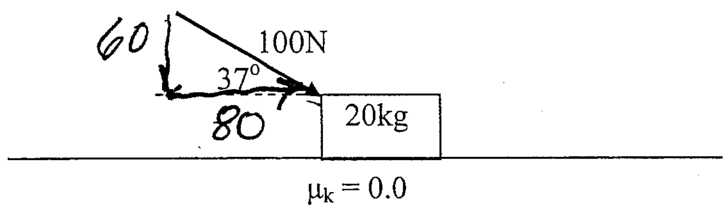
b) The force is horizontal and the kinetic coefficient of friction (μ_k) between the block and the plane is 0.15. *(4pts)*

$a = \frac{100-30}{20} = 3.5\ m/s^2$

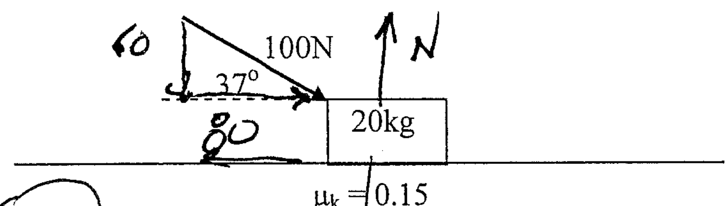


c) The force makes an angle of 37° to the horizontal and the surface is frictionless. *(4pts)*

$a = \frac{80}{20} = 4.0\ m/s^2$



d) The force makes an angle of 37° to the horizontal and the kinetic coefficient of friction (μ_k) between the block and the plane is 0.15. *(9pts)*



$F_f = \mu N$

$N - 60 - 200 = 0$

$N = 260$ (140: -3

$a = \frac{80 - F_f}{m} = \frac{80-39}{20}$

$= 2.05\ m/s^2$

$mg = 200$

$N = mg$

-5

3. A 20-kilogram block is free to move on a ramp that makes an angle of 30° to the horizontal. A cord that is fastened to this block passes over a pulley and hence to a second 20-kilogram block that hangs freely.

a) Show that in the absence of friction between the plane and the first block that the blocks will accelerate at g/4 (2.45 m/s² or 2.5 m/s², depending on what you chose to use for "g"). *(8pts)*

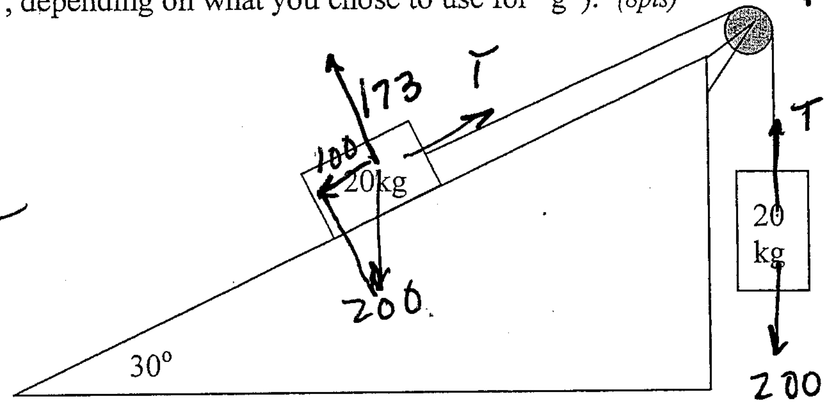
a

$200 - T = 20a$

$T - 100 = 20a$

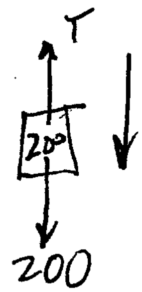
$100 = 40a$

$a = 2.5\ m/s^2$



However, the plane is not frictionless, and the blocks move with an acceleration of 2.0 m/s² when they are released. In this case, determine:

b) The tension in the cord joining the two blocks. *(4pts)*



$200 - T = 20a$

$T = 160N$

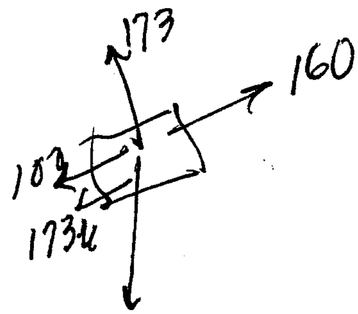
OMIT (-3)

c) The kinetic coefficient of friction (μ_k). *(8pts)*

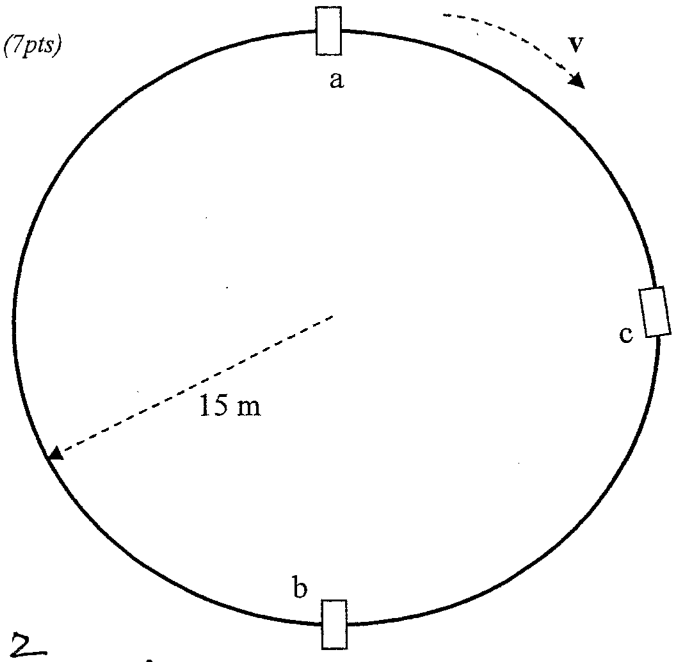
$160 - 100 - 173\mu = 40$

$173\mu = 20$

$\mu = 0.12$



4. A ferris wheel has a radius of 15 meters. When the wheel is moving with a velocity **v** the apparent weight of a 50-kilogram passenger in a chair at the top is reduced to 400 Newtons.



a) Determine the velocity **v** of the ferris wheel. *(7pts)*

400

500

$a = \frac{v^2}{R}$

$400 = ma$ (-5)

$\frac{50 v^2}{15} = 100$

$v^2 = 30$

$v = 5.5\ m/s$

b) Determine the apparent weight of this same passenger when in a chair at the bottom. *(7pts)*

N

$\frac{v^2}{R}$

500

$N - 500 = \frac{mv^2}{R} = 100$

$N = 600N$

c) * Determine the apparent weight of the passenger when the passenger is in a chair that is half-way up. *(6pts)*

$\vec{N} + m\vec{g} = \frac{mv^2}{R} = 100$

$N = \sqrt{(100)^2 + (500)^2} \approx 510N$

$\theta = \tan^{-1}\frac{100}{500} = 11.3°$

mv^2/R

N θ mg

$N + mg = 100$ (-3)

WRONG DIAGRAM (-4)

v^2/R

500

$N = mg$ $(a = 0)$

(-5)

Name WALES (please print)

1 *20pts*	
2 *20pts*	
3 *20pts*	
4 *20pts*	
TOTAL *80pts*	

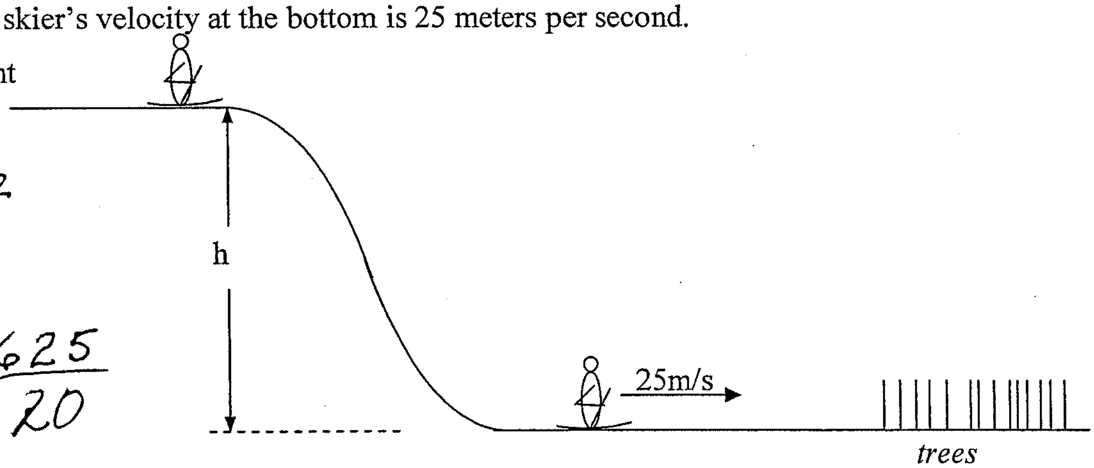
Physics 008

Second Examination
November 9, 2009

Please show all work on these sheets. Your grade will depend both on your answers and on the work you do to get those answers. If you need more space use the back of these sheets. You may use a calculator and the information on the "formula" sheet. NOTE: You may use "g" = 10.0 m/s^2 (instead of 9.8 m/s^2) in any case where it is convenient for you.

1. A skier of mass 60 kilograms, initially at rest at the top of a frictionless hill of height h, skis to the bottom of the hill. The skier's velocity at the bottom is 25 meters per second.

   a) Determine the height of the hill. *(10pts)*



$$mgh = \frac{mv^2}{2}$$

$$h = \frac{v^2}{2g} = \frac{625}{20}$$

$$= 31.25\text{ m}$$

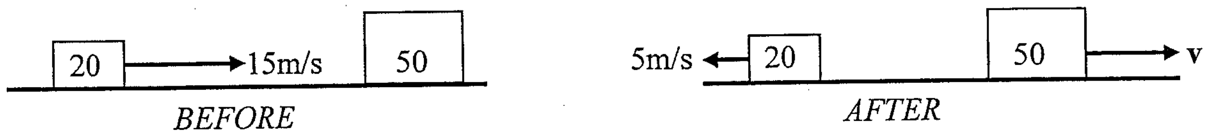
After the skier crosses a short level frictionless distance the skier crashes into a grove of small trees. The skier is stopped by the trees after penetrating a distance of 15 meters into the grove of trees.

   b) Determine the <u>average force</u> that the grove exerts on the skier as it stops the skier's progress. *(10pts)*

$$\frac{mv^2}{2} = Fd$$

$$F = \frac{mv^2}{2d} = \frac{60(25)^2}{2(15)} = 1250\text{ N}$$

2. A 20-kilogram block, moving with a velocity of 15 meters per second on a horizontal frictionless surface, collides with a 50-kilogram block that is initially at rest. After the collision the 20-kilogram block bounces backward with a velocity of 5 meters per second.



a) Determine the velocity **v** of the 50-kilogram block after the collision. *(10pts)*

$$20(15) = 20(-5) + 50v$$

$$400 = 50v$$

$$v = 8\ m/s$$

b) Determine the amount of kinetic energy that was lost in the collision. *(10pts)*

$$KE_i = \frac{20(15)^2}{2} = 2250\ J$$

$$KE_f = \frac{20(5)^2}{2} + \frac{50(8)^2}{2}$$

$$= 250 + 1600 = 1850\ J$$

$$\text{LOSS} = 400\ J$$

3. Tarzan, with a mass of 75 kilograms, grabs a vine of length 20 meters, which initially makes an angle θ_o with the vertical. Tarzan swings down in a circle on the vine. His velocity at the bottom of the swing is 10 meters per second.

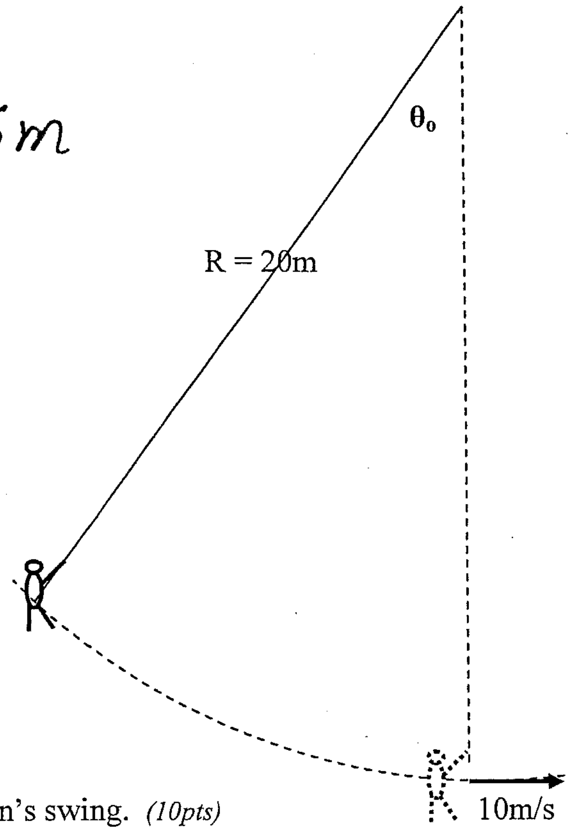
a) Determine the angle θ_o *(10pts)*

$$\frac{mv^2}{2} = mgh \qquad h = \frac{v^2}{2g} = 5m$$

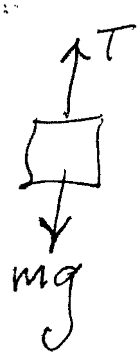
$$20 - 20\cos\theta = 5$$

$$\cos\theta = \frac{15}{20}$$

$$\theta = 41.4^\circ$$



b) Determine the tension in the vine at the bottom of Tarzan's swing. *(10pts)*



$$T - 750 = 75\frac{v^2}{R}$$

$$= \cancel{70}\,\frac{7500}{20}$$

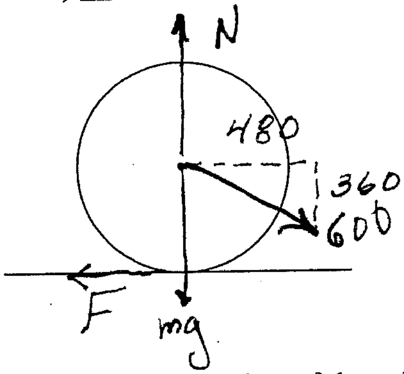
$$= 375$$

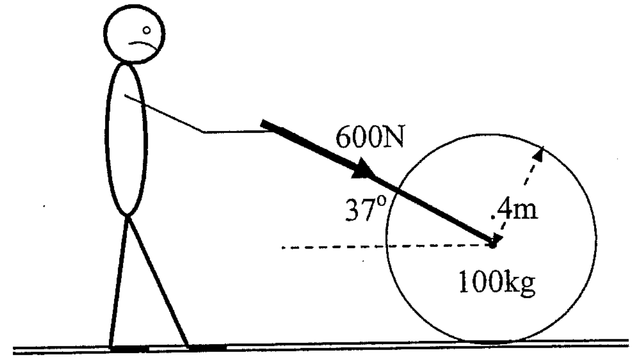
$$T = 750 + 375$$

$$= 1125N$$

4. A very strong gardener using a lawn roller exerts a force of 600 Newtons along the handle of the roller. The roller (a solid cylinder, $I = MR^2/2$) has a mass of 100 kilograms and a radius of 0.40 meter. The handle of the roller makes an angle of 37° to the horizontal. The roller rotates without slipping.

a) In the figure below indicate (with arrows and and labels) all of the forces on the roller. *(4pts)*





b) Determine the acceleration of the roller. *(10pts)*

$480 - F = 100a \leftarrow$ (+2)

$\cancel{FR} = I\alpha = \frac{MR^2}{2}\frac{a}{\cancel{R}} = \frac{MRa}{2}$ (+2)

$F = \frac{Ma}{2}$

$480 = 150a$

$a = 3.2\,m/s^2$

$F = ma$ (+1)

$\tau = I\alpha$ (+1)

$I = \frac{MR^2}{2} = 8$ (+1)

$\alpha = \frac{a}{R}$ (+1)

c) Determine the minimum value of the coefficient of friction (μ_s) that will ensure that the roller rotates without slipping. *(6pts)*

$F_f = \frac{Ma}{2} = 50(3.2) = 160N$

$= \mu_s N = \mu_s(1360$

$\mu_s = \frac{160}{1360} = .12$

$F_x - F_f = ma$

$F_f = 480 - 320 = 160N$

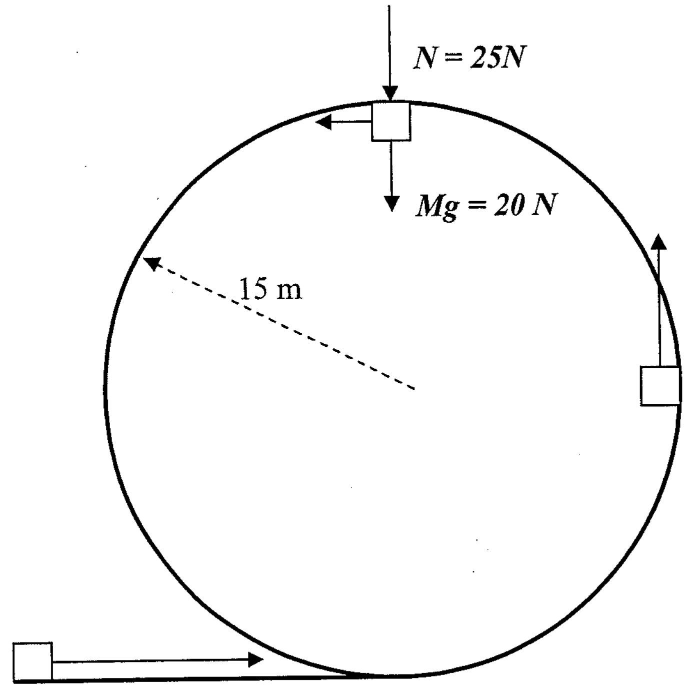
PHYSICS 008

Fall, 2009

Practice Examination No. 2

(With Solutions)

1. An object of mass 2.0 kilograms approaches a frictionless loop-the-loop with a radius of 15 meters and goes up and around the loop. The normal force of the loop on the object, at the top of the loop, is 25 Newtons.



a) In the diagram, show (with labeled arrows) the forces on the object when it is at the top of the loop.

b) Determine the velocity of the object when it is at the top of the loop.

$$F = ma = mv^2/r$$

$$45 = 2v^2/15$$

$$v = 18.4\ m/s$$

c) Determine the velocity of the object when is at the bottom of the loop.

$$U_i + K_i = U_f + K_f$$

$$Mgh_i + mv_i^2/2 = mv_f^2/2$$

$$2(10)30 + 2(18.4)^2/2 = 2v^2/2$$

$$v = 30.6\ m/s$$

d) Determine the normal force on the object when it is half-way up the loop.

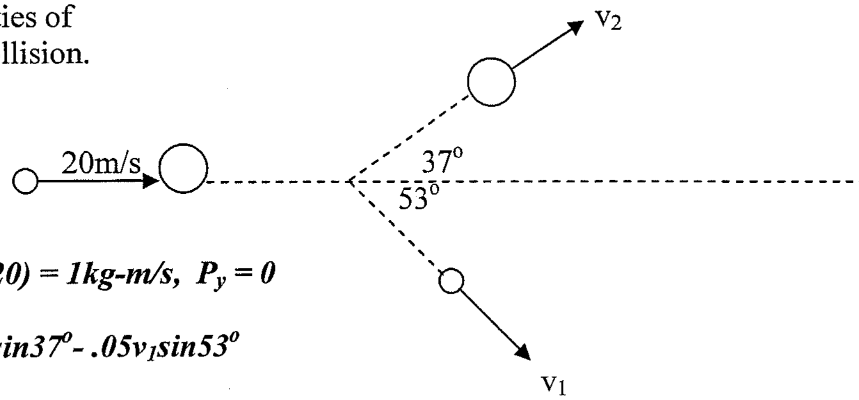
$$2(10)30 + 2(18.4)^2/2 = 2(10)15 + 2v^2/2$$

$$v^2 = 637.5$$

$$N = mv^2/r = 2\ (637.5)/15 = 85\ N$$

2. Consider the following situation. A ball of mass 0.050 kilogram, moving with a velocity of 20 meters per second, strikes a ball of mass 0.100 kilogram that is initially at rest. The collision is not directly head on. The 0.050-kilogram ball bounces off at an angle of 53° to its original direction and the 0.100-kilogram ball moves at an angle of 37° to that direction. (Note: This collision is not elastic)

   a) Determine the velocities of both balls after the collision.



Initially: $P_x = 0.05(20) = 1 kg\text{-}m/s, \ P_y = 0$

Finally: $Py = .10v_2 \sin 37° - .05v_1 \sin 53°$

$P_x = 1 = 0.10v_2 \cos 37° + 0.05v_1 \cos 53°$

Solve for $v_1 = 12\ m/s, \ v_2 = 8\ m/s$

   b) Determine the amount of energy that was lost in the collision.

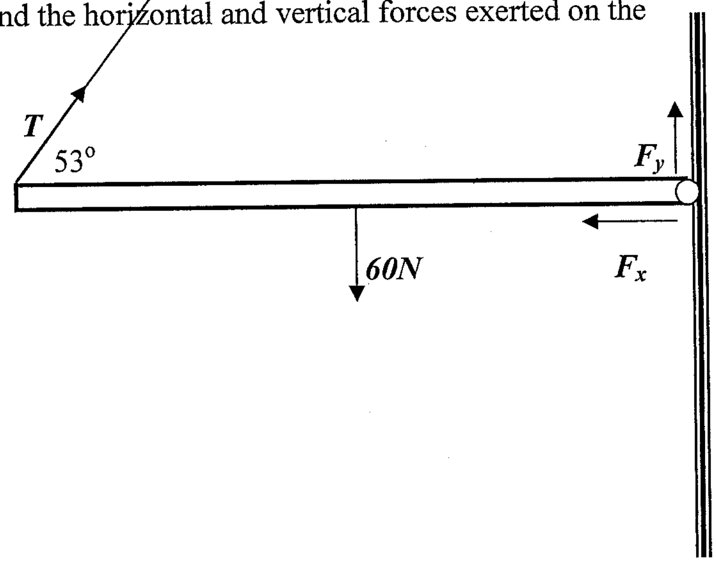
$K_i = .05(20)^2/2 = 10J$

$K_f = .05(12)^2/2 + .10(8)^2/2 = 6.8J$

$10 - 6.8 = 3.2J$ ***lost***

3. A uniform beam of length 1.50 meter and mass 6.00 kilograms is hinged at a wall and held in a horizontal position by a cord that makes an angle of 53.0° to the horizontal.

a) Determine the tension in the wire and the horizontal and vertical forces exerted on the beam by the hinge.



$60(.75) - T(1.5)(\sin 53^o) = 0$

$T = 37.5\ N$

$F_x = T\cos 53^o = 22.5\ N$

$F_y + T\sin 53^o - 60 = 0$

$F_y = 30\ N$

The cord is cut, and the bar swings downward toward the wall.

b) Determine the initial (just after the cord is cut) angular acceleration of the beam.

(*Note:* The moment of inertia of a uniform beam rotating about an axis on one end is $I = ML^2/3$)

$\tau = 60(.75) = 45$

$I = 6(1.5)^2/3 = 4.5$

$\alpha = \tau/I = 10/sec^2$

c) Determine the angular velocity of the bar just before it hits the wall.

$U_i = K_f$

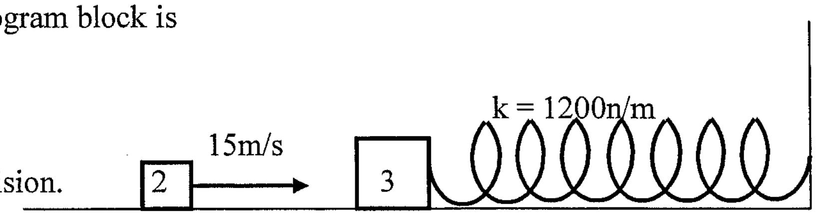
$Mgh = I\omega^2/2$

$60(.75) = 4.5\omega^2/2$

$\omega^2 = 20, \quad \omega = 4.5/sec$

4. A block of mass 3.0 kilograms is at rest on a horizontal frictionless surface. A spring with an elastic constant (k) of 1200 newtons per meter connects the mass to a wall. A second mass of 2.0 kilograms, moving with a velocity of 15 meters per second, makes a head-on collision with the 3-kilogram block. After the collision the 2.0-kilogram block is at rest.

a) Determine the velocity of the 3-kilogram block immediately after the collision.



$P_i = P_f$

$2(15) = 3v$

$v = 10 m/s$

b) Determine the amount of energy that was lost in the collision.

$K_i = 2(15)^2/2 = 225J$

$K_f = 3(10)^2/2 = 150K$

Lost $= 75J$

After the collision the 3-kilogram block compresses the spring, stops, and returns to its original position, where a second collision occurs.

c) Determine the maximum compression of the spring.

K_i ***(<u>after collision</u>)*** $= 150J$

$U_f = kx^2/2 = 600x^2$

$K_i = U_f$

$x = .50\ m$

1. A ball is thrown directly upward from the edge of a 25 meter high building with an initial velocity of 20 meters per second. On the way down the ball misses the edge of the building and falls to the ground.

   a) Determine the maximum height (above the ground) reached by the ball.

   $y = y_o + (v^2 - v_o^2)/2a$

   $y = 25 + (0 - 20^2)/2(-10) = 45\ m$

   b) Determine the velocity of the ball when it hits the ground.

   $v^2 = v_o^2 + 2a(y - y_o)$

   $v^2 = 20^2 + 2(-10)(0 - 25) = 900$

   $v = -30\ m/s$

   c) Determine the total time the ball is in the air.

   $t = (v - v_o)/a$

   $t = (-30-20)/(-10) = 5\ sec.$

   A second ball, dropped from the edge of the building a short time later, hits the ground at the same instant as the first ball.

   d) Determine how much time elapsed between the throwing of the first ball and the dropping of the second ball.

   t_2 = *time for second ball*

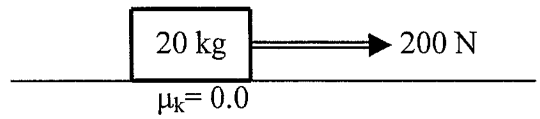
   $y = y_o + v_o t_2 + a t_2^2/2$

   $0 = 25 + (0)t_2 + (-10)t_2^2/2$: $\quad t_2^2 = 5$: $\quad t_2 = 2.24\ sec$: $\quad \Delta t = 2.76\ sec$

2. A block of mass 20 kilograms rests on a horizontal surface. A force F accelerates the block. In each case below determine the acceleration of the block.

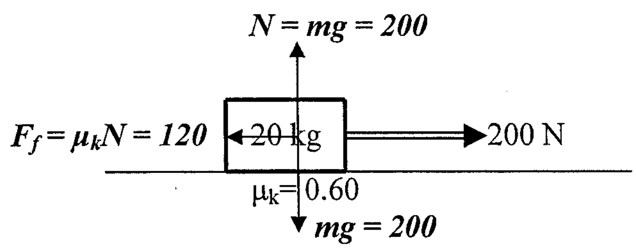
a) The surface is frictionless and the force is 200 Newtons and horizontal.

$a = 10\ m/s^2$



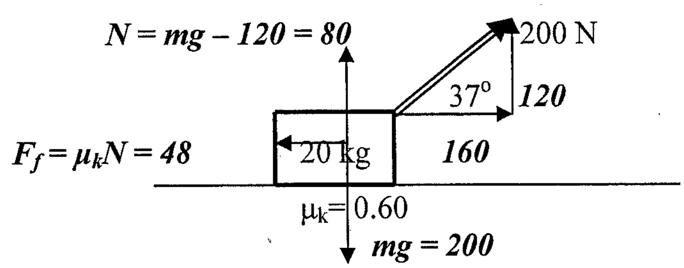
b) The coefficient of kinetic friction (μ_k) between the surface and the block is 0.60. The force is 200 Newtons and horizontal.

$a = (200\text{-}120)/20 = 4\ m/s^2$



c) The coefficient of kinetic friction (μ_k) between the surface and the block is 0.60. The force is 200 Newtons and makes an angle of 37° to the horizontal.

a = *$(160\text{-}48)/20 = 5.6\ m/s^2$*

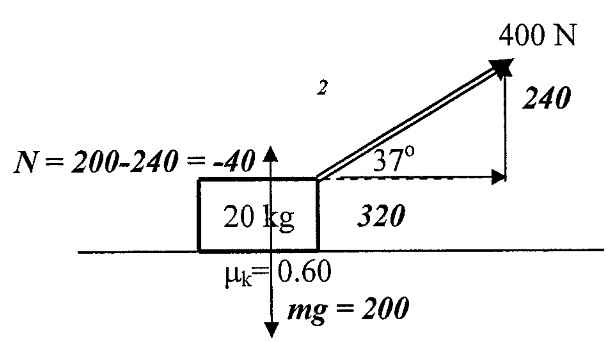


d) The coefficient of kinetic friction (μ_k) between the surface and the block is 0.60. The force is 400 Newtons and makes an angle of 37° to the horizontal.

N cannot be negative: No friction:

Flies into air!

$a_x = 320/20 = 16\ m/s^2$, $a_y = (240\text{-}200)20 = 2 m/s^2$



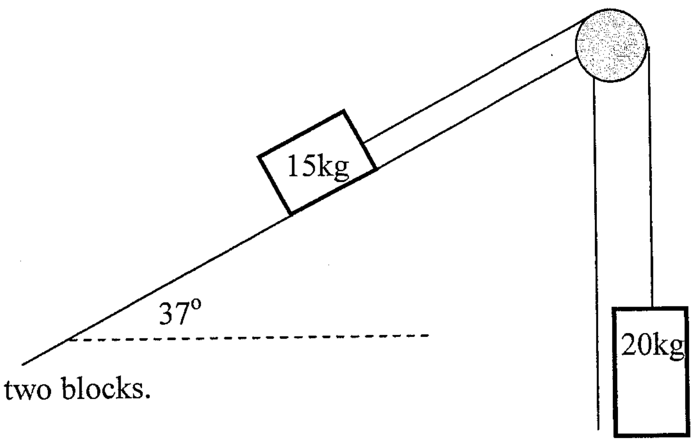
3. A block of mass 15 kilograms slides on an inclined plane that makes an angle of 37° with the horizontal. A cord passes from this block over a massless and frictionless pulley to a second block of mass 20 kilograms. When the system is released the first block moves up along the plane with an acceleration of 2.0 m/s². *NOTE*: Do not assume the plane is frictionless.

a) Determine the velocity of the first block after it has moved a distance of 3.0 meters along the plane.

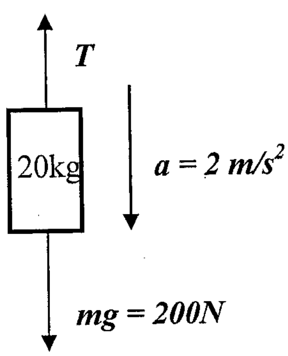
$v^2 = v_o^2 + 2a(x-x_o)$

$= 0 + 2(2)3 = 12$

$v = 3.46\ m/s$



b) Determine the tension in the cord joining the two blocks.



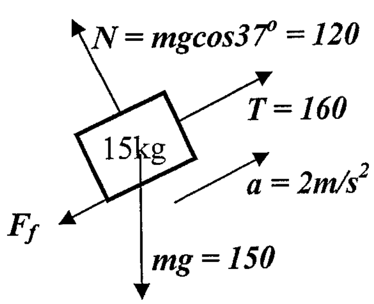
$mg - T = ma$

$T = mg - ma$

$= 200 - 2(20)$

$= 160\ N$

c) Determine the coefficient of kinetic friction (μ_k) between the first block and the plane.



$F_f = \mu_k N = 120\ \mu_k$

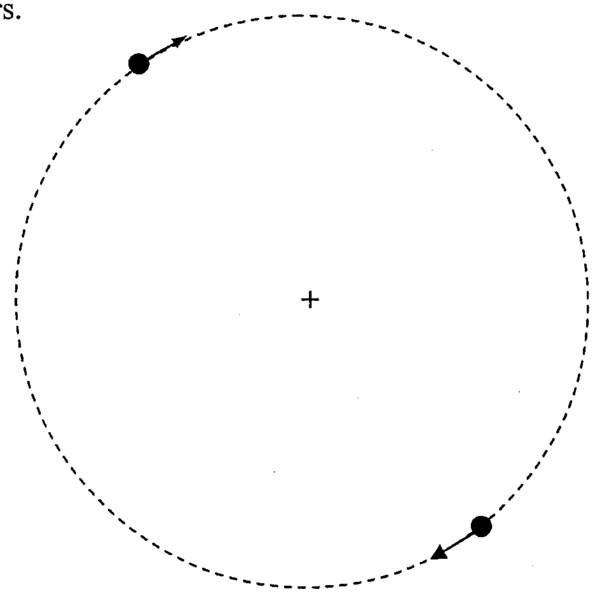
$T - mgsin37^o - F_f = ma$

$160 - 150(.6) - 120\ \mu_k = 15(2)$

$= (160 - 90 - 30)/120 = 0.33$

4. A symmetric double star consists of two stars of equal mass in circular orbits about a point midway between them. Consider a double-star system with two stars each of mass of 1.0×20^{30} kg (about the mass of our own sun) separated by a distance of 3.0×10^{11} meters.

a) Determine the attractive force between the two stars.



$F = GM_1M_2/R^2$; with $R = 3.0x10^{11}$

$= 6.67x10^{-11}x(2.0x10^{30})^2/(3.0x10^{11})^2$

$= 2.96x10^{27}$ ***Newtons***

b) Determine the velocity of each star.

$F = Mv^2/r$; with $r = 1.5x10^{11}$ ***meters***

$2.96x10^{27} = 2x10^{30}\ v^2/1.5x10^{11} =$

$v^2 = 2.22x10^8$

$v = 1.49x10^4$ ***m/s***

c) Determine the time it would take for each star make a complete circle around the point midway between them.

$T = 2\pi r/v$

$= 2\pi \times 1.5x10^{11}/1.49x10^4$

$= 6.33x10^7$ ***seconds*** ***(about 2 years)***

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14 2-3
16 3
18 3-4

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