Physics 9, Fall 2018, Homework #1.

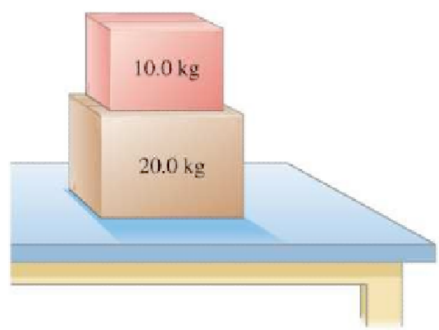
Due at start of class on Friday, September 14, 2018

Problems marked with (*) must include your own drawing or graph representing the problem and at least one complete sentence describing your reasoning.

One thing to keep in mind throughout this course is **significant digits.** If (for example) all of the inputs to your calculation are given to only three significant digits (e.g. 3.14, 22.1, 0.834), then your answer should not be reported to more than three or four significant digits. Reporting an answer like 2.71828 (6 significant digits) implies a precision of 0.0004%, which would not make sense if your calculation used inputs that were known to only 0.1% (implied by e.g. 9.99) or maybe 1% (implied by e.g. 1.01). You'll generally want to keep extra digits for intermediate results, then round your final answer to the appropriate precision. I'm not very fussy about significant digits — I just want you to be in the habit of thinking about whether the number of digits that you write down in your final answers makes sense for the given information.

Problems for Giancoli Chapter 4 (Newton's laws)

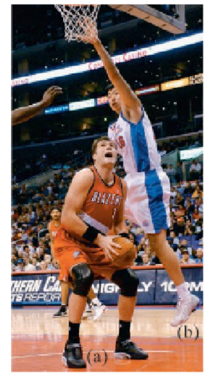
1. A 20.0 kg box rests on a table, and a 10.0 kg box rests on top of the 20.0 kg box. (a) Name all three forces acting on the 20.0 kg box and write their magnitudes and directions. (b) Draw a free-body diagram for the 20.0 kg box. (c) Name the two forces acting on the 10.0 kg box and write their magnitudes and directions. (d) Draw a free-body diagram for the 10.0 kg box.



2. A 12.0 kg bucket is lowered vertically by a rope in which there is 163 N of tension at a given instant. (a) Draw a free-body diagram for the bucket, showing all forces acting on the bucket. (b) What is the acceleration of the bucket? Is it upward or downward?

3. (a) A person stands on a bathroom scale in a motionless elevator. Draw a free-body diagram for the person. (b) When the elevator first begins to move, the scale briefly (just for an instant) reads only 0.75 of the person's regular weight. Draw a free-body diagram for the person during this instant. (c) Calculate the magnitude and the direction of the acceleration of the elevator (which is the same as the acceleration of the person) for part (b).

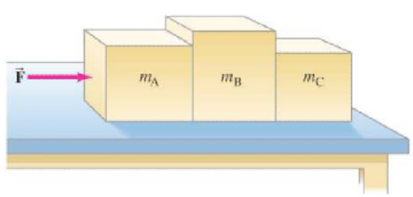
4. (a) Draw the free-body diagram for a basketball player (a) the instant before she or he leaves the ground on a jump, and (b) while the player is in the air. Note: for part (a), the player's feet are still on the ground, but the player's center of mass is accelerating upward.



5. Sketch the free-body diagram of a baseball (a) at the instant it is hit by the bat, and again (b) after it has left the bat and is flying toward the outfield. Ignore air resistance.

6*. One 3.85 kg paint bucket is hanging by a massless rope from another 3.85 kg paint bucket, also hanging by a massless rope. (a) If the buckets are at rest, what is the tension in each rope? (The tension in the top rope equals the upward force exerted by the top rope on the top bucket. The tension in the bottom rope equals the downward force exerted by the bottom rope on the top bucket, which also equals the upward force exerted by the bottom rope on the bottom bucket.) (b) If the top of the upper rope is pulled upward such that each bucket accelerates upward at 1.96 m/s^2, calculate the tension in each rope.

7*. Three blocks on a **frictionless** horizontal surface are in contact with each other, as shown below. A force $\vec{F}$ = 90.0 N (pointing to the right) is applied to block A (mass m_A). The blocks' masses are $m_A = m_B = m_C = 10.0$ kg. (a) Draw three free-body diagrams: one for each block. (In this problem, just focus on the horizontal forces, since the two vertical forces on each block will sum to zero.) (b) Find the acceleration of the three-block system. (c) Find the net force (magnitude and direction) acting on each block. (d) What are the magnitudes and directions of the two horizontal forces acting on block A? (e) What are the magnitudes and directions of the two horizontal forces acting on block B? (f) What are the magnitude and direction of the one horizontal force acting on block C?



Problems for Giancoli Chapter 11 (Vibrations and waves)

8. A spring hangs from the ceiling with relaxed length 1.00 m. When I suspend a 1.00 kg mass from the spring, the spring stretches to a total length of 1.10 m. (a) What is the spring constant k of the spring? (The units should be newtons per meter.) (b) If I pull the mass down a bit (stretching the spring a bit more) and release it, what will the period of oscillations be? (The units should be seconds.)

9. I give my cousin a push (just one push) so that she begins to swing on a playground swingset. The lightweight chains supporting the seat are 3.0 m long, and my cousin's center of mass is very close to the seat. (a) At what frequency (in Hz, or cycles per second) does she swing back and forth? (b) Does the frequency depend on how much she weighs? (c) Does the frequency depend on how hard I push (within reason)?

10*. While on a sailboat at anchor, you notice that 12 waves pass its bow every 60 seconds. (a) If the waves have a speed of 6.0 m/s, what is the distance between two adjacent wave crests? (b) In this problem, what is the frequency, f, of the waves? (c) What is the wave velocity, v? (d) What is the wavelength, λ?

One problem for PTFP Chapter 3 (Gravity, etc.)

11. By setting the gravitational force GmM_E/r^2 equal to the centripetal force mv^2/r, show (as we did in class on September 5) that a geostationary orbit is about 6.6 Earth radii away from Earth's center (i.e. it is about 5.6 Earth radii from Earth's surface, above the equator). You need to know Newton's universal gravitational constant $G = 6.67 \times 10^{-11}\,\mathrm{Nm^2/kg^2}$, that Earth's mass is $M_E \approx 6.0 \times 10^{24}\,\mathrm{kg}$, and that Earth's radius is $R_E \approx 6.4 \times 10^6\,\mathrm{m}$. So the desired result is that $r \approx 6.6 R_E$, for the orbit radius r whose circumference is traversed once per day ($24 \times 60 \times 60$ seconds).

Remember **online response** at `positron.hep.upenn.edu/wja/jitt/?date=2018-09-14`