Your Name: ______________________________

Teammates: ____

Physics 8, Fall 2023, Worksheet #3.

`http://positron.hep.upenn.edu/p8/files/ws03.pdf`

Upload PDF (smartphone scan or tablet edit) to Canvas by end of day on Mon, Sep 11, 2023.

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

Discuss each problem with your teammates (usually groups of 3), then write up your own solution. Be sure to compare final results with your teammates, as a way to catch mistakes. It can also be very interesting when you and a teammate use different methods to arrive at a result. Do not hesitate to ask for help from other students or from the instructors — but don't just copy down other people's results!

1*. At the unused tables (9, 10), we have placed several copies of today's hands-on activity. The materials are a rubber "super" ball, an orange/white striped meter stick, and a vise to hold the meter stick upright. From roughly a meter above the table, release the ball from rest, let it bounce twice, and catch it some time after its second bounce. (I usually like to catch it near its peak height.) If possible, to aid your graphing, use one teammate's smartphone to film a slow-motion video, with the orange/white striped meter stick in the background. Sketch a graph of $x(t)$, of $v_x(t)$, and of $a_x(t)$. Ask us or your neighbors for help or advice where needed, and compare with your neighbors' results! Expressing and labeling key features in a clear way is more important than drawing a perfect graph.

Optional: If you have extra time, try uploading your video to the "video analysis" web app `https://www.physics.upenn.edu/undergraduate/undergraduate-physics-labs/loggerpro` and use Video Analysis to analyze your slo-mo video. If you do this, either show or email the results to Bill (`ashmansk@hep.upenn.edu`) for **extra credit**.

2. (§3.5) You start your car from rest and accelerate at a constant rate, heading east (toward the Jersey Shore). Your speed is $26.8\,\mathrm{m/s}$ after $23.5\,\mathrm{s}$. (a) What is your acceleration? (State both magnitude and direction.) (b) How far do you travel during these $23.5\,\mathrm{s}$?

3. (§3.6) An astronaut finds herself on the planet Mars, whose acceleration due to gravity she wishes to verify. To find this acceleration, she drops a rock, which falls $2.55\,\mathrm{m}$ in $1.17\,\mathrm{s}$. What is the magnitude of acceleration due to gravity, as determined by this astronaut?

4. (§3.6) With what minimum speed must a ball be thrown straight up in order to reach a height of 13.5 m above the launch position? How many seconds does the ball take to reach this height? (Neglect air resistance.)

5*. (§3.6) On a top-secret mission, an espionage agent prepares to drop a flash-memory stick from a bridge railing 33.8 m to the deck of a speedboat approaching on the river. Channel markers are spaced regularly along the river (with one of them just below the drop position), and the boat is passing them at the rate of 1 marker every 0.875 s. How many markers away should the boat be when the agent drops the film?

6*. (§3.7) A woman steps outside one winter day to go to work. Her icy driveway is 13.5 m long from top to mailbox, and it slopes downward at 6.0° from the horizontal. She sets her briefcase on the ice at the top while opening the garage, and it slides down the driveway. (a) What is its acceleration? (b) How many seconds does it take to get halfway to the mailbox? (c) How many seconds (after setting it down) until it reaches the mailbox? (d) What is its speed at the instant it reaches the mailbox?

XC7* (optional/XC). A piece of roof ballast (stone) that falls (effectively, is released from rest) from the top of a building travels 12.8 m in the last second before it hits the ground. How high is the building? (This is **very** tricky, but we discussed it at length in the video lecture.) By the way, describing a projectile as stone (vs hollow plastic, for example) is one way to imply that air resistance is likely to be negligible in comparison to gravity.

XC8* **(way beyond optional/XC!)**: if you do this, email it to me directly. Assuming that air drag is a force (a term not yet used in this course) proportional to v^2, use dimensional analysis to argue that the force of air drag is proportional to $R^n \rho_{\rm air}\, v^2$, where R is the size (radius) of the projectile, and find the required (integer) value of the exponent n. Then express the ratio of the drag force to the gravitational force in terms of the size (R) and density of the projectile and the density of air. Use this ratio to explain why air drag tends to be negligible (compared with gravity) for objects that are large and dense and not too fast, but is not negligible for objects that are small or whose density is low or which are moving very quickly. This problem will only make sense if you have studied physics before — I was inspired to write it up after re-reading XC7 above and asking myself under what circumstances we expect air resistance to be negligible. Feel free to revisit this XC problem after we've studied forces a few weeks from now.

***** Please check in with one of the instructors before you leave, so that we can give you some quick feedback on your work and get your impressions of the appropriateness of today's assignment. *****