Oberlin College Physics 103, Fall 2023

Sample Final Exam

Wednesday, 6 December

There will be a 2-hour final exam on Tuesday, 19 December, from 2:00 to 4:00 pm. I recommend that you write in your own words a one-page summary (use both sides) of the most important and most difficult-to-remember equations, principles, and ideas, and bring it to this exam. This is the only written material you may consult while taking the exam. Calculators are permitted, collaboration is not.

The exam will have eight problems: four will deal with the topics touched on in the first two hour-exams (motion in one- and two-dimensions, particularly motion with constant acceleration; vectors; force and Newton's laws; work; kinetic and potential energy; impulse and momentum; collisions; projectile motion) the other four deal with the topics we've treated since (rotation, including angular acceleration, moment of inertia, angular momentum; gravity; fluids; oscillations; waves; measuring the speed of sound and the index of refraction).

Sample exam:

1. A rolling 31 ton railroad boxcar collides with a stationary flatcar. The coupling mechanism activates so the cars latch together and roll down the track attached. Of the initial kinetic energy, 38% dissipates as heat, sound, vibrations, mechanical deformation, and so forth. How much does the flatcar weigh? (*Answer:* 19 tons.)

2. A tortoise lumbers north on Professor Street at speed v. A hare hopping across Professor Street glances up to notice the tortoise a distance d to the north. The hare bounds after the tortoise with acceleration a, while the tortoise continues lumbering north at speed v. How much time is required for the hare to catch up with the tortoise? (*Answer:* $(v + \sqrt{v^2 + 2ad})/a$.)

3. A block of wood rests on a sheet of sandpaper glued to a horizontal tabletop. I push the block with a force of 3.74 newtons, and it moves 45.7 cm, but because of the sandpaper the block stops moving the instant I stop pushing it. How much work was done by friction between the sandpaper and the block? (*Answer:* -1.71 J. Note the negative sign and the three significant figures, both required for full credit.)

4. A ball dropped from ten meters requires 1.2 seconds to reach the ground. The same ball dropped from twenty meters requires: (a) 2.4 seconds; (b) between 1.2 seconds and 2.4 seconds; (c) more than 2.4 seconds. Justify your choice briefly but cogently.
(*Answer:* (b), because it travels faster during the second half of the fall than during the first half.)

5. A uniform disk of mass M and radius R rotates with angular velocity ω_0 about a central axis perpendicular to the disk. A break is applied that removes kinetic energy at uniform rate b. (The units of b would be joules/second.) How much time elapses before the disk stops? (*Answer:* $MR^2\omega_0^2/(4b)$.)

6. I hope you remember the in-class demonstration we did with a glider on an airtrack between two springs that executed simple harmonic oscillation. In experiment (a) the glider is displaced by 7.3 cm from its equlibrium position and then released from rest. Experiment (b) is exactly the same except that the initial displacement is twice as much. What is the ratio of the energy in experiment (b) to that of experiment (a)? (*Answer:* With initial displacement x the energy is $\frac{1}{2}kx^2$, so the answer is 4.)

7. Two identical loudspeakers, separated by distance 3.38 m, emit the same tone. You stand 1.69 m in front of one of the loudspeakers. What is the lowest frequency that results in complete destructive interference? Take the speed of sound in air to be 343 m/s. (*Answer:* 82.1 Hz.)

8. Maple syrup has a density of 1.33 g/cm^3, ice has a density of 0.917 g/cm^3. When an ice cube floats in maple syrup, what percentage of the volume of the cube is below the syrup surface? (*Answer:* 68.9%)