Physics 110

Assorted Practice Problems for Final Exam

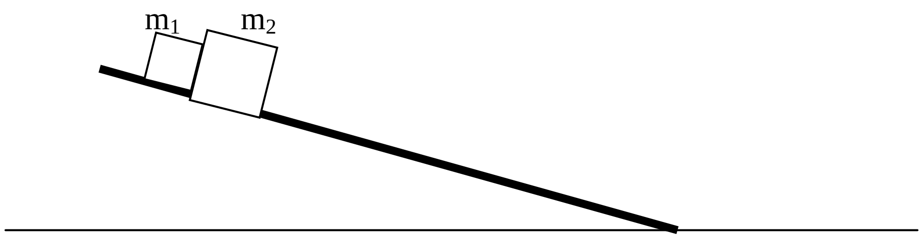
1. An 80 kg novice skydiver is flying in a plane at an altitude of 3000 meters. Reluctant to jump on his own, he is pushed out of the plane by the skydiving instructor, and screams at a constant 440 Hz all the way down.
a) His parachute opens automatically after 10 seconds. What is his vertical speed when the chute opens?
b) How far has he fallen when the chute opens?
c) The opening of the parachute cuts his velocity in half. He falls an additional 150 meters while the parachute is slowing him down. What is his average acceleration during this time? What average force is exerted by the parachute during this time?

2. A 0.01 kg bullet is fired at 350 m/s into a 2 kg pendulum, lodges in the bob and sets it swinging.
a) Is this collision elastic or inelastic?
b) What is the velocity of the pendulum bob after the collision?
c) What maximum height does the bob rise to?
d) How much energy is lost to heat in the collision?

3. A 200 kg playground merry-go-round with a 2 m radius is subject to a frictional torque of 40 N-m.
a) If the merry-go-round goes round with a linear velocity of 6 m/s on the outside edge, what is the angular velocity?
b) What force must be applied by one of a child's parents pushing on the outside edge to keep the merry-go-round moving at a constant angular velocity ($I=1/2\ MR^2$ for this system)
c) When the parent gets tired and lets go, how long does the merry-go-round take to stop?
d) At a point when the merry-go-round has lost half its initial angular velocity, how much energy has been lost to frictional heating of the system?

4. A scientist playing with musical instruments has a 1 m long guitar string with total mass 0.010 kg hooked up to a mechanical oscillator.
a) If the string oscillates in the second harmonic with $f_2 = 330$ Hz, what is the tension in the string?
b) If the scientist doubled the oscillation frequency, how many oscillating lobes would there be?
c) Also in the laboratory is a pipe, open at both ends, which the scientist wants to have resonate in the fundamental mode at the same 330 Hz from part (a). How long should this pipe be?
d) The pipe in part c) is slightly too long, such that the beat note between the fundamental mode of the pipe and the 330 Hz from part a) is 5 Hz. How much should it be shortened to reach the resonance sought in part c)?
e) A second pipe in the laboratory has resonances at 330 Hz, 550 Hz, and 770 Hz. Is this pipe open or closed?

5. Two small blocks, of masses $m_1 = 0.1$ kg and $m_2 = 0.3$ kg, initially at rest and touching one another, slide down a frictionless plane that makes an angle of 15 degrees with the horizontal. The top of the plane is 0.5 m above the horizontal.



a) Draw a free-body diagram for each block
b) Clearly find the acceleration of each block. Are they still touching when they reach the horizontal?
c) From your results, find the speed of block 1 when it reaches the horizontal.
d) Use "energy considerations" to get the same results as you obtained in part c).

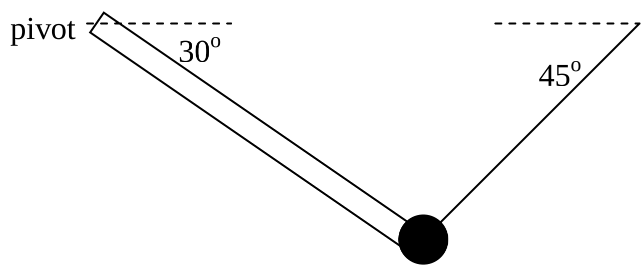
Assume that both blocks are touching when they are on the horizontal. A person now exerts a force of 6 N on block 1 of the two touching block system.
e) What is the acceleration of the block system?
f) Find the force that block 1 exerts on block 2. What is the force that block 2 exerts on block 1?

6. A horizontal spring, with constant $k = 50$ N/m, is compressed from equilibrium by a force which does 9 joules of work.
a) What is the amplitude of the compression?
A mass of 0.6 kg is now attached to the spring and the spring-mass system released from rest (the mass remains attached to the spring).
b) What is the speed of the mass when it reaches the equilibrium position?
c) What is the frequency of the subsequent periodic motion?
d) At what value of x ($x = 0$ at equilibrium) is the speed of the mass equal to half of its maximum speed?
If the same spring mass system was forced to undergo simple harmonic motion with twice the amplitude
e) Now, what are the answers to parts (b), (c), and (d)?

7. A fountain shoots a stream of water vertically upward. Assume that the stream is inclined very slightly to one side so that the descending water does not interfere with the ascending water. The upward velocity at the base of the column of water is 15 m/s.
a) How high will the water rise?
b) The diameter of the column of water is 7.0 cm at the base. What is the diameter at the height of 10 m?

8. A drummer begins to drum on iron railway tracks with a regular beat. You are nearby with your ear near the tracks and hear two sets of drumming, one starting 0.8 s after the other. (The speed of sound in air is 345 m/s and in iron is 5000 m/s.)
a) How far away are you from the drummer?
b) If the delayed sounds are 5 dB less intense than the first set of drumming heard, find the ratio of the intensities of the two sounds.

9. A 2 kg ball is attached to the end of a 1.5 m long very light rigid pole free to pivot without friction about a horizontal axis at the other end, as shown. The ball is initially supported by the light cord shown in the figure.



a) Draw a carefully labeled free-body diagram for the ball and write the equations that describe the translational equilibrium of the ball (Do not solve)
b) Write an equation for the torque about the pivot point and use it to solve for the tension in the cord.
c) If the cord were cut, find the initial angular acceleration of the ball.
d) After being released from rest when the cord is cut in part c), find the angular velocity of the ball at its lowest point (Hint: the angular acceleration is not a constant – use energy ideas)