Student #: _____ Student Name: _____

Physics 12 Homework Unit 2: Momentum & Energy

(Plus some questions from Unit 1)

1. Can an object ever be accelerating and experiencing an instantaneous velocity of $0\,\mathrm{m/s}$? Explain, or give an example.

2. In a game of egg-toss, you and a partner are throwing an egg back and forth trying not to break it. Given your vast knowledge of momentum, what hint(s) could you give to your partner to keep the force of impact on the egg as low as possible? Clearly explain your answer.

3. Does the situation depicted below defy the law of conservation of momentum? Explain.

4. A boy does $465\,\mathrm{J}$ of work pulling an empty wagon along level ground with a force of $111\,\mathrm{N}$ at 31° below horizontal. A frictional force of $155\,\mathrm{N}$ opposes the motion and is actually slowing the wagon down from an initial high velocity. The distance the wagon travels is:

5. A $20.0\,\text{kg}$ curling stone travels $30.0\,\text{m}$ along the ice surface. Assuming that all the work done by friction is converted to heat. If the frictional force is $10.0\,\text{N}$, the thermal energy produced is:

6. A spring with a force constant of $167\,\text{N/m}$ is compressed $1.0\,\text{cm}$. The work done on the spring is:

7. A sledgehammer strikes a spike with an average force of $2125\,\text{N}$ [down] over a time interval of $0.0205\,\text{s}$. The impulse of the interaction is:

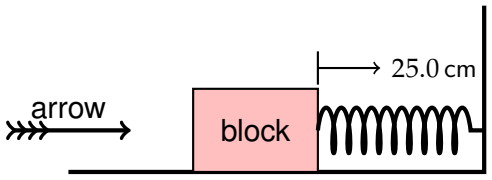
8. A spring hanging from the ceiling of a house has a spring constant of $15.3\,\text{N/m}$ and a maximum extension of $1.2\,\text{cm}$. What is the largest mass that can be placed on the spring without damaging it?

9. In a crash test, a car strikes a wall with an average force of $1.23 \times 10^7\,\text{N}$ [S] over an interval of $21.0\,\text{ms}$. Calculate the impulse.

10. In a crash test similar to the one described in the last problem, another car, with the same mass and velocity as the first car, experiences an impulse identical to the value you calculated in the last problem. However, the second car is designed to crumple more slowly than the first. As a result, the duration of the crash is $57.1\,\text{ms}$. Determine the average force exerted on the second car.

11. A $1.0\,\text{kg}$ red "super ball" moving at $5.0\,\text{m/s}$ collides head-on with stationary blue super ball of mass $4.0\,\text{kg}$ in an elastic collision. What are the final velocities of the two super balls after the collision?

12. A $0.500\,\text{kg}$ block is sits on a horizontal, friction-less surface. The block is connected to a horizontal spring with a spring constant of $124\,\text{N/m}$. The other end of the spring rests against a wall. When a $100.0\,\text{g}$ arrow is fired into the wooden block (where it becomes embedded), the spring compresses by $25.0\,\text{cm}$. (see diagram)



(a) What is the *maximum* potential energy stored in the spring?

(b) What is the kinetic energy of the arrow and block just after the collision?

(c) What is the speed of the arrow and block just after collision?

(d) What is the initial kinetic energy of the arrow?

(e) Explain any difference between (a) and (d). Is the collision elastic?

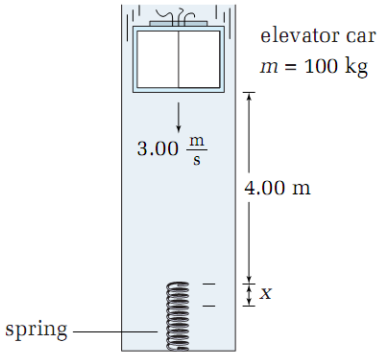
13. A $1385\,\text{kg}$ cannon containing a $58.5\,\text{kg}$ cannon ball is on wheels. The cannon fires the cannon ball, giving it a velocity of $49.8\,\text{m/s}$ [N]. What is the initial velocity of the cannon the instant after it fires the cannon ball?

14. Two amusement park bumper cars are heading directly towards each other. The combined mass of car A plus driver is $375\,\text{kg}$ and it is moving with a velocity of $1.8\,\text{m/s}$. The combined mass of car B plus driver is $422\,\text{kg}$ and it is moving with a velocity of $-1.4\,\text{m/s}$. When they collide, they become stuck together and continue moving along the same straight line. What is their velocity immediately after they collide?

15. A $1875\,\text{kg}$ car is travelling along a country road when the driver sees a deer dart out onto the road. The driver slams on the brakes and manages to stop before hitting the deer. The driver of a second car (mass $2135\,\text{kg}$) is driving too close. When the driver realizes that the car ahead has stopped, he hits the brakes but is unable to stop. The two cars lock together and skid another $4.58\,\text{m}$ along a straight line before coming to a stop. If the coefficient of friction between concrete and rubber is 0.750, what is the speed of the second car when it hits the stopped car?

16. While playing a game of billiards, your $0.17\,\text{kg}$ cue ball, travelling at $1.9\,\text{m/s}$, glances off a stationary $0.16\,\text{kg}$ "eight ball" so that the eight ball moves off at $1.3\,\text{m/s}$ at an angle of 32° clockwise from the cue ball's original path.
    (a) What is the final velocity (both magnitude and direction) of the cue ball?
    (b) Calculate the total kinetic energy before and after the collision. Is the collision elastic?

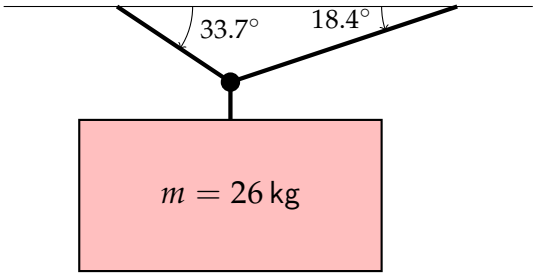
17. An empty freight elevator car with a total mass of $100.0\,\text{kg}$ is moving downward at $3.00\,\text{m/s}$ when the cable snaps. The car falls $4.00\,\text{m}$ onto a huge spring with a spring constant of $8.000 \times 10^3\,\text{N/m}$. By how much will the spring be compressed when the car reaches zero velocity? (For simplicity, assume that gravitational potential is zero at the bottom.)



18. An $80\,\text{kg}$ astronaut has become detached from the safety line connecting her to the International Space Station. She is $200\,\text{m}$ from the station, and at rest relative to it. She only has 4.0 minutes of air remaining. To get herself back, she tosses a $10\,\text{kg}$ tool kit away from the station at $8.0\,\text{m/s}$. Will she make it back in time?

19. A sharpshooter shoots a bullet horizontally over level ground with a velocity of $3.0 \times 10^2\,\text{m/s}$. At the instant that the bullet leaves the barrel, its empty shell casing falls vertically and strikes the ground with a vertical velocity of $5.00\,\text{m/s}$. (Hint: Think about what gravity does to both the bullet and the casing.)
    (a) Neglecting air friction, how far does the bullet travel?
    (b) What is the vertical component of the bullet's velocity at the instant before it hits the ground?

20. One method to increase the storage space in a very small house is to hand storage bins from the ceiling using ropes. In this example, a $26\,\text{kg}$ bin is hung from the ceiling using 2 ropes of different tension, as shown in the diagram. What is the tension in each of the ropes?



21. Large insects such as locusts can jump as far as $75\,\text{cm}$ horizontally on a level surface. An entomologist analyzed a photograph and found that the insect's launch angle was 55°. What was the insect's initial velocity?

22. Two blocks are free to slide along the friction-less wooden track shown below. The block of mass $m_1 = 4.98\,\text{kg}$ is released from the position shown, at height $h = 5.00\,\text{m}$ above the flat part of the track. Protruding from its front end is the north pole of a strong magnet, which repels the north pole of an identical magnet embedded in the back end of the block of mass $m_2 = 9.40\,\text{kg}$, initially at rest. The two blocks never touch. Calculate the maximum height to which m_1 rises after the elastic collision.