SJPO Training
Energy & Momentum Problem Set

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1 General Round

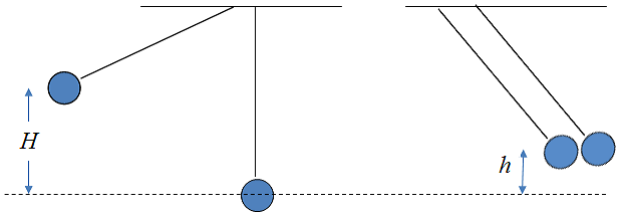
1.1 Collisions

1. A baseball is thrown vertically upward and feels no air resistance. As it is rising,
    A. both its momentum and its mechanical energy are conserved.
    B. both its momentum and kinetic energy are conserved.
    C. its kinetic energy is conserved but its momentum is not conserved.
    D. the gravitational potential energy is not conserved but its momentum is conserved.
    E. its momentum is not conserved but its mechanical energy is conserved.

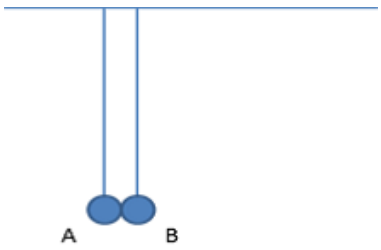
2. A large truck and a small car collided near Bukit Timah road one day and the two vehicles were stuck together. Which vehicle has undergone a larger change in momentum?
    A. The car.
    B. The truck.
    C. The momentum change was the same for both vehicles.
    D. One cannot tell which vehicle has undergone a larger momentum change without knowing the final velocity of the combined mass.
    E. One cannot tell which vehicle has undergone a larger momentum change without knowing the masses of the truck and car.

3. A fast moving small bullet of mass m hits and passes through a heavy stationary wooden block of mass M. When the bullet passes through the block,
    A. M and m experience the same impulse.
    B. The mutual force between the bullet and the wooden block will do the same amount of work.
    C. The bullet's speed will reduce by the same amount as the increase in the wooden block's speed.
    D. The bullet's momentum will reduce by the same amount as the increase in the wooden block's momentum.
    E. The bullet's temperature will increase by the same amount as the increase in the wooden block's temperature.

4. Two identical masses are hung on strings of the same length. One mass is released from a height H above its free-hanging position and strikes the second mass; the two stick together and move off. They rise to height h given by



5. In the diagram shown below, balls A and B of mass m_A and m_B respectively, hanging on strings of the same length are touching each other when they are at their equilibrium positions. Ball A is then slightly pulled to the left and released. Which of the following statements are correct after the first collision?



   A. If $m_A > m_B$, the next collision will be to the right of the equilibrium position.
   B. If $m_A < m_B$, the next collision will be to the right of the equilibrium position.
   C. The next collision will be at the equilibrium position.
   D. There is not enough information in the question to predict any of the above outcomes.

6. A soccer ball approaches a player at $v = 12\,\text{m/s}$. At what velocity v should the player's foot move in order to stop the ball upon contact? Assume that the mass of the foot is much greater than that of the ball and that the collision is elastic.

   A. $u = 12\,\text{m/s}$ in the direction opposite to the original velocity of the ball.
   B. $u = 6\,\text{m/s}$ in the direction opposite to the original velocity of the ball.
   C. $u = 6\,\text{m/s}$ in the same direction as the original velocity of the ball.
   D. $u = 0\,\text{m/s}$, i.e. he should hold his foot very still.
   E. This feat cannot be done.

7. Suppose 1.0 kg of clay travelling at speed v smashes into 1.0 kg of clay which is not moving. They stick and become one 2.0 kg lump of clay. What proportion of the kinetic energy in the originally moving lump was turned into heat and sound during the collision?

   A. 0%

   B. 25%

   C. 50%

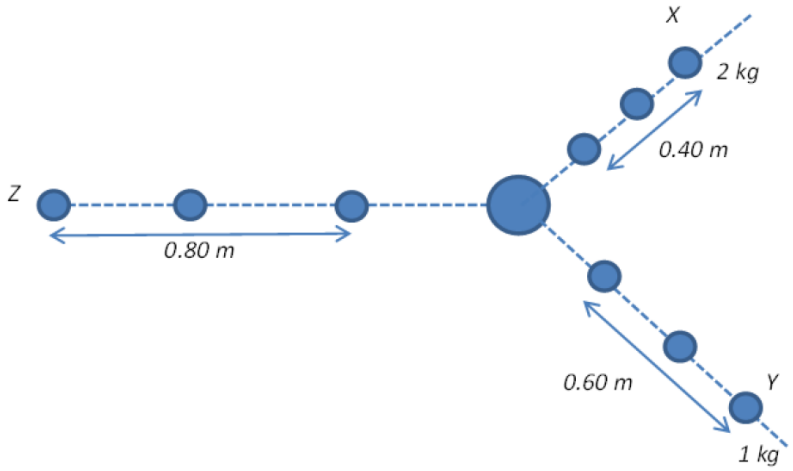
   D. 75%

   E. 100%

8. A 8.0 g bullet is shot into a 4.0 kg block, at rest on a frictionless horizontal surface. The bullet remains lodged in the block. The block moves toward a spring and compresses it by 9.4 cm. The force constant of the spring is 1000 N/m. Determine the initial speed of the bullet.

9. A man of mass m on an initially stationary boat gets off the boat by leaping to the left in an exactly horizontal direction. Immediately after the leap, the boat, of mass M, is observed (by an Earth obsever) to be moving to the right at speed v. How much work did the man do during the leap (both to his own body and on the boat)?

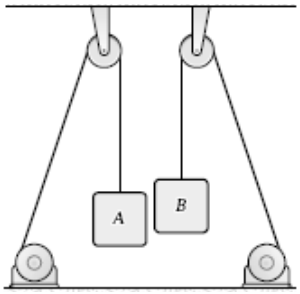
10. A body at rest explodes breaking into three pieces which move off at different velocities, all in the same horizontal plane. The following figure shows the experimental results as drawn from a stroboscopic photograph of the event. The time interval between flashes was 0.10 s. The pieces X and Y travel at right angles to each other and are collected after the explosion and their masses are found to be 2.0 kg and 1.0 kg respectively. Piece Z was unfortunately lost after the explosion. What is the mass of piece Z?



A. 1.25 kg
B. 1.50 kg
C. 2.00 kg
D. 0.85 kg
E. 3.00 kg

1.2 Work, Energy and Power

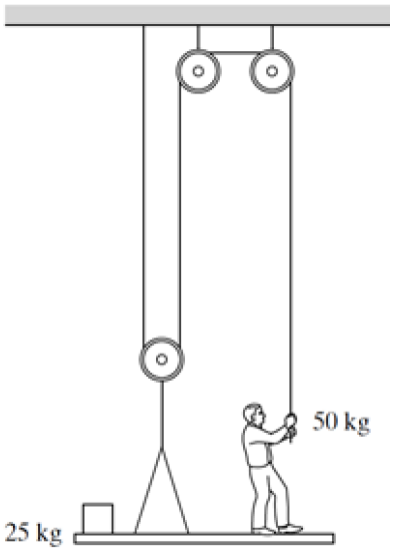
1. Two equal masses are raised at constant velocity by ropes that run over pulleys as shown. Mass B is raised twice as fast as mass A. The magnitudes of the forces are F_A and F_B, while the power supplied respectively P_A and P_B. Which of the following statement(s) is correct?



   A. $F_B = F_A$, $P_B = P_A$.
   B. $F_B = F_A$, $P_B = 2P_A$.
   C. $F_B = 2F_A$, $P_B = P_A$.
   D. $F_B = 2F_A$, $P_B = 2P_A$.
   E. $F_B = 2F_A$, $P_B = 4P_A$.

2. A tennis ball bounces on the floor three times. If each time it loses 23.0% of its energy due to heating, how high does it bounce after the third time, given that we released it 4.90 m from the floor?

3. A 50 kg person stands on a 25 kg platform. He pulls on the rope that is attached to the platform via the frictionless pulley system shown here. If he pulls the platform up at a steady rate, with how much work does the person do in order to pull the platform (and himself) up by 2.0 m? Ignore friction.



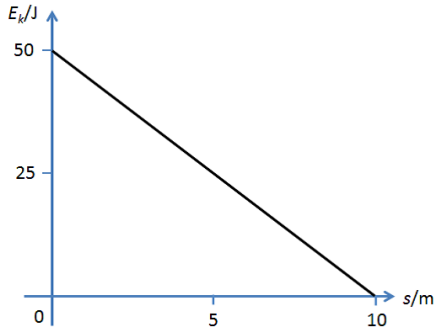
A. 1000 J
B. 750 J
C. 630 J
D. 500 J
E. 1500 J

4. The same constant force is used to accelerate two carts of the same mass on frictionless tracks. The force applied to cart A is twice as long in time as it is applied to cart B. The work the force does on A is W_A; that on B is W_B. Which statement is correct?

A. $W_A = W_B$.
B. $W_A = \sqrt{2}W_B$.
C. $W_A = 2W_B$.
D. $W_A = 4W_B$.
E. $W_B = 2W_A$.

5. A car with mass 100 t starts from rest, driven by an engine with uniform power output of 5 MW. Forty seconds later, it is 400 m from the starting point and has velocity v. If the resistance experienced by the car is always 0.1 times of the car weight, what is the value of v? Take g to be 10 m/s^2.

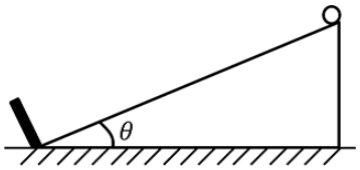
6. A 2 kg mass slides across a rough surface and its kinetic energy is plotted as a function of distance. What is the time that it took to slide across the surface?



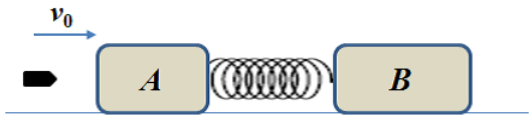
7. The magnitude of the resistive force on a cruising plane is directly proportional to v^2 where v is the plane's velocity. If the power expended by the plane is P when the plane is cruising at velocity v, what will be the power expended by the plane when the plane is cruising at velocity $2v$?

2 Special Round

1. (8 points) As shown in the figure below, a ball slides along a frictionless ramp of length L. As it reaches the bottom, it hits the board and slides up along the slope again. If the speed of the ball after the collision is 4/5 times of the speed of the ball just before the collision, find the total distance travelled by the ball when it comes to a complete stop.



2. (8 points) Two wooden blocks A and B, connected by an unstretched spring with a spring constant $k = 950\,\mathrm{N/m}$, are initially at rest on a frictionless surface. A bullet of mass $50\,\mathrm{g}$ moving horizontally with a initial speed of $v_0 = 120\,\mathrm{m/s}$ hits Block A and becomes embedded in it. The embedding takes place within a very short time. The mass of Block A is $1.2\,\mathrm{kg}$ and that of Block B is $2.0\,\mathrm{kg}$. Calculate



1. the maximum compression (Δx_{x}) of the spring.
2. the maximum and minimum speeds of Block B in its subsequent motion.