Student #: _____ Student Name: _____

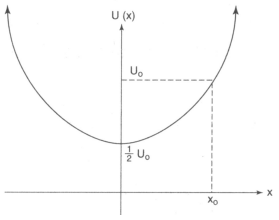
AP Physics Class 3: Momentum & Energy

Multiple-Choice Questions

1. If a projectile thrown directly upward reaches a maximum height h and spends a total time in the air of T, the average power of the gravitational force during the trajectory is
   (a) $P = 2mgh/T$
   (b) $P = -2mgh/T$
   (c) 0
   (d) $P = mgh/T$
   (e) $P = -mgh/T$

2. Given that the constant net force on an object and the object's displacement, which of the following quantities can be calculated?
   (a) the net change in the object's velocity
   (b) the net change in the object's mechanical energy
   (c) the average acceleration
   (d) the net change in the object's kinetic energy
   (e) the net change in the object's potential energy

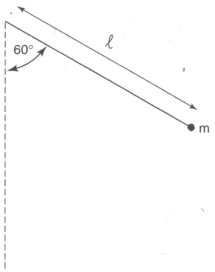
3. Consider the potential energy function shown below. Assuming that no non-conservative forces are present, if a particle of mass m is released from position x_0, what is the maximum speed it will achieve?
   (a) $\sqrt{4U_0/m}$
   (b) $\sqrt{2U_0/m}$
   (c) $\sqrt{U_0/m}$
   (d) $\sqrt{U_0/2m}$
   (e) The particle will achieve no maximum speed but instead will continue to accelerate indefinitely.



4. Which of the following is the most accurate description of the system introduced in the previous question?
   (a) stable equilibrium
   (b) unstable equilibrium
   (c) neutral equilibrium
   (d) a bound system
   (e) There is a linear restoring force

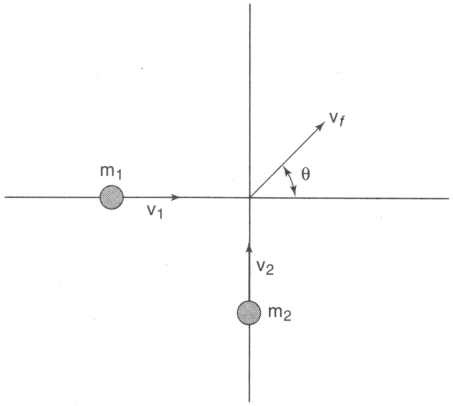
5. If the only force acting on an object is given by the equation $F(x) = 2 - 4x$ (where the force is measured in newtons and position in meters), what is the change in the object's kinetic energy as it moves from $x = 2$ to $x = 1$?
   (a) $+4$ J
   (b) -4 J
   (c) $+2$ J
   (d) -2 J
   (e) $+8$ J

6. A pendulum bob of mass m is released from rest as shown in the figure below. What is the tension in the string as the pendulum swings through the lowest point of its motion?



(a) $T = \frac{1}{2}mg$
(b) $T = mg$
(c) $T = \frac{3}{2}mg$
(d) $T = 2mg$
(e) None of the above

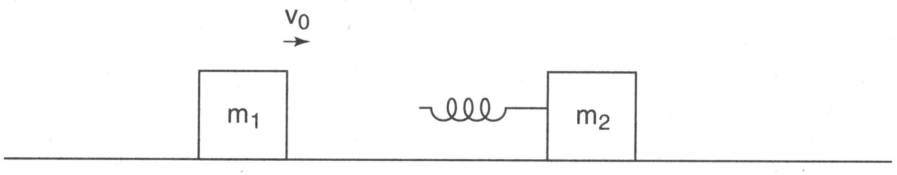
7. Two masses moving along the coordinates axes as shown collide at the origin and stick to each other. What is the angle θ that the final velocity that makes with the x-axis?



(a) $\tan^{-1}(v_2/v_1)$
(b) $\tan^{-1}[m_1v_1/(m_1+m_2)]$
(c) $\tan^{-1}(m_1v_2/m_2v_1)$
(d) $\tan^{-1}(m_2v_2^2/m_1v_1^1)$
(e) $\tan^{-1}(m_2v_2/m_1v_1)$

8. A mass traveling in the $+x$ direction collides with a mass at rest. Which of the following statements is true?
   (a) After the collision, the two masses will move with parallel velocities
   (b) After the collision, the masses will move with antiparallel velocities
   (c) After the collision, the masses will both move along the x-axis
   (d) After the collision, the y-components of the velocities of the two particles will sum to zero.
   (e) None of the above

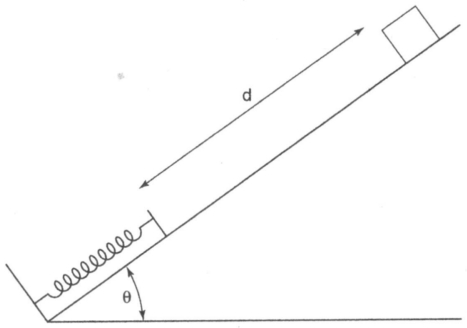
9. A mass m_1 initially moving at speed v_0 collides with and sticks to a spring attached to a second, initially stationary mass m_2. The two masses continue to move to the right on a frictionless surface as the length of the spring oscillates. At the instant that the spring is maximally extended, the velocity of the first mass is



(a) v_0
(b) $m_1^2v_0/(m_1+m_2)^2$
(c) m_2v_0/m_1
(d) m_1v_0/m_2
(e) $m_1v_0/(m_1+m_2)$

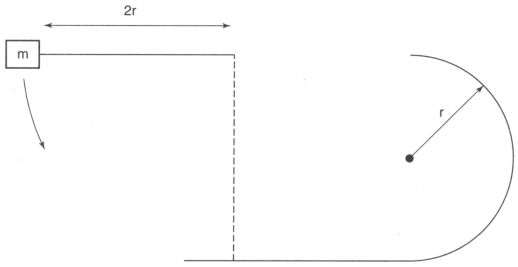
Free-Response Questions

10. A mass m is placed on an incline of angle θ at a distance d from the end of a spring as shown below. The coefficient of kinetic friction between the mass and the plane is μ.



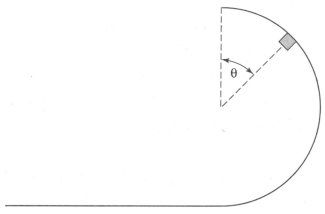
(a) The mass is released from rest at the position shown. Using Newton's laws, calculate the block's speed when it reaches the spring.
(b) Using energy conservation, calculate the block's speed when it reaches the spring.
(c) The spring has spring constant k. At what value x of the compression of the spring does the object reach its maximum speed?

11. A mass m attached to a string of length $2r$ swings, starting at rest when the string is horizontal, until the string is vertical. At the instant the string is vertical, the mass makes contact with the horizontal surface, the string is cut, and the mass continues along a frictionless track as shown below.



(a) What is the speed of the mass attached to the string the instant the string is cut?
(b) Sketch the forces acting on the mass when it is in the position shown below.

When the mass is in the position shown below,



(c) find the object's speed as a function of θ
(d) find the object's centripetal acceleration as a function of θ
(e) determine at what angle θ the mass will fall of the track

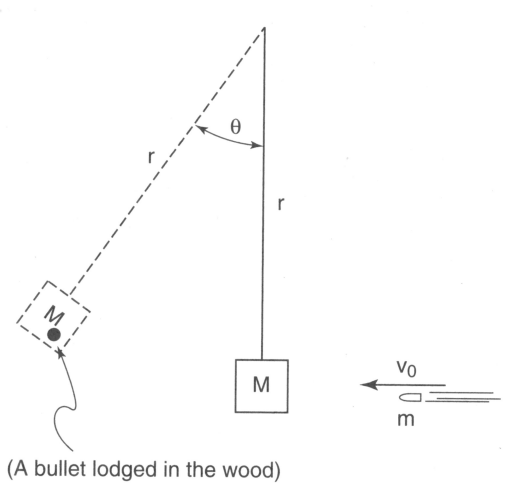
12. A projectile is fired from the edge of a cliff $100\,\mathrm{m}$ high with an initial speed of $60\,\mathrm{m/s}$ at an angle of elevation of 45°.

    (a) Write equation for $x(t)$, $y(t)$, v_x and v_y. Choose the origin of your coordinate system at the particle's original location.
    (b) Calculate the location and velocity of the particle at time $t = 5\,\mathrm{s}$.

    Suppose the projectile experiences an internal explosion at time $t = 4\,\mathrm{s}$ with an internal force purely in the y-direction, causing it to break into $2\,\mathrm{kg}$ and a $1\,\mathrm{kg}$ fragment.

    (c) If the $2\,\mathrm{kg}$ fragment is $77\,\mathrm{m}$ above the height of the cliff at $t = 5\,\mathrm{s}$, what is the y-coordinate of the position of the $1\,\mathrm{kg}$ piece?
    (d) If the speed of the $2\,\mathrm{kg}$ fragment is $46\,\mathrm{m/s}$ and the fragment is falling at $t = 5\,\mathrm{s}$, what is the y-component of the velocity of the $1\,\mathrm{kg}$ fragment?

13. The Ballastic Pendulum. To determine the muzzle speed of a gun, a bullet is shot into a mass M from a string as shown below, causing M to swing upward through a maximum angle of θ.

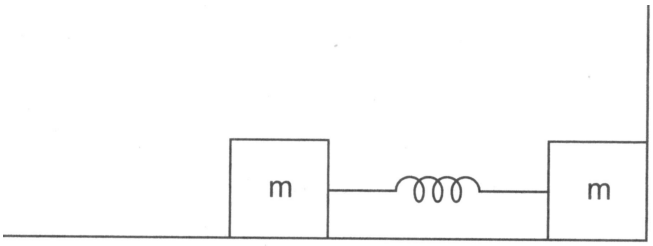


    (a) What is the speed of M the instant after the bullet lodges in it?
    (b) What is the speed of the bullet before it hits M?
    (c) What is the tension in the string at the highest point of the pendulum's swing (when the string makes an angle of θ with the vertical as shown)?

14. Two masses are connected by a spring (spring constant k) resting on a frictionless horizontal surface as shown. The right mass is initially in contact with a wall. A brief blow to the left block leaves it with an initial velocity v_0 to the right.

    (a) What is the maximum compression of the spring as the left block moves to the right?

    After the spring is maximally compressed, it eventually moves to the left, away from wall. As it moves away from the wall, it continues oscillating.



    (b) What is the net momentum of the two masses after they leave the wall?

    (c) What is the total mechanical energy of the oscillating spring system?

    (d) What is the relative velocity of the two masses when the spring is maximally compressed?

    (e) What is the maximum compression of the spring after the two masses have left the wall? Compare the compression to the maximum compression calculated in part (a) and explain any similarities and differences.