AP Physics C Name: ______________________________

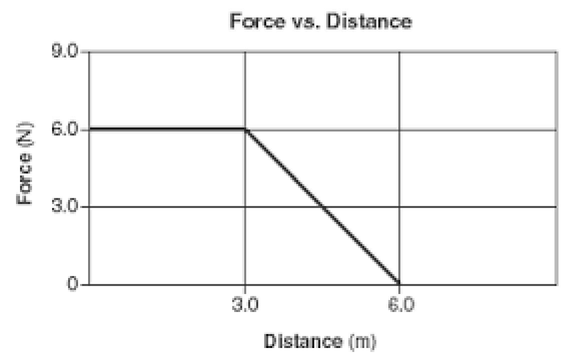
Unit 3: Work & Energy Test

Part 1: Multiple Choice - Choose the answers that best answers the questions below. If an exact answer is not present, chose the closest available answer. (4 points each)

1. A spooky scary skeleton falls from a height h from the top of Tokyo Tower with negligible air resistance. Which of the follow statements is true?

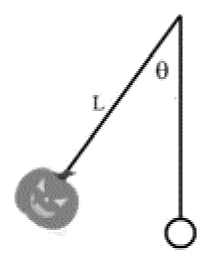
A) The potential energy of the skeleton is conserved as it falls.
B) The kinetic energy of the skeleton is conserved as it falls.
C) The difference between kinetic energy and potential is a constant.
D) The sum of the kinetic and potential energies of the skeleton is a constant.
E) The total energy of the skeleton increases as it falls since it gains speed.

2. A spooky 3.0 kg object is traveling at a velocity of 2.0 m/s when it is subjected to a force. The value of the force as function of distance traveled is given in the graph to the right. Find the speed of the object at t = 6.0 s.



A) 3.4 m/s B) 36 m/s
C) 4.2 m/s D) 27 m/s
E) 4.7 m/s

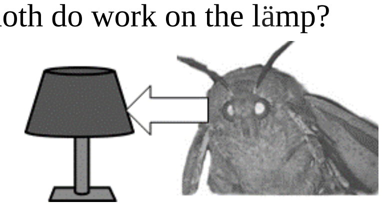
3. A spooky pendulum bob of mass m on a cord of length L is pulled sideways until the cord makes an angle θ with the vertical as shown. At that point, it is released from rest and allowed to move. Which of the following is equal to the magnitude of the maximum kinetic energy of the pendulum bob as it moves?



A) $mgL(1 + \cos\theta)$ B) $mgL(1 - \sin\theta)$ C) $mgL\sin\theta$
D) $mgL(1 - \cos\theta)$ E) $mgL\cos\theta$

4. A spooky moth pushes a lämp of mass m which moves with constant speed v across a horizontal floor. The coefficient of friction between the lämp and the floor is μ. At what rate does the moth do work on the lämp?

A) $v/\mu mg$ B) $\mu mg/v$
C) mgv D) μmg
E) μmgv

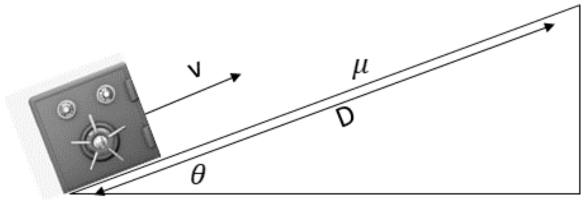


5. A block is traveling at a speed v when it comes to a rough surface. The block moves a distance D before it comes to a complete stop. If the block had been moving at $2v$, how far would it slide before stopping?

A) D B) 2D C) D/2 D) 4D E) 8D

6. A force of magnitude 40 N does 80 J of work on an object that is displaced with its displacement given by the vector $\vec{r} = (3\hat{\imath} - 8\hat{\jmath})$ J. Calculate the angle between the force and the path of the object's motion.

A) 74° B) 78° C) 84° D) 87° E) 6.7°



7. Gabe secures the dough in a safe of mass M. Gabe kicks the safe up an incline that is angled at θ as shown. He kicks it with initial speed v. The incline has a coefficient of kinetic friction, μ. Which of the expressions below is equal to the distance, D, that the block slides up the incline before stopping?

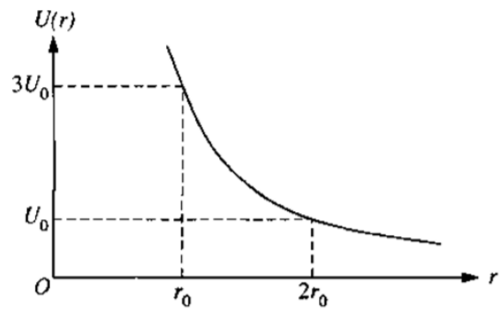
A) $\frac{v^2}{2g(1+\mu cot\theta)}$ B) $\frac{v^2}{2g(sin\theta+\mu cos\theta)}$ C) $\frac{v^2}{2g(1+\mu tan\theta)}$

D) $\frac{v^2}{2g(cos\theta+\mu sin\theta)}$ E) $\frac{v^2}{2g(tan\theta+\mu)}$

8. The potential energy of an object as function of position is given by $U(x) = 2e^{2x}$ When the object has moved 0.5 m from its starting position, what is the magnitude of the force associated with the potential energy function?

A) -2.7 N B) 10.8 N C) 2.7 N D) -10.8 N E) 5.4 N

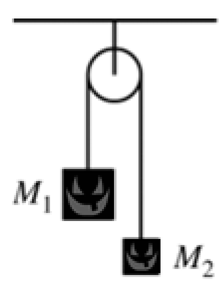
9. The potential energy for a particle, U, as a function of distance from the origin is given by the graph below:



If the particle is released from rest at position r_0, which of the following gives it speed at position $2r_0$?

A) $\sqrt{\frac{8U_0}{m}}$ B) $\sqrt{\frac{6U_0}{m}}$ C) $\sqrt{\frac{4U_0}{m}}$ D) $\sqrt{\frac{2U_0}{m}}$ E) $\sqrt{\frac{U_0}{m}}$

10. The system shown consists of two objects of unequal masses, M_1 and M_2, and pulley with negligible mass and friction. Which of the following is true about the changes in the gravitational potential energy, ΔU, and kinetic energy, ΔK, of the system soon after the objects are released from rest?



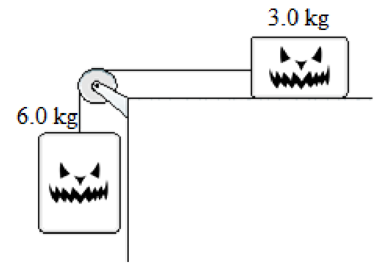
A) $\Delta U < 0$ and $\Delta K > 0$ B) $\Delta U = 0$ and $\Delta K > 0$

C) $\Delta U < 0$ and $\Delta K = 0$ D) $\Delta U = 0$ and $\Delta K = 0$

E) $\Delta U > 0$ and $\Delta K < 0$

11. The two blocks shown are connected by a frictionless pulley. The 3.0 kg block is a on table with friction. The system is released from rest. After the 6.0 kg block falls a vertical distance of 1.5 m, it is found to have a speed of 4.0 m/s. Calculate the work done by friction during this time.

A) -63 J B) -42 J C) -51 J
D) -45 J E) -18 J

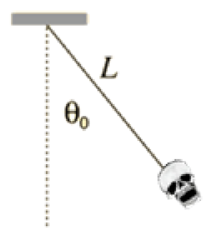


12. Which of the following forces does positive work?

A) The force of a gravity on a block that is slowly lowered from a desk to the ground.
B) The force of gravity on a block that is being pushed up an incline and speeding up.
C) The force of gravity on a satellite that is orbiting the earth.
D) The force of friction on a block that is being pulled across a flat surface at constant velocity.
E) The force of velocity on a free-body diagram.

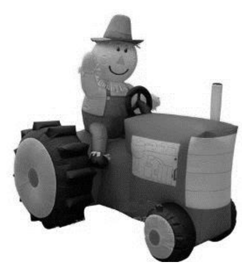
13. A bob of mass m = 0.5 kg is fixed to a string of length L=1.0 m that originally makes an angle of $\theta_0 = 20°$ with the vertical and is released from rest at this angle. The other string is affixed to the ceiling as shown. The bob falls and swings as a pendulum. Calculate the instantaneous tension in the string at the bottom of its swing

A) 4.4 N B) 5.6 N C) 5.0 N D) 6.2 N E) 11 N

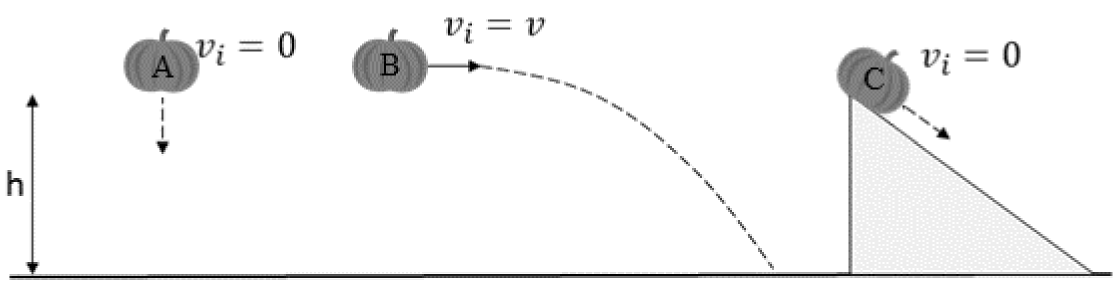


14. A spooky scarecrow drives a tractor of mass 20 kg. The position of the tractor over time can be given by $x(t) = 4t^3 + 4t$. Calculate the instantaneous power of the tractor at time $t = 13.0\ s$.

A) 143MW B) 12.7 MW C) 499 kW
D) 39.3 kW E) 2.22 kW



15. Three identical pumpkin spice flavored objects each take a different path from a height h to the ground. Object A is released from rest. Object B is projected horizontally with an initial speed v. Object C is released from rest and slides down a frictionless incline.

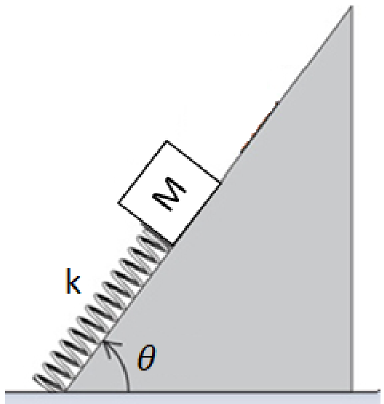


Rank the objects in terms of the speed of the blocks just before hitting the ground.

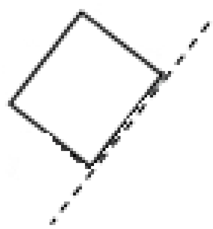
A) $v_A > v_C > v_B$
B) $v_B > v_A = v_c$
C) $v_A = v_B = v_c$
D) $v_B > v_A > v_c$
E) $v_A > v_B = v_c$

Part 2: Free Response. **You must show all steps** required to arrive at the correct answer for the problem below, including any relevant free body/pseudo free body diagrams. You are graded for your demonstration of physics and problem-solving methods, and not for simply writing the correction answer. A correct answer with no justification will receive no more than one point. All numeric answers must be given with correct units.

16. (12 points) This is the ideal spring. You may not like it, but this is what peak performance looks like. In an experiment to determine the elastic constant, k of the ideal spring a student slides different masses down a frictionless incline to compress the spring. For each known mass, the student sets the mass at rest at end of the spring that is initially in equilibrium position and measures x, the distance the spring is compressed from its uncompressed position. The angle of inclination of the incline is θ=60°.



a) Draw a free body diagram of all forces acting on the mass when it is compressing the spring.



b) Write an equation that expresses the spring constant as a function of m, the mass of the block.

c) The student uses different masses finds the following values for the distance the spring is compressed. The data are given in the table below.

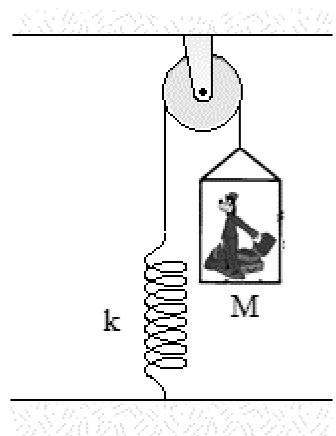
mass (k)	2.0 kg	4.0 kg	6.0 kg	8.0 kg	10.0 kg
distance compressed (m)	.11 m	0.19 m	0.33 m	0.36 m	0.47

From the data, find the value of the spring constant, k.

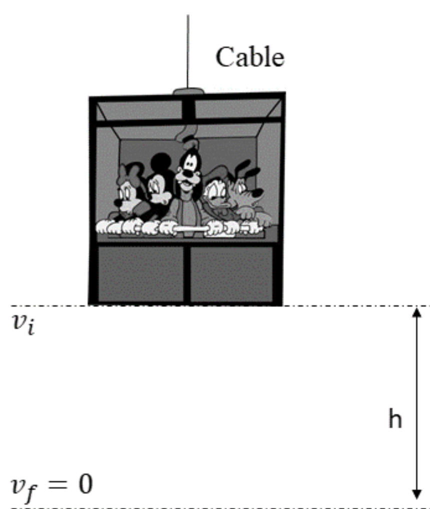
17. (15 points) The Hollywood Tower Hotel has a system of unique elevators.

a) Assume that the total mass of the main elevator is 800 kg and is lifted a height of 150 m in 20 s. The motor that runs the elevator supplies 80,0000 W. Calculate the efficiency of the motor.

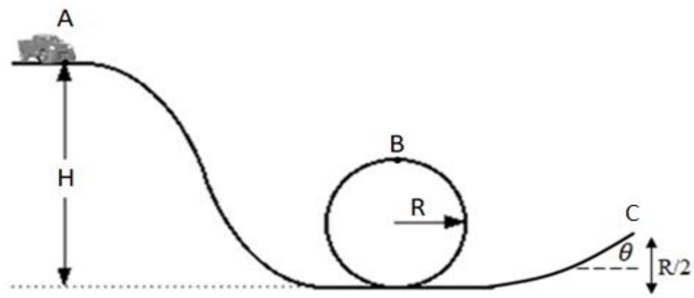
b) A maintenance service elevator is attached to a spring as shown. The elevator has a total mass of M = 300 kg and is attached to a light spring over a pulley as shown. The spring is non-ideal, with its elastic force given by $F(x) = kx^2$. The elevator is released form rest and reaches a speed of 8.0 m/s after falling 10 m. Calculate the spring constant, k.



c) The tower has a terrifying elevator that descends while slowing down during part of its motion. The elevator has initial downward velocity $v_i = 40\frac{m}{s}$. After dropping for a distance of h = 40 m, the elevator stops. The elevator and its passengers have a total mass of 1200 kg. Calculate the tension in the cable supporting the elevator as it descends.



18. (15 points) A car of mass M is released from rest from height H at point A as shown. The car travels along a frictionless track, going through a vertical loop of radius R. It leaves the track at point C a height of R/2 and is projected into the air at angle of θ above the horizontal.



a) Determine the height H if the normal force on the car at the top of the loop is twice its weight.

b) Determine an expression for the maximum height of the car after leaving the track at point C.

c) Another track that has the same configuration, but is not frictionless, is used. Determine an expression for the minimum amount of work that must be done by friction between points A and B so that the car just starts to lose contact with the track at point B.