AP Physics C Name: _____

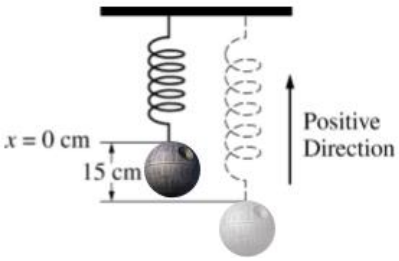
Unit 7 Test: Oscillations and Gravity Period: _____

Part 1: Multiple Choice. Directions – Select the answer choice that best answers the question posed. If an exact answer is not present, chose the closest available answer. (4 points each)

1. Hello there. For a body undergoing simple harmonic motion the velocity and acceleration are:
   A) constant
   B) always in opposite directions.
   C) in the same direction for a quarter of the period.
   D) always in the same direction.
   E) in the same direction for half the period.

2. **General Kenobi** attaches a mass to a spring and allows it to oscillate. The acceleration of the mass-spring system is given by $a(t) = -54\cos(3t + 7)$. Find the amplitude of the mass's motion.
   A) 3 m B) 6 m C) 18 m D) 54 m E) 512 m

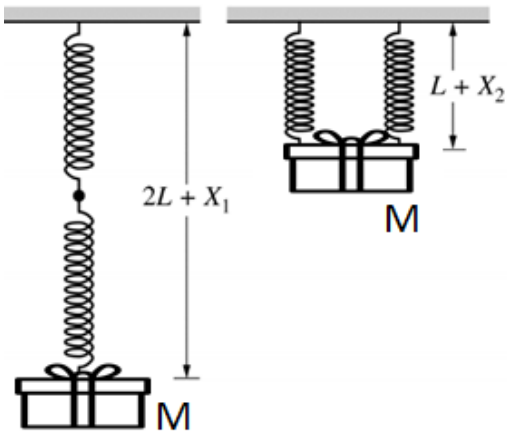
3. An object is initially hanging in equilibrium from a vertical spring. The object is pulled down 15 cm from its equilibrium position, as illustrated above, and released at time t = 0. The object then oscillates with a period of 2.0 s. Let x = 0 be the equilibrium position and let the positive direction be upward. What is the position of the object at t = 3.0 s?



   A) 15 cm B) 7.5 cm C) 0 cm
   D) -7.5 cm E) -15 cm

4. The motion of a particle connected to a spring is described by $x(t) = 10\sin(\pi t)$. At what time is the potential energy of the system equal to the kinetic energy?
   A) 0 s B) 0.25 s C) 0.50 s D) 0.79 s E) 1.0 s

5. A block of mass M is suspended from two identical springs of negligible mass, spring constant K and unstretched spring length L. First, one spring is attached to the end of the other spring. The block is then attached to the end of the second spring and slightly lowered to its equilibrium position. The two springs stretch a total distance of X_1, as shown. Next, the two springs are hung side by side. The block is attached to the ends of the springs and again lowered to equilibrium. The springs stretch a distance of X_2, as shown. Which of the following correctly relates X_1 and X_2?



   A) $X_1 = X_2$ B) $X_1 = \sqrt{2}X_2$
   C) $X_1 = 2X_2$ D) $X_1 = 4X_2$ E) $X_1 = 8X_2$

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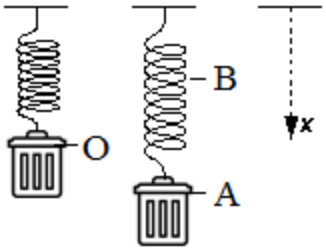
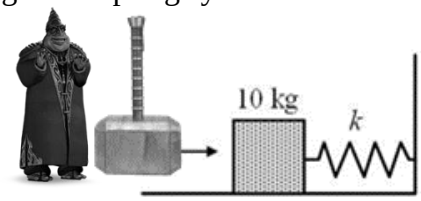
6. A copy of Star Wars Episode VIII: The Last Jedi is a point O when suspended from a spring, as shown. When it is pulled down and released, it oscillates between positions A and B. Which statement about the system consisting of the spring and the object is correct?



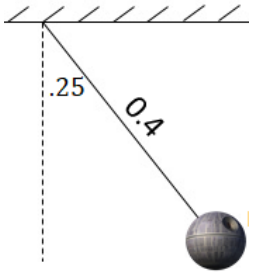
A) The gravitational potential energy of the system is greatest at A.
B) The elastic potential energy of the system is greatest at O.
C) The rate of change of momentum has its greatest magnitude at A and B.
D) The rate of change of gravitational potential energy is smallest at O.
E) The momentum of the system has its greatest magnitude at A and B.

7. A 10-kg box is at rest at the end of an unstretched spring with constant k = 360 N/m. The mass is struck with a hammer giving it a velocity of 6.0 m/s to the right across a frictionless surface. What is the maximum acceleration of the resulting oscillating mass-spring system?



A) 3.1 m B) 6.0 m/s^2 C) 10 m/s^2 D) 12 m/s^2 E) 36 m/s^2

8. A simple ideal pendulum of length L = 0.4 m is displaced a small angle $\theta = 0.5\ radians$ from the vertical and then released on Earth. Which of the following functions could represent the velocity of the pendulum bob as a function of time?



A) $v(t) = .02\sin(.2t)$
B) $v(t) = .1\sin(5t)$
C) $v(t) = 0.5\cos(.2t)$
D) $v(t) = 0.5\sin(5t)$
E) $v(t) = .1\cos(.2t)$

9. On earth, an object swings on the end of a cord as a simple pendulum with period T. Another object oscillates back and forth at the end of a spring with period T. The objects are now brought to Bespin, a planet with Lando, the same radius as Earth, and four times the density of Earth. What are the period of the pendulum and spring on Bespin in terms of T (their Earth periods)?

	Pendulum	Spring
A)	$2T$	T
B)	$T/2$	T
C)	T	2T
D)	$2T$	$T/2$
E)	$T/2$	$2T$

10. Mustafar is a planet known for its high ground. Mustafar has a mass equal to twice that on Earth, but only half the radius of Earth. Anakin has a weight of W on Earth. What is his weight on Mustafar?

A) $8W$ B) $4W$ C) W D) $W/4$ E) $W/8$

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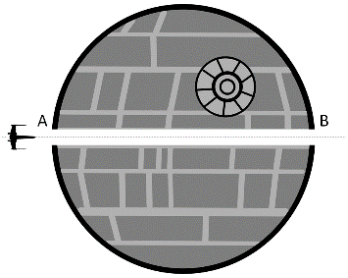
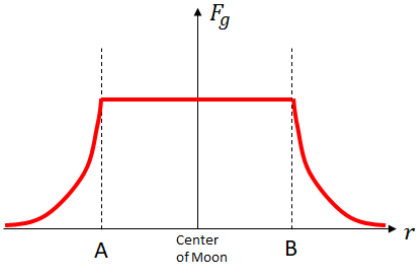
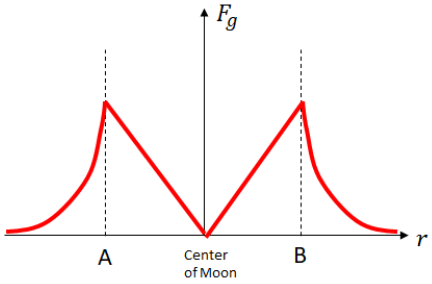
11. A moon is solid and of uniform density. Luke flies directly through the planet due to a hollow shaft running through the center of the moon as shown. Luke's X-wing spacecraft flies from space towards the moon, goes under the surface of the moon at A and emerges at point B on the other side and then flies away from the moon. Which of the graphs below best represents the force of gravity between the moon and Luke's spacecraft as a function from the center of the moon, r?



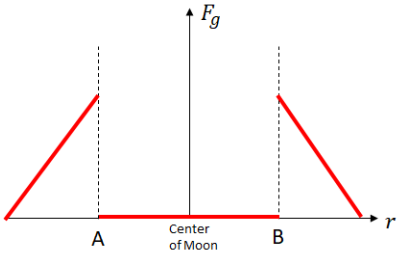
A)



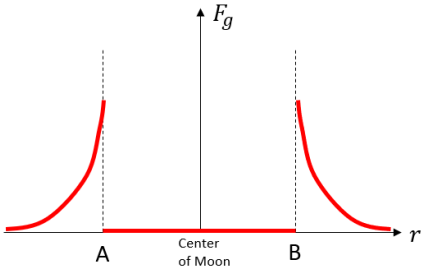
B)



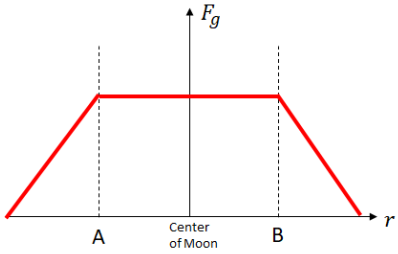
C)



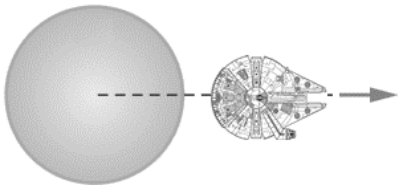
D)



E)

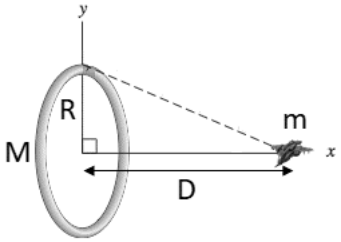


12. The Millennium Falcon (a spaceship) takes off from the planet Corellia. It is launched on the surface of Corellia with a velocity equal to three times the escape velocity of the planet. After the ship is launched, no further force is provided to propel the rocket ship. What speed will the Millenium Falcon has once it completely escapes Corellia's gravity? Answer in terms of v_e, the escape velocity of the planet.



A) $2\sqrt{2}v_e$ B) $\sqrt{2}v_e$ C) $2v_e$ D) $\sqrt{3}v_e$ E) v_e

13. Master Chief is in space aboard a ship of mass m. He is a distance of D along the x-axis from a thing Halo ring of mass. The ring is of uniform mass M and radius R. It is center at the origin as shown. Which of the following expressions, when evaluated, would give the force of gravity between Master Chief's ship and the Halo ring of mass?



A) $F = \int_0^{2\pi} \frac{GMm}{2\pi R(R^2+D^2)} d\theta$ B) $F = \int_0^{\pi} \frac{GMmD}{2\pi(R^2+D^2)} d\theta$

C) $F = \int_0^{R} \frac{GMmD}{(R^2+D^2)^{\frac{3}{2}}} dy$ D) $F = \int_0^{R} \frac{GMm}{(R^2+D^2)} dy$ E) $F = \int_0^{2\pi} \frac{GMmD}{2\pi(R^2+D^2)^{\frac{3}{2}}} d\theta$

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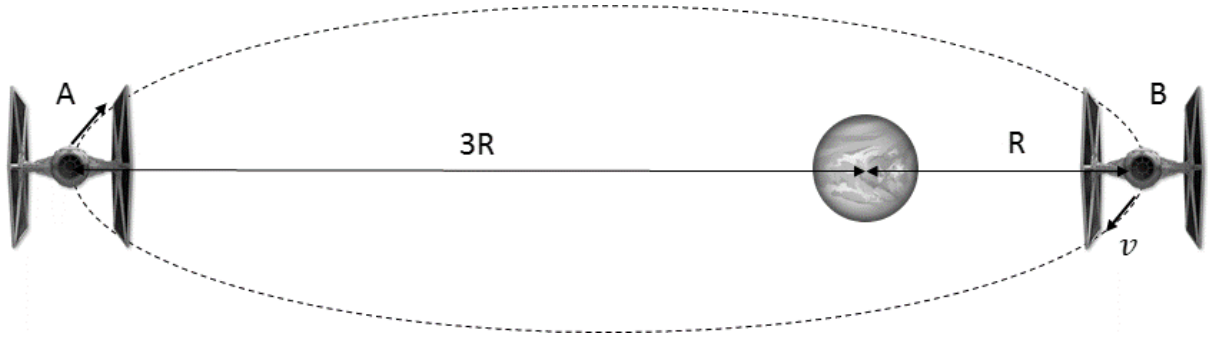
(14-15) It is a dark time for the Rebellion. Although the Death Star has been destroyed, Imperial troops have driven the Rebel forces from their hidden base and pursued them across the galaxy. Evading the dreaded Imperial Starfleet, a group of freedom fighters led by Luke Skywalker have established a new secret base on the remote ice world of Hoth. The evil lord Darth Vader, obsessed with finding young Skywalker, has dispatched thousands of remote probes into the far reaches of space. A tie fighter spacecraft maintains an elliptical orbit around Hoth as shown. Point B is the point in its orbit closest to Hoth (R from Hoth's center) while point A is the furthest point in its orbit (3R away). At point B, the spacecraft's speed is found to be v.



14. What is the value of speed of the spacecraft at point A?

A) $v/3$ B) $v/9$ C) v D) $3v$ E) $9v$

15. Which of the following quantities decreases as the space-ship flies from A to B?

A) the acceleration of the spacecraft
B) the potential energy of the spacecraft-planet system
C) the kinetic energy of the spacecraft
D) the force of gravity on the tie fighter
E) the total energy of the spacecraft-planet system

Multiple Choice Answers: Please enter your multiple choice answers below.

1. _____	6. _____	11. _____
2. _____	7. _____	12. _____
3. _____	8. _____	13. _____
4. _____	9. _____	14. _____
5. _____	10. _____	15. _____

Part 2: Free Response (14 points each) Show the steps required to arrive at the answer to the questions below. You are being graded for your problem-solving methods and understanding more than the final answer. Ensure all numerical answers include units. Don't forget to like, comment and subscribe.

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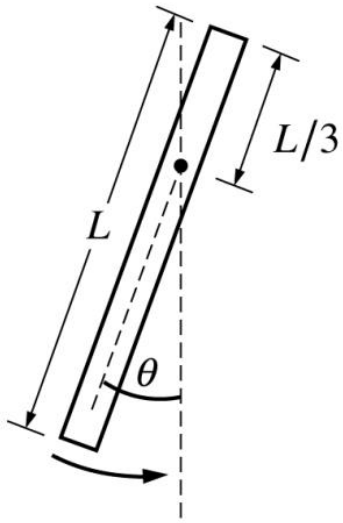
16. A uniform rod of mass M and length L is pivoted at a point a distance of L/3 from the top end, as shown. The rod is pulled back so it makes a small angle θ with the vertical and then released.



a) Using integral calculus, determine an expression for the rotational inertia of the rod about the pivot.

b) Using Newton's 2nd law for rotation, write, but do not solve, a differential equation in terms of M, L, and physical constatns, that can be used to determine the angular displacement, θ, as a function of time, t.

c) Using your equation from b), determine an expression for the period of oscillation.

d) Determine an expression for the velocity of the physical pendulum when its potential energy is a minimum.

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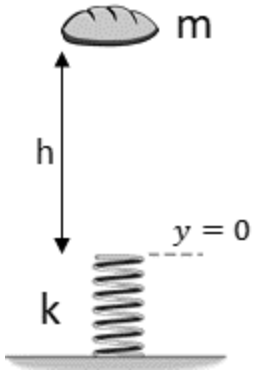
17. Let's get this bread to oscillate by landing a loaf of bread on a spring as shown. A loaf of bread of mass m = .50 kg is dropped from a height of h = 1.0 m above an uncompressed ideal spring (k = 20 N/m). The bread strikes the spring and sticks to it.



a) What is the amplitude of the resulting simple harmonic motion?

b) Calculate the distance the spring is compressed from y = 0 when the spring is at its maximum velocity.

c) Taking the original unstretched position of the top of the spring as y = 0, and the time when the bread first makes contact with the spring as t = 0, derive an expression for the position of the spring as a function of time, $y(t)$.

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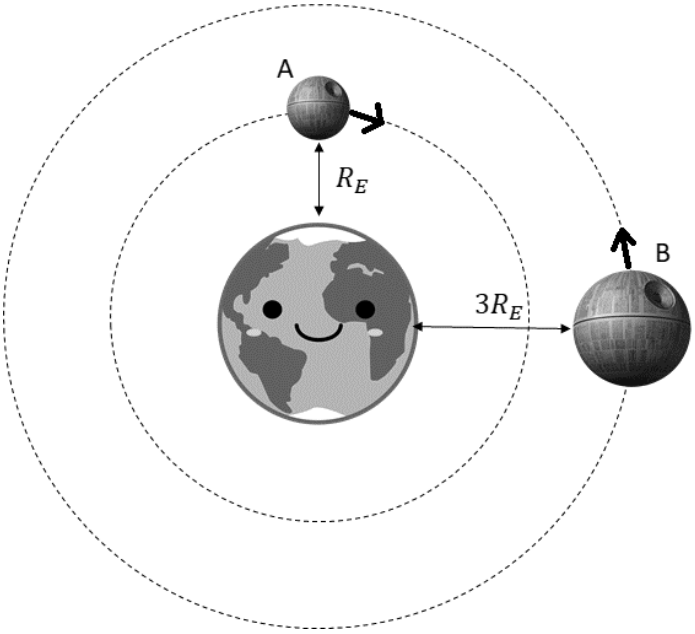
18. Earth is the planet you are on. It has a mass of M and a radius of R_E. 2 satellites orbit Earth. Satellite A, of mass m, orbits at a distance of R_E above the *surface* of Earth. Satellite B has mass 2m and orbits at a distance of $3R_E$ above the surface. Both satellites have circular orbits about the planet.



a) Suppose that satellite A wants to increase its orbital radius to satellite B's radius. Determine an expression for the magnitude and sign of the work required for satellite A to reach the higher orbit.

b) With A's new orbit from part B, satellite A has the same orbital radius of B. Assume that the two orbit in opposite directions and eventually collide and stick together.

i. Determine an expression for the velocity of the combined satellites after they collide.

ii. The combined satellites will drop to a lower orbit (closer to Earth) after colliding. Briefly explain why this is so.

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