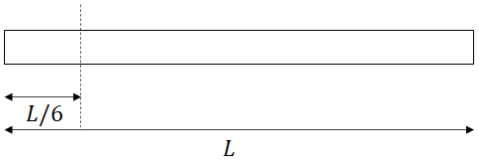
AP Physics C
Unit 7 Test: Oscillations and Gravity

Name: _____

Directions – Hello there. Don't be a stuck up, half-witted, scruffy looking nerf herder, show your work.

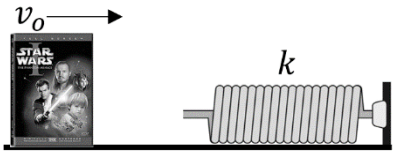
1. (16 points) The rod of mass M = 8.0 kg and length L = 12.0 m is pivoted at a distance of L/6 from its left end as shown. It is free to swing as a physical pendulum.



a) Calculate the moment of inertia of the rod. (5)
b) The rod now oscillates as a physical pendulum because this test is about oscillations.
i. Oh, I'm not brave enough for calculus. By applying the appropriate equation of motion to the bar, write, but do not solve, the differential equation for the angle θ the bar makes with the vertical. (2)
ii. By applying the small-angle approximation to your differential equation, calculate the period of the bar's motion. (4)
c) Calculate the maximum linear speed of the center of mass of the rod. (5)

2. (6 points) A pendulum is placed on Urth (g = π^2). The string of the pendulum is 4 m and the mass at the end is 1.0 kg. The string is released at an angle of $\frac{\pi}{10}$ and released from rest at time t = 0. Determine a function for the velocity of the mass as a function of time.

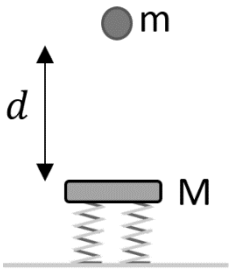
3. (8 points) A DVD copy of the cinematic classic, Star Wars: Episode 1 The Phantom Menace is sliding across a frictionless surface. The DVD has a mass of $m = 20\ kg$ and velocity of $v_o = 10\ m/s$. It hits and sticks to an ideal spring of constant $k = 400\frac{N}{m}$.



a) Determine the amplitude of the resulting oscillatory motion. (4)
b) Determine the maximum acceleration of the resulting oscillation. (4)

4. (10 points) A 2.0 kg object suspended on a spring oscillates such that its acceleration as a function of time *t* is given by the equation $a(t) = 0.6\cos(2t)$. The system is originally at rest.
a) When does the object reach its maximum velocity for the first time? (5)
b) Determine an expression for the total energy of the system as a function of time. (5)

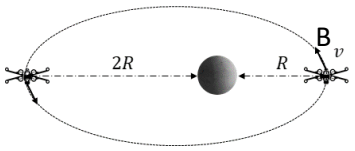
5. (24 points) A platform of mass M = 10 kg rests of two springs in parallel as shown. The springs each has an elastic constant of k = 20 N/m. A piece of silly putty of mass m = 2.0 kg is dropped on an sticks to the platform.



a) Calculate the effective spring constant. (3)
b) Determine the amplitude of the resulting harmonic motion once the putty sticks to the block. (5)
c) Taking the original height (y=0) as being the block right before the clay hits it at time t = 0, write a function for the vertical position y(t) of the block once the putty sticks to it. (5)
d) Determine the distance the spring is compressed from its new equilibrium position when its speed is a maximum. (3)
e) Suppose the putty bounced off the block instead of sticking to it.
i. Would the period of the oscillation increase, decrease, or remain the same? Why? (4)
ii. Would the amplitude of the oscillation increase decrease, or remain the same? Why? (4)

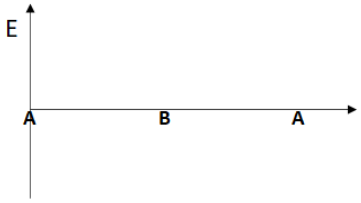
6. (6 points) But what about the droid attack on the Wookiees? The Wookiee home plant is Kashyyk; it's not a system we can afford to lose. Kashyyk has twice the mass and twice the density of Earth. A pendulum has a period of 8 s on Earth. What would the period of the same pendulum be if it were brought to Kashyyyk?

7. (8 points) Luke Skywalker has returned to his home planet of Tatooine in an attempt to rescue his friend Han Solo from the clutches of the vile gangster Jabba the Hutt. Luke pilots his X-wing of mass M in an elliptical orbit about Tatooine as shown above. At one point (point B) in his orbit, he is a distance of R from the center of Tatooine and moving at speed v. At another point in his orbit, he is a distance 2R (point A) from the center of Tatooine.

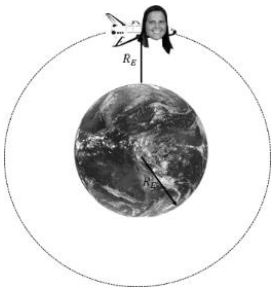


a) Determine an expression for Luke's orbital speed at point B. (4)

b) On a copy of the graph below, sketch the potential and kinetic energy of the X-wing as it orbits Tatooine. (4)



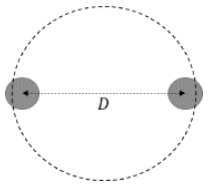
8. (8 points) Mrs. Russel has been banned from Earth for thinking her test questions are oh so clever. Assume has a mass of M_E and a radius of R_E. Mrs. Russel flies in a stable orbit in a spaceship of total mass m at a height of R_E above the surface of Earth. Mrs. Russel's spaceship suddenly drops to a new stable orbit at a distance of only $\frac{1}{4}R_E$ above Earth's surface.



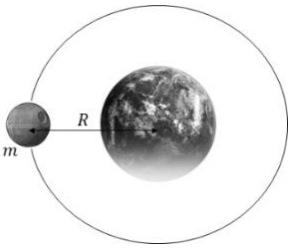
a) Does gravity do positive or negative work? (3)

b) Determine the magnitude of the work done by gravity during this process. (5)

9. (6 points) Two stars of equal mass M orbit each other as part of a binary system. The stars Are a distance of D apart. Determine an expression for the orbital period of one of the stars.



10. (8 points) A satellite of mass m is orbiting the planet Alderaan in a stable circular orbit of radius R. The mass and radius of Alderaan are M_A and R_A, respectively. Alderaan is a peaceful planet, they have no weapons.



a) Determine the value of the ratio $\frac{escape\ velocity\ of\ the\ satellite\ from\ its\ orbit}{orbital\ velocity\ of\ the\ satellite}$. (5)

b) The satellite is replaced with a similar satellite that has twice the mass. The new satellite is placed into the same orbit as the original satellite. Is the new satellite's orbital speed greater than, less than, or equal to the original satellite's orbital speed? Justify your answer. (3)