PHY 140Y – FOUNDATIONS OF PHYSICS
2001-2002
Term Test #1
Thursday, October 25, 2001
6:30 PM - 8:30 PM

INSTRUCTIONS:

Please give your name, student number, and TA's name on ALL examination booklets used.
Answer ALL questions. Total marks = 100.
Marks, shown in brackets, will be given for workings and units as well as for final answers.
[Non-]programmable calculators may be used. No aid/crib sheets are allowed.
Constants: $g = 9.81\ m/s^2$

Calvin's approach is not recommended!

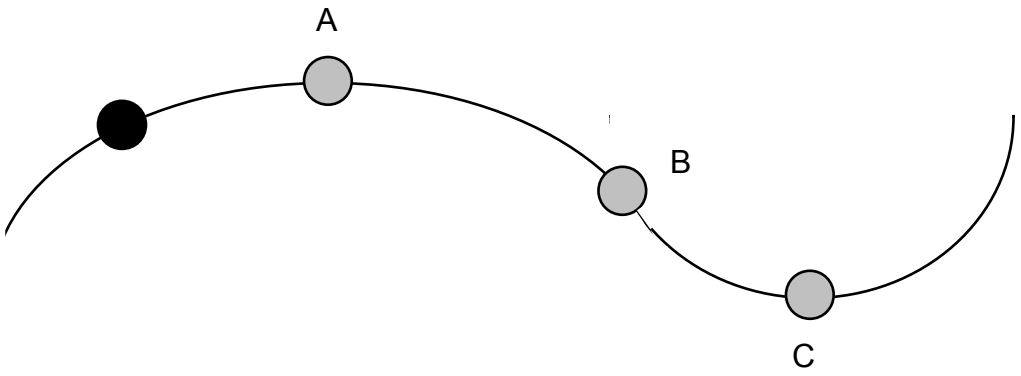
QUESTIONS:

1. Give BRIEF answers to each of the following. ***[5 marks each for 20 total]***

(a) Define and briefly explain the difference between inertial and noninertial frames of reference. What is a fictitious force and why does it arise?

(b) A passenger in a car travelling at 60 km/hour pours a cup of coffee for the tired driver, with it taking the coffee 0.10 seconds to reach the cup. Describe the path of the coffee as it moves from a Thermos bottle into a cup as seen by (i) the passenger, and (ii) someone standing beside the road and looking in the window of the car as it drives past. (iii) What happens if the car accelerates while the coffee is being poured?

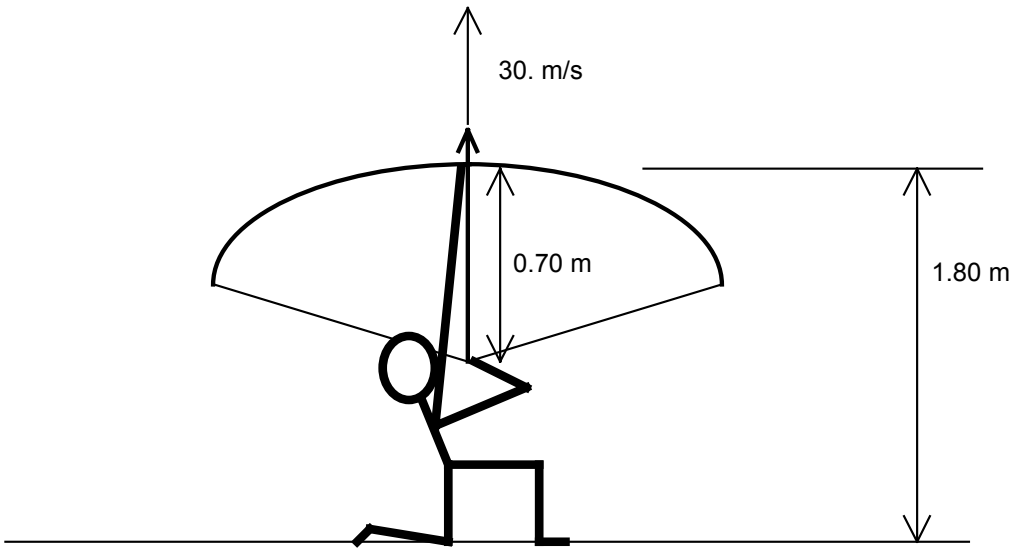
(c) A bead slides freely along a curved wire at constant speed, as shown in the following overhead view. At each of the points A, B, and C, describe the magnitude and direction of the force that the wire exerts on the bead in order to cause it to follow the path of the wire at that point.



(d) A person steps from a boat towards a dock. Unfortunately s/he forgot to tie the boat to the dock, and the boot scoots away as s/he steps from it. Analyze this situation in terms of Newton's Third Law. Would the outcome be the same for a small dog jumping from the boat? Why or why not?

[Each of the following five questions is worth 16 marks.]

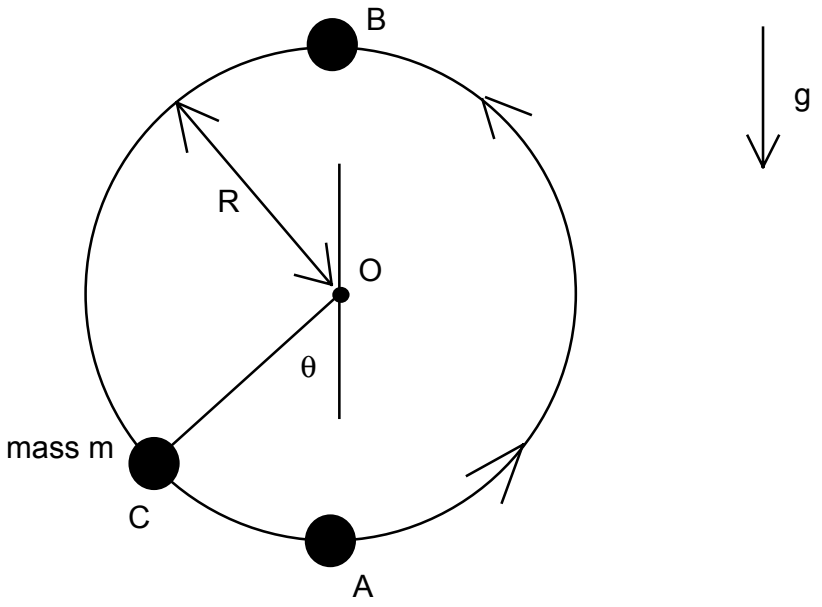
2. The draw on Robin Hood's archery bow is 0.70 m, as shown in the figure below.
   (a) Calculate the magnitude of the acceleration of an arrow that leaves the bow with a speed of 30. m/s. Assume that the arrow experiences a constant acceleration over the 0.70 m distance before it leaves the bow.
   (b) If the arrow is shot vertically upwards and leaves the bow at distance 1.80 m from the ground, find the maximum height to which the arrow rises and the total time of flight until the arrow hits the ground (assuming that the archer moves out of the way!).



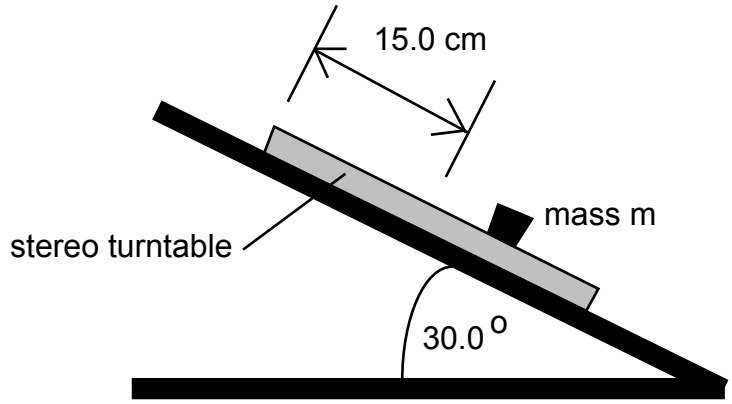
3. A naturalist observes a frog leap vertically to a height h.
   (a) With what speed did the frog leave the ground? Express your answer in terms of h and g.
   (b) If the frog used the same speed to leap horizontally for a maximum range, what distance could it cover?
   (c) To what height does the frog ascend in making the leap for maximum horizontal range?

4. Sergeant Pepper is on a water bombing run in a helicopter aimed horizontally northward above a road. The speed of the helicopter is 40.0 m/s relative to the air. The wind is blowing to the west at a constant speed of 8.6 m/s relative to the ground.
   (a) What is the speed of the helicopter relative to the ground? Provide a sketch of the geometry.
   (b) A water bomb is dropped from an altitude of 150. m in the direction of a fire, and just barely misses its target. How long will it take the bomb to hit the ground?
   (c) Where, relative to the helicopter, will the water bomb hit?
   (d) What is the speed of the water bomb the instant before impact?

5. A small sphere of mass m is attached to the end of a cord of length R that rotates counter-clockwise in a vertical circle about a fixed point O as shown. Define θ as the angle that the cord makes with the vertical.
   (a) Draw the free-body diagram for mass m when it is at points: (i) A - the bottom of the circle, (ii) B - the top of the circle, and (iii) C – at angle θ as shown.
   (b) What are the radial and tangential components of the acceleration?
   (c) Find an expression for the tension in the cord at time t in terms of the speed of the sphere, v(t), θ(t), m, and R.
   (d) What is the minimum magnitude of the tension and at what position does it occur? What is the maximum magnitude of the tension and at what position does it occur?
   (e) At what position is the cord most likely to break if the speed increases? Why?



6. An old stereo turntable of 15.0 cm radius turns at 33.0 rev/min while mounted on a plane inclined at 30.0° to the horizontal as shown in the figure below.
   (a) If a mass m can be placed anywhere on the turntable without slipping, where is the most critical place on the disk where slipping might occur? Why?
   (b) Sketch a force diagram for mass m, indicating all of the forces acting on it.
   (c) Calculate the minimum possible coefficient of friction that must exist if no slipping occurs. Is your answer independent of mass m? Is this a static or kinetic coefficient of friction?



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