Supplemental Midterm Examination Physics 100

October 31, 2013

Name/Student #:

Instructions: Formulas at the back (you can rip that sheet off). There is also an extra formula on the last page of the exam. Questions are on both sides. Calculator permitted. Put your name and student number at the top of the question sheet and complete all questions on the question sheet. Point values are shown with the questions. Complete the questions in any order. Total exam is worth 59 points. Duration is 50 minutes.

1. The space shuttle orbits the earth in counter clockwise circular orbit, completing one revolution in 5000 seconds. The radius of the orbit is 6.2×10^6 m (slightly smaller than it is in reality).

   (a) Draw a motion diagram using time steps of 500 s. (3)

   (b) Calculate the angular velocity ω in radians per second. (2)

   (c) Calculate the speed in metres per second. (2)

   (d) The acceleration should be toward the centre. Pick two velocity vectors and show that this is at least approximately true. (3)

   (e) Calculate the magnitude of the centripetal acceleration. The result should look familiar. (2)

2. You begin sliding down a 15° ski slope. You may assume a mass of 55 kg. Ignore friction and air resistance.

   (a) Draw a free-body diagram and include the axes and indicate where the 15° angle is. (3)

   (b) Write the Newton's 2nd law expressions for the motion using "ramp" style coordinates. Are any of the net forces zero? (3)

   (c) If $a_{xramp} = 2.54$ m/s^2 how fast will you be moving after 10 s? (2)

3. You throw a ball straight up into the air and catch it when it comes back. Assume there is no drag force. Give $y(t)$, $v_y(t)$, and $a_y(t)$ graphs for the time interval when the ball is not in your hand. (6 points) How can we find the $v_y(t)$ graph from the $y(t)$ graph? (2 points) Qualitatively demonstrate how this works by comparing points on the $y(t)$ and $v_y(t)$ graphs at A. $t = 0$, B. when the ball is part way up and C. when the ball has reached its maximum height. (3 points)

4. King Arthur's knights use a catapult to launch a rock from their vantage point on top of the castle wall, 12 m above the moat. The rock is launched at a speed of 25 m/s and an angle of 30^o above the horizontal.

   (a) How long does the rock spend in the air? (Answer: $\Delta t = 3.29$ s)? (5)

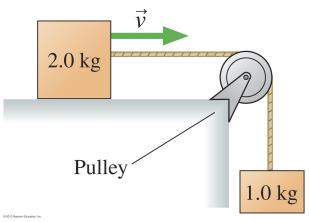
(b) How far from the castle wall does the launched rock land? (4) (for partial credit assume that $\Delta t = 3.29$ s if you can't solve the quadratic equation)

5. Two blocks are connected by a string as shown in the figure below. The coefficient of kinetic friction between the block and the table is 0.20. The string and pulley are massless and the pulley doesn't have any friction. I will call the upper block block 2 and the hanging block block 1 If you use Newton's 2nd law you find that $m_2 a_{x2} = T - \mu_k m_2 g$ and $m_1 a_{y1} = T - m_1 g$

   (a) Show how you obtain either one of these equations using the free-body diagram and Newton's 2nd law. (3)

   (b) How are a_{x2} of the upper block and a_{y1} of the hanging block related? (2)

   (c) Calculate the acceleration of the upper block. You may use the short cut method if you like. (4)



6. In class I showed you a top that would float above a base due to some magnetic forces. I also showed you that when the top "floated" the base became "heavier" as measured by a scale. Essentially the scale measures the normal force on the base (it reads a mass but that mass is equal to the normal force divided by g). Explain what is happening with details. (A good diagram is worth many words!) (10 points)

———Space for extra notes———

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \tag{1}$$