UNIVERSITY OF TORONTO

FACULTY OF APPLIED SCIENCE AND ENGINEERING

FINAL EXAMINATION, DECEMBER 2002

First year - Engineering Science

PHY180F - PHYSICS I - MECHANICS

Exam Type: C

Examiner: J. M. Pitre

Duration 2½ hours

Do all questions. All questions are of equal value. There are 80 possible marks.

Start the answer to each question on a new page.

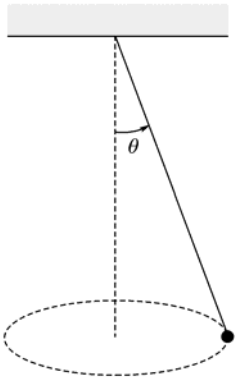
You do not need to do the problems in order.

Use g = 9.80 ms^{-2} for the acceleration due to gravity in all problems.

1) A ball starts from rest and accelerates at 0.500 $m \cdot s^{-2}$ while moving down an inclined plane 9.00 m long. When it reaches the bottom, the ball rolls smoothly onto a horizontal plane and then smoothly up another plane, where, after moving 15.0 m up the plane it comes to rest. You may ignore the rotational motion of the ball.
   a) What is the speed of the ball at the bottom of the first plane?
   b) How long does it take to roll down the first plane?
   c) What is the acceleration along the second plane?
   d) What angle, in degrees, does the first plane make with the horizontal?

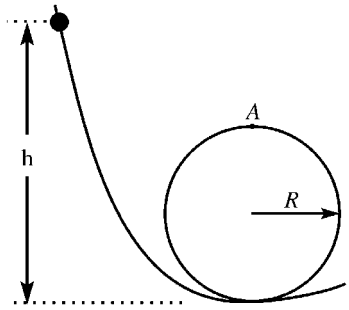
2) A projectile is fired from ground level at an angle θ to the horizontal and hits the ground at x = L at time t = T. At time T/2 the height of the projectile is L/3. What is the angle θ in degrees?

3) A ball on the end of a wire is travelling in a horizontal circle. This arrangement is called a conical pendulum. Consider a conical pendulum consisting of a ball of mass 80.0 kg on the end of a wire of length 10.0 m. The wire makes an angle θ = 5.00˚ with the vertical and this angle **never** changes.



   a) Determine the horizontal and vertical components of the force exerted by the wire on the ball.
   b) Determine the radial acceleration of the ball.
   c) Determine the period of the conical pendulum.

4) A bead with a mass of 5.00 grams slides without friction around a loop-the-loop. The bead is released from a height **h** = 3.50 **R**.

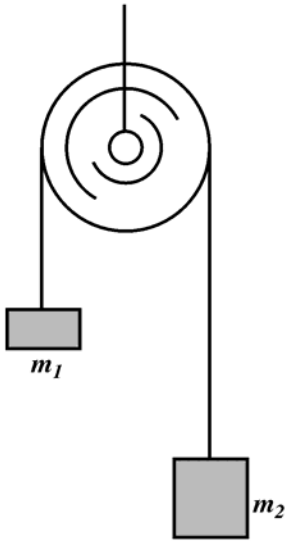


   a) What is the speed of the bead at point **A** in terms of **R**?
   b) What is the force exerted on the bead by the track at the point **A**?

5) A 75.0 kg firefighter slides down a pole while a constant frictional force of 300 N retards her motion. A horizontal 20.0 kg platform is supported by a spring at the bottom of the pole to cushion the fall. The firefighter starts from rest a distance 4.00 m above the platform. The spring constant is 4000 N/m. Assume that the frictional force acts during the **entire motion** of this problem.
   a) Find the firefighter's speed just before she collides with the platform.
   b) Find the speed of the firefighter and platform just after she lands on the platform.
   c) Find the quadratic equation that you need to solve in order to find the maximum distance that the spring is compressed. (You don't need to solve the equation.)

6) A woman with a mass of 60.0 kg stands at the rim of a horizontal turntable having a moment of inertia of 500 kg·m^2 and a radius of 2.00 m. The turntable is initially at rest and is free to rotate about a frictionless, vertical axle through its centre. The woman then starts walking around the rim clockwise (as viewed from above the system) at a constant speed of 1.50 m/s relative to the Earth.
   a) In what direction and with what angular speed does the turntable rotate?
   b) How much work does the woman do to set herself and the turntable into motion?
   c) If the origin is at the centre of the turntable, what is the angle, in degrees, between the initial and final position vectors of the woman after the turntable has completed one revolution?

7) A cylindrical steel wire of length **L** with a cross-sectional diameter **d** is placed over a light (massless) frictionless pulley, with one end of the wire connected to a mass $\mathbf{m_1}$ and the other end connected to a mass $\mathbf{m_2}$ where $\mathbf{m_2 > m_1}$. The mass of the wire is negligible. The wire stretches by an amount equal to 1.5 x 10^{-5} **L** while the masses are in motion. Find Young's modulus for steel in terms of $\mathbf{m_1}$, $\mathbf{m_2}$ and **d**.



8) The earth has radius $\mathbf{R_E}$ and a mass $\mathbf{M_E}$ and may be assumed to have a constant density.
   a) **Derive** $|\vec{\mathbf{g}}|$ the magnitude of the gravitational field on the surface of the earth in terms of $\mathbf{R_E}$ and $\mathbf{M_E}$.
   b) **Derive** two (2) values of **R**, the distance from the centre of the earth for which the magnitude of the gravitational field is half of its value on the surface of the earth.