

# PHY180H1F TERM TEST I

OCTOBER 14, 2004

Answer all three questions. They are of equal value. Only aids are calculators, drawing instruments and a student supplied 8.5 x 11 inch aid sheet (both sides).

For this test the acceleration due to gravity is  $g = 9.80 \text{ ms}^{-2}$ .

- 1) A car accelerates down a hill which makes an angle  $\theta$  with the horizontal. It starts from rest and it accelerates to  $30.0 \text{ ms}^{-1}$  in  $6.00 \text{ s}$ . A toy of mass  $m = 0.100 \text{ kg}$  is hanging from the ceiling. For this acceleration the string remains perpendicular to the ceiling.
  - a) Determine the angle  $\theta$ .
  - b) Determine the tension in the string.
- 2) For this question, all answers should be in terms of symbols given in the question. A solid cylindrical disk of mass  $M$  and radius  $R$  is rolling along the floor without slipping. The velocity of the centre of mass is  $v_{\text{CM}}$ . One may analyse the motion by considering the object to be rotating either about the centre of mass or about the point  $P$  which is in contact with the floor. Calculate the total kinetic energy of the disk if rotation is considered to be about:
  - a) the center of mass.
  - b) the point  $P$  which is contact with the floor.
  - c) Should your answers in (a) and (b) be the same or different? Explain.
  - d) If the point  $P$  is in contact with the floor at time  $t = 0$  and this point on the floor is taken to be the origin, write down the equation for the displacement of the point  $P$  in the  $y$  direction as a function of time.
- 3) Cannon balls are fired at a bunker and the artillery soldiers are so good that they hit the bunker every time. An entrepreneur wants to build a hotel in the middle of the battlefield with the location and width shown. He cannot communicate with the artillery soldiers. Assume that the origin is at the mouth of the cannon and the height of the bunker is negligible.
  - a) What is the maximum height to which the hotel can be built so that it is never hit by these accurate artillery soldiers when they shoot at the bunker if the initial speed of the cannon balls is  $72 \text{ ms}^{-1}$ ?
  - b) When the hotel is at its maximum height, what is the velocity of the artillery shells **in cylindrical coordinates** when the shells hit the ground at the bunker?

