PHAS1247 Classical Mechanics
Problems for Week 2 of Lectures (2016)

1. The driver of a car moving at 50 km/hr sees an obstacle 20 m ahead. Assuming that the driver instantly applies the brakes (i.e. the 'thinking time' is negligible) and that the deceleration produced by the brakes is uniform, find what deceleration is required in order for the car to stop in time to avoid hitting the obstacle.

   How would your answer change if the car was moving twice as fast?

2. The captain of an oil tanker needs to stop his ship within a distance of 1 km. If the mass of his ship is 50,000 tonnes or 5×10^7 kg and the initial speed is $10\,\mathrm{ms}^{-1}$, what retarding force needs to be applied from the propellors?

3. A particle of mass $m = 2\,\mathrm{kg}$ starts from rest at time $t = 0$. It then experiences, for 2 seconds, a time-dependent force given by

$$\mathbf{F}(t) = [t(2-t)\hat{\mathbf{i}} + 4\hat{\mathbf{j}}]\,\mathrm{N},$$

   where t is the time measured in seconds. After time $t = 2$ the force is zero.

   (a) Calculate the total impulse imparted to the body by the force. Hence find the body's velocity at time $t = 2$.

   (b) Show that after two seconds the object has moved approximately 4.06 m from its original position. In what direction has it moved?

   (c) Describe the particle's motion after the force has ceased to act. Hence find its displacement vector after a total time $t = 5\,\mathrm{s}$ has elapsed (i.e., 3 s after the force ceased to act).

4. A child at a fair throws a coconut at a plate on a stall; hitting the plate wins a prize. The child throws the coconut from a starting height h, with initial speed u and at an angle of elevation α to the horizontal; neglecting air resistance, find the height above the ground and the horizontal distance moved by the coconut as a function of time t.

   Hence show also that the vertical height z above the ground is related to the horizontal displacement x by

$$\frac{gx^2}{2u^2}\tan^2(\alpha) - x\tan(\alpha) + z - h + \frac{gx^2}{2u^2} = 0.$$

   If $u = 5\,\mathrm{ms}^{-1}$ and $h = 1\,\mathrm{m}$, while the plate is a distance $d = 3\,\mathrm{m}$ away and at a height of 0.4 m, find two possible values of the angle α which would enable the child to hit the plate and win the prize.

   The child successfully wins a prize and wants another go. The crafty stallholder decides to place a new target the same horizontal distance away, but too high for the child to hit. Assuming the child always throws with the same initial speed u, what is the minimum target height the stallholder must choose?