MP170/180 Problem Sheet One

One-Dimensional Kinematics

This is not part of your assessment. These are for discussion in tutorials.

1. Sketch position vs time and velocity vs time diagrams for each of the following situations:

   (a) A cyclist travels at 5 ms^{-1} for 10 s and then steadily slows down to rest for a further 10 s.

   (b) A car starts from rest and increases steadily to a velocity of 10 ms^{-1} in 5 s. The car continues at this velocity for 10 s and slows steadily to rest for a further 10 s.

   (c) A person jumps from an aircraft and falls until the parachute opens. The person then falls steadily to the ground.

2. A particle is set in motion at time $t = 0$ s and its subsequent position is given by $s(t)$. For each of the following cases:

   (i) $s(t) = 4 + 5t - 2t^2$, (ii) $s(t) = t^2 - 4t + 1$, (iii) $s(t) = 3 + 18t - 7.5t^2 + t^3$

   - Calculate the velocity after 2 s.
   - Find the time when the particle comes to rest instantaneously.
   - Find the acceleration after 1 s.

3. Find the first and second derivatives of the following functions of t:

   (a) $s(t) = t + 2t^2 - 3$
   (b) $f(t) = t^2 - 1/t$
   (c) $f(t) = (1 - 2t + t^3)^{-1}$
   (d) $g(t) = (1 + 4t)/(2 - 3t^2)$

4. Evaluate the following indefinite integrals:

$$\text{(a)} \int (t - 3t^2)\, dt$$

$$\text{(b)} \int \left(4t^4 - 1/t^2\right)\, dt$$

$$\text{(c)} \int \left(5t^2 - 7t^4 + 2t^5\right)\, dt$$

5. Evaluate the following definite integrals:

$$\text{(a)} \int_0^1 t^5\, dt$$

$$\text{(b)} \int_0^2 t\,(1 - t^3)\, dt$$

$$\text{(c)} \int_{-1}^4 \left(2t^5 - 3t^3 - t\right)\, dt$$

6. A rocket is travelling at 80 ms^{-1}. The engines are then switched on for 6 s and the rocket accelerates at a constant rate of 40 ms^{-2}. Calculate the distance travelled in the 6 s. (Answer: 1200 m.)