Section 1: Motion in two dimensions

Exercise level 1

1. The position vector of a particle at time t is given by $\begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} 3t+1 \\ 2-t \end{pmatrix}$.
   (i) Find the velocity of the particle.
   (ii) Find the acceleration of the particle.

2. A particle is initially at rest at the origin. It experiences a variable acceleration given by $\mathbf{a} = (3t+2)\mathbf{i} + (2t^2 - 5)\mathbf{j}$.
   (i) Find an expression for the velocity of the particle at time t.
   (ii) Find an expression for the position of the particle at time t.

3. A particle moves with a velocity given by $\mathbf{v} = 2t\mathbf{i} + (3t^2 - 4t)\mathbf{j}$ ms^{-1}.
   (i) Given that at time t = 2 s, the particle is at position $7\mathbf{i} + 4\mathbf{j}$, find an expression for the position of the particle at time t.
   (ii) Find the position of the particle after 5 s.

4. **In this question take g to be 10 ms^{-2}.**
   A ball is fired from a point on level ground with velocity $\mathbf{u} = 15\mathbf{i} + 20\mathbf{j}$.
   (i) Write in terms of $\mathbf{i}$ and $\mathbf{j}$ the velocity vector and the position vector of the ball after t seconds**.**
   (ii) Find the time at which the ball will be moving in a direction of 45° to the horizontal.
   (iii) Find the time at which the ball returns to the ground**.**

5. **In this question take g to be 10 ms^{-2}.**
   A boy fires a stone from the top of a tower 10 m high using a catapult. The initial velocity of the ball is $12\mathbf{i}$.
   (i) Write in terms of $\mathbf{i}$ and $\mathbf{j}$ expressions for the velocity and displacement of the stone at time t seconds after projection.
   (ii) How far horizontally from the base of the tower does the stone land?

6. At time t the position vector of particle P is given by $\mathbf{r} = 8t^3\mathbf{i} + t^4\mathbf{j}$.
   Find its velocity and acceleration after 2 seconds.

7. Particle P has velocity vector $\mathbf{v}$, where $\mathbf{v} = 2t\mathbf{i} + 3t^2\mathbf{j}$, at time t seconds.
   Initially the position vector of P is given by $\mathbf{r} = \mathbf{i} + 4\mathbf{j}$.
   Find the position vector of P at time t.