A particle moves such that its velocity $\mathbf{v} = \begin{pmatrix} 3t \\ 2t^2 + 1 \end{pmatrix}$ at time t. When $t = 2$ its displacement from the origin O is $\begin{pmatrix} 5 \\ 10 \end{pmatrix}$. Find its displacement at $t = 1$.

Two forces, $\mathbf{F}_1 = 2\mathbf{i} + 4\mathbf{j}$ and $\mathbf{F}_2 = 3\mathbf{i} - 5\mathbf{j}$ act on a particle. The resultant of these is $\mathbf{F}$. Find

i) $\mathbf{F}$

ii) $|\mathbf{F}|$

iii) The direction $\mathbf{F}$ makes with the horizontal.

A cyclist and bike of combined mass 93 kg are travelling on a horizontal road. A forward force of 150 N causes the cyclist to accelerate at 0.6 ms^{-2}. A constant resistance force F N opposes the motion. Find F.

A ball is thrown vertically upwards with initial speed 15 ms^{-1} from a point 0.7 m above the ground. Find

i) The maximum height of the ball.

ii) The time before the ball returns to the ground.

A car moves from rest on a horizontal road. The first 40 seconds of its motion can be modelled by three separate stages.

For the first 10 seconds the car accelerates from rest to a velocity of 5 ms^{-1}. For the next 20 seconds the car is travelling at this constant speed, and for the final 10 seconds accelerates uniformly to a velocity of 12 ms^{-1}.

i) Sketch a velocity-time graph.

ii) How far does the van travel in this time?

Using a velocity-time graph derive the following SUVAT equations.

i) $s = \frac{1}{2}(u + v)t$, ii) $v = u + at$, iii) $v^2 = u^2 + 2as$ and iv) $s = ut + \frac{1}{2}at^2$

Two particles, A and B of masses 4 kg and 5 kg respectively are connected by a light, inextensible string over a small pulley. The particles are released from rest. Find the acceleration of the particles and the tension in the string.

A trolley is dragged along a rough floor by a rope at 45° degrees to the horizontal. The trolley weighs 2 kg and the coefficient of friction is $\mu = 0.4$. Supposing that the trolley moves with constant velocity find the magnitude of the tension in the rope.

A particle is projected at an angle α from the horizontal with an initial speed U ms-1. At time t the horizontal displacement of the ball from its initial position O, is x metres and its vertical displacement is y metres.
Show that

$$y = x\tan(\alpha) - \frac{gx^2}{2U^2}(1 + \tan^2(\alpha))$$

A particle rests on a rough slope inclined at an angle α. The particle is on the point of slipping. Find a relationship between the coefficient of friction μ and α.

A particle of mass 5 kg is placed on a rough slope inclined at an angle of 25° to the horizontal. When the particle is released it accelerates down the slope at 0.2 ms^{-2}. Find the coefficient of friction between the slope and the particle.

A uniform plank is used to cross a brook. The plank has mass 20 kg and is 4 m long. It is supported on either side by blocks. One block is 0.4 m from the left hand end and the other is 0.6 m from the right hand end of the plank. Determine the forces exerted on the plank by the blocks.