4. [*In this question* **i** *and* **j** *are horizontal unit vectors*.]

A particle P of mass m kg lies on a smooth horizontal plane. The particle is acted upon by two forces, $\mathbf{F}_1$ N and $\mathbf{F}_2$ N, where $\mathbf{F}_1 = (3\mathbf{i} + \mathbf{j})$ and $\mathbf{F}_2 = (5\mathbf{i} - 16\mathbf{j})$.

Given that P moves with acceleration $68\,\text{m s}^{-2}$

(a) find the value of m.

(4)

Given that the force $(\mathbf{F}_1 + k\mathbf{F}_2)$ N, where k is a constant, acts in a direction which is perpendicular to the vector $(2\mathbf{i} + \mathbf{j})$

(b) find the exact value of k.

(4)

(Total for Question 4 is 8 marks)

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5. A motor race between two cars, A and B, takes place on a straight horizontal track.

At time $t = 0$, A has speed $35\,\text{m s}^{-1}$ and is 1 km from the finishing line. It then moves with constant acceleration $0.4\,\text{m s}^{-2}$ until it reaches the finishing line at time $t = T$ seconds.

(a) Find the value of T.

(3)

At time $t = 0$, B has speed $44\,\text{m s}^{-1}$ and is 200 m behind A.

Car B then moves with constant acceleration $0.5\,\text{m s}^{-2}$ until it reaches the finishing line.

(b) Find the length of time, from the instant when the speed of B is $9.5\,\text{m s}^{-1}$ **greater than** the speed of A, to the instant when B catches up with A.

(7)

(Total for Question 5 is 10 marks)