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8. [*In this question, the unit vectors* **i** *and* **j** *are in a vertical plane*, **i** *being horizontal and* **j** *being vertically upwards*.]

Two fixed points, X and Y, lie on horizontal ground with $XY = 60\,\text{m}$. At time $t = 0$ a particle, P, is projected from X with velocity $(12\mathbf{i} + b\mathbf{j})\,\text{m s}^{-1}$. At the same instant, another particle, Q, is projected from Y with velocity $(-c\mathbf{i} + d\mathbf{j})\,\text{m s}^{-1}$.

Given that the particles collide at a point Z and that b, c and d are positive constants,

(a) show that $b = d$.

(1)

The point Z is 10 m above the horizontal ground and the collision occurs at time $t = 3$ seconds.

(b) Find the value of d.

(2)

(c) Find the length of time for which Q is at least 10 m above the ground.

(3)

(d) Find the direction of motion of Q at the instant before it collides with P.

(5)

At time $t = T$ seconds, the direction of motion of P is perpendicular to its direction of motion at time $t = 0$

(e) Find the value of T.

(4)

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TOTAL FOR PAPER: 75 MARKS

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