10 In this question the unit vectors **i** and **j** are in the directions east and north respectively.

A particle R of mass 2 kg is moving on a smooth horizontal surface under the action of a single horizontal force **F** N. At time t seconds, the velocity $\mathbf{v}\,\text{m s}^{-1}$ of R, relative to a fixed origin O, is given by $\mathbf{v} = (pt^2 - 3t)\mathbf{i} + (8t + q)\mathbf{j}$, where p and q are constants and $p < 0$.

(a) Given that when $t = 0.5$ the magnitude of **F** is 20, find the value of p. **[6]**

When $t = 0$, R is at the point with position vector $(2\mathbf{i} - 3\mathbf{j})$ m.

(b) Find, in terms of q, an expression for the displacement vector of R at time t. **[4]**

When $t = 1$, R is at a point on the line L, where L passes through O and the point with position vector $2\mathbf{i} - 8\mathbf{j}$.

(c) Find the value of q. **[3]**