1. A particle P of mass 0.5 kg moves along the positive x-axis under the action of a single force of magnitude F newtons.

The force acts along the x-axis in the direction of x increasing.

When P is x metres from the origin O, it is moving away from O with

speed $\sqrt{\left(8x^{\frac{3}{2}} - 4\right)}$ m s^{-1}

Find F when P is 4 m from O.

(5)

(Total for Question 1 is 5 marks)

Question Number	Scheme			Marks
1	A complete method to find acceleration by differentiating v or v^2			M1
	Method 1 $v^2 = 8x^{\frac{3}{2}} - 4$ $2v\dfrac{dv}{dx} = 12x^{\frac{1}{2}}$ $v\dfrac{dv}{dx} = 6x^{\frac{1}{2}}$	Method 2 $\dfrac{dv}{dx} = \dfrac{1}{2}\left(8x^{\frac{3}{2}} - 4\right)^{-\frac{1}{2}} \times 12x^{\frac{1}{2}}$ $v\dfrac{dv}{dx} = \dfrac{1}{2} \times 12x^{\frac{1}{2}}$	Method 3 $\dfrac{dv}{dt} = \dfrac{1}{2}\left(8x^{\frac{3}{2}} - 4\right)^{-\frac{1}{2}} \times 12x^{\frac{1}{2}} \times \dfrac{dx}{dt}$ $\dfrac{dv}{dt} = \dfrac{1}{2}\left(8x^{\frac{3}{2}} - 4\right)^{-\frac{1}{2}} \times 12x^{\frac{1}{2}} \times \left(8x^{\frac{3}{2}} - 4\right)^{\frac{1}{2}}$	A1 A1
	$F = 0.5 \times 6x^{\frac{1}{2}} = 3x^{\frac{1}{2}}$			DM1
	$x = 4 \Rightarrow F = 6$			A1
				(5)
				(5 marks)

Notes	
M1	Complete method to find acceleration by differentiating in terms of x Must use correct form of acceleration (E.g. $\dfrac{dv}{dt} = \dfrac{1}{2}\left(8x^{\frac{3}{2}} - 4\right)^{-\frac{1}{2}} \times 12x^{\frac{1}{2}}$ is M0)
A1	Differentiation of their method with at most one numerical error (E.g. fraction or sign error)
A1	Correct acceleration i.e. correct derivative used or for example "acceleration =" Could be implied by correct value used in $F = ma$
DM1	Use of $F = 0.5a$ to obtain an expression in terms of x (seen or implied). Dependent on first M1.
A1	Cao

2. A spacecraft S of mass m moves in a straight line towards the centre of the Earth.

The Earth is modelled as a sphere of radius R and S is modelled as a particle.

When S is at a distance x, $x \geqslant R$, from the centre of the Earth, the force exerted by the Earth on S is directed towards the centre of the Earth.

The force has magnitude $\frac{K}{x^2}$, where K is a constant.

(a) Show that $K = mgR^2$

(2)

When S is at a distance $3R$ from the centre of the Earth, the speed of S is V.

Assuming that air resistance can be ignored,

(b) find, in terms of g, R and V, the speed of S as it hits the surface of the Earth.

(7)

(Total for Question 2 is 9 marks)