3. **In this question you must show all stages of your working.**
Solutions relying on calculator technology are not acceptable.

At time t seconds ($t \geqslant 0$) a particle P has position vector **r** metres, with respect to a fixed origin O, where

$$\mathbf{r} = (16t - 3t^3)\mathbf{i} + (t^3 - t^2 + 2)\mathbf{j}$$

Find

(a) the velocity of P at the instant when it is moving parallel to the vector **j**,

(5)

(b) the magnitude of the acceleration of P when $t = 4$

(4)

(Total for Question 3 is 9 marks)

Question Number	Scheme	Marks
3(a)	Differentiate **r** w.r.t. t	M1
	$\left(\mathbf{v} = \frac{\mathrm{d}\mathbf{r}}{\mathrm{d}t} =\right) \quad (16 - 9t^2)\mathbf{i} + (3t^2 - 2t)\mathbf{j}$	A1
	Sets **i** component = 0: $\quad 16 - 9t^2 = 0$	M1
	$t = \frac{4}{3} \Rightarrow \mathbf{v} = \ldots$	dM1
	$\mathbf{v} = \left(3 \times \frac{16}{9} - 2 \times \frac{4}{3}\right)\mathbf{j} = \frac{8}{3}\mathbf{j}$	A1
		(5)
3(b)	Differentiate **v** w.r.t. t	M1
	$\left(\mathbf{a} = \frac{\mathrm{d}\mathbf{v}}{\mathrm{d}t} =\right) \quad (-18t)\mathbf{i} + (6t - 2)\mathbf{j}$	A1ft
	Substitutes $t = 4$ and finds magnitude	dM1
	$\lvert\mathbf{a}\rvert = \sqrt{72^2 + 22^2} = \sqrt{5668} = 75 \ (\mathrm{m\ s^{-2}})$	A1
		(4)
		(9 marks)

Notes (*N.B. Column vectors are acceptable throughout*)	
(a) M1	Differentiates **r** w.r.t. t: at least one power decreasing by one in both **i** and **j** components.
A1	Correct vector
M1	Sets their **i** component equal to zero.
dM1	Solves for t **and** substitutes to find a velocity (or speed). Dependent on both previous M marks.
A1	Cao. Penalise extra solutions unless clearly discounted. Must be a vector. ISW if they go on to find a speed.
(b) M1	Differentiates **v** w.r.t. t: at least one power decreasing by one in both **i** and **j** components.
A1	Follow their **v** providing both **i** and **j** components are non-zero.
DM1	Substitutes $t = 4$ into their acceleration **and** uses Pythagoras' to find a magnitude. Dependent on previous M mark
A1	Cao. 75 or better (75.28612…) from correct working.

4.

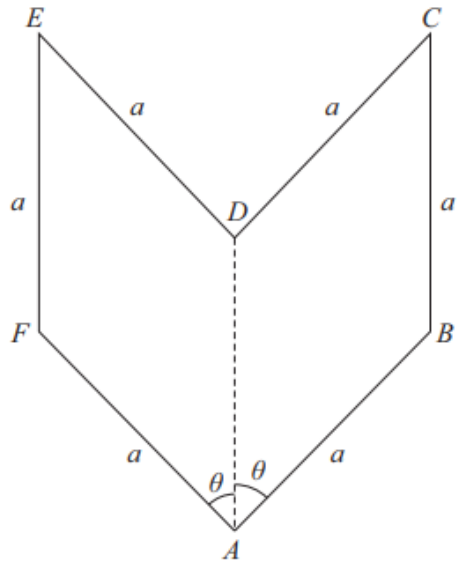


Figure 1

The uniform plane lamina $ABCDEF$ shown in Figure 1 is made from two identical rhombuses.

Each rhombus has sides of length a and angle BAD = angle $DAF = \theta$.

The centre of mass of the lamina is $0.9a$ from A.

(a) Show that $\cos\theta = 0.8$

(5)

The weight of the lamina is W.

A particle of weight kW is fixed to the lamina at the point A.

The lamina is freely suspended from B and hangs in equilibrium with DA horizontal.

(b) Find the value of k.

(4)

(Total for Question 4 is 9 marks)