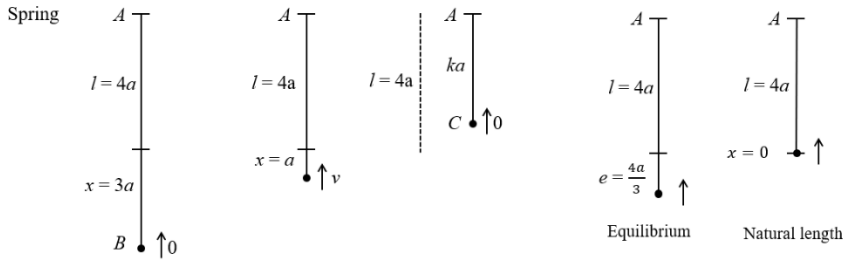
Question Number	Answer	Mark
4(a)		
	Equation of motion at B ($x = 3a$)	M1
	$\frac{3mg(3a)}{4a} - mg = \pm m\ddot{x}$	A1
	$(acc =) \pm \frac{5g}{4}$	A1
		(3)
4(b)	Either $\frac{3mg(3a)^2}{8a}$ or $\frac{3mg(a)^2}{8a}$ seen	B1
	Conservation of energy to the point where $x = a$	M1
	$\frac{3mg(3a)^2}{8a} = mg(2a) + \frac{3mg(a)^2}{8a} + \frac{1}{2}mv^2$	A1 A1
	$v = \sqrt{2ga}$	A1
		(5)
4(c)	A second EPE term (**different** to the one awarded a mark in part (b))	B1
	Conservation of energy to C ($v = 0$)	M1
	Correct energy equation to C e.g. From B to C • if x is the compression in the spring at C $\frac{3mg(3a)^2}{8a} = mg(x+3a) + \frac{3mg(x)^2}{8a}$ • if x is the extension in the spring at C $\frac{3mg(3a)^2}{8a} = mg(3a-x) + \frac{3mg(x)^2}{8a}$ • if $x = \pm(4a - ka)$ is the extension $\frac{3mg(3a)^2}{8a} = mg(7a-ka) + \frac{3mg(ka-4a)^2}{8a}$	A1
	Solve to obtain $k =$	DM1
	$k = \frac{11}{3}$ (only)	A1
		(5)
		(13)
	Notes for Question 4	
4(a)		

M1	Use Hooke's Law in an equation of motion at *B*. Tension must have an extension of 3*a*. All required terms present and no extras. Dimensionally correct. Condone sign errors. Condone *a* for acceleration but M0 if it is treated as a length.	
A1	Correct unsimplified equation	
A1	Accept 12, 12.3 (ms^{-2})	
4(b)		
B1	One correct EPE term	
M1	Form an equation using conservation of energy from *B* to $x = a$. All required terms present and no extras. Dimensionally correct. Condone sign errors. EPE must have the form $\frac{\lambda x^2}{\mu a}$ where $x = a$ and μ is a constant (condone $\mu = 1$). GPE must have the form *mgh* where $h = 2a$	
A1	Unsimplified equation with at most one error	
A1	Correct unsimplified equation	
A1	Or equivalent in terms of *a* and *g* Accept a correctly rounded decimal instead of $\sqrt{2}$ but must have $\sqrt{ga}$. Calculator display for $\sqrt{2}$ = 1.414213562	
4(c)		
B1	A correct relevant EPE term, it must be **different** to the one awarded in (b) and it must be used in (c).	
M1	Form a dimensionally correct conservation of energy equation Condone sign errors. EPE term must have the form $\frac{\lambda x^2}{\mu a}$ where *x* is their extension and μ is a constant (condone $\mu = 1$). GPE term must have the form *mgh* where *h* is a height in terms of *a* and/or *x* All required terms present and no extras. • ***B* to *C*:** 2 EPE terms and GPE • **Alternative point to *C*:** KE, GPE, 2 EPE (but 1EPE if using natural length position) **Equilibrium to *C***: $x = \frac{4a}{3}$, $v^2 = \frac{25}{12}ga$ leads to $\frac{3mg\left(\frac{4a}{3}\right)^2}{8a} + \frac{1}{2}m\left(\frac{25}{12}ag\right) = mg\left(\frac{16a}{3} - ka\right) + \frac{3mg(ka-4a)^2}{8a}$ **Natural length to *C***: $x = 0,\ v^2 = \frac{3}{4}ga$ leads to $\frac{1}{2}m\left(\frac{3}{4}ag\right) = mg(4a - ka) + \frac{3mg(ka-4a)^2}{8a}$ **Point in (b) to *C*:** $x = a\ ,\ v^2 = 2ga$ leads to $\frac{3mg(a)^2}{8a} + \frac{1}{2}m(2ga) = mg(5a - ka) + \frac{3mg(ka-4a)^2}{8a}$	
A1	Correct unsimplified equation (using their letter for length)	
DM1	Dependent on first M1. Solve to find a value for *k*.	
A1	3.7 or better	

5.

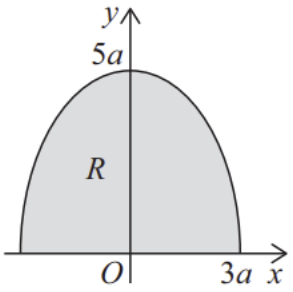


Figure 3

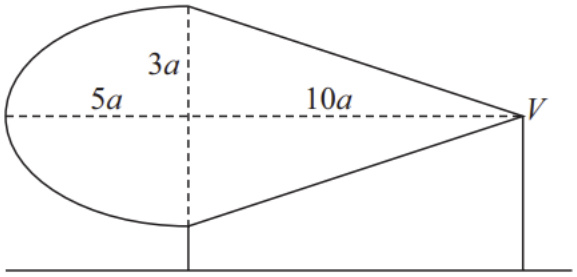


Figure 4

The region R, shown shaded in Figure 3, is the region enclosed between the x-axis and the curve with equation $\frac{x^2}{9a^2} + \frac{y^2}{25a^2} = 1$

Region R is rotated through π radians about the y-axis to form a solid of revolution. A uniform solid S has the same shape and size as this solid of revolution.

The volume of S is $30\pi a^3$

The distance of the centre of mass of S from O is d.

(a) Use algebraic integration to show that $d = \frac{15}{8}a$.

(6)

The solid S is joined to a uniform solid right circular cone C that is made of the **same material** as S to form a model.
The cone has vertex V, height $10a$ and base radius $3a$.
The plane face of S and the plane face of C coincide.
The model is supported on two light vertical rods.

- the first rod has one end attached to the model at V and the other end attached to horizontal ground
- the second rod has one end attached to the model at a point on the rim of the common plane face and the other end attached to the horizontal ground

The model rests in equilibrium with its axis of symmetry horizontal and in the same vertical plane as the two rods, as shown in Figure 4.

Given that the weight of the model is $2W$

(b) find, in terms of W, the thrust in the rod attached to the model at V.

(4)