M3 May 13 2015

1. A particle P of mass 0.5 kg is attached to one end of a light elastic spring, of natural length 1.2 m and modulus of elasticity λ newtons. The other end of the spring is attached to a fixed point A on a ceiling. The particle is hanging freely in equilibrium at a distance 1.5 m vertically below A.

(a) Find the value of
$$\lambda$$
.

(3)

The particle is now raised to the point B, where B is vertically below A and AB = 0.8 m. The spring remains straight. The particle is released from rest and first comes to instantaneous rest at the point C.

(b) Find the distance AC.

(4)

1)	P(1): T-0.5g=0	The state of the s	
	T=0-Sq		
	using Hoones law:		
	$T = \lambda x$		
	0.59 - 2 (0.3)		
	0.5g - 1 (0.3)		
	λ= 19.6		
			A
		1	
	AL B	8.0	ξ 1
		•	3 }
-	$E \cdot E = \frac{\lambda x^2}{21}$		
		0.4+x	7
	: 19.6(0.4)2		\ \x
+	2(1.2)		C S V
	98		9
	98 75 P.E. mgl.		0.59
+	P.E. mgL.	ob 3+ = 7	0 33
	: 0.50 (0-11-0-)		
1	: 0.5g (0.4+x)		
-	= 0.2g + 0.5gx	using conservation	of energy
t	KE = 0	98 + 0.29 +1	$3.89x - 49x^{2}$
	At C	75 49 x2	$-4.9x - \frac{49}{15}$
	f. F 1. 2		
+	£:E = 122 ²	x = 1	$x = -\frac{2}{5}$ (reject)
-	2	A = 1.2+1	
	= 19.6 x		and a second state of the second seco
-	2(1.2)	= 2.2 m	
	= 49 x2		
	KE = 0.	(1-3) 111	
	PE-0		

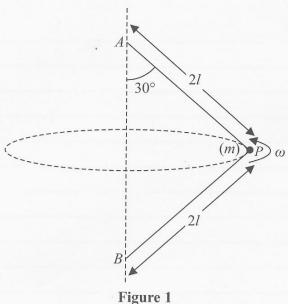
2. The finite region bounded by the x-axis, the curve with equation $y = 2e^x$, the y-axis and the line x = 1 is rotated through one complete revolution about the x-axis to form a uniform solid.

Use algebraic integration to

- (a) show that the volume of the solid is $2\pi(e^2 1)$, (4)
- (b) find, in terms of e, the x coordinate of the centre of mass of the solid.

(6)

2a	Volume: (1 4e Tr dx	2 2 2 T/ (0) 2 (d)
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		AL THE STATE OF TH
	$= \pi \left[2\vec{e} - 2\vec{e} \right]$ $= 2\pi \left[e^2 - 1 \right]$	15 82 X - 52 A
	27 [02 - 1]	
		2.81 × Z
21	$VOL \times \bar{x} = \int_{-\pi}^{\pi} y^2 x dx$	let us ~ let du se
20.	VOL X 2 = 11 9 1 0,2	Let $u = x$ Let $\frac{dv}{dx} = e^{2x}$ $\frac{du}{dx} = 1$ $\frac{dv}{dx} = \frac{1}{2}e^{2x}$
	Jo	Osc 2
	= 11 4 xe 2x	
	10/ [2x] [' 2x	42))
	$-4\pi \left(\left[\frac{1}{2} \times e^2 \times \right]^{\frac{1}{2}} - \int_{0}^{2} \frac{1}{2} e^{2x} \right)$	
	$4\pi \left(\frac{1}{2}e^2 - \frac{1}{4}\left[e^{2x}\right]^i dx\right)$	72-20 02 0 - 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
	(2 41 10)	V 102-10 - 105-10 -
	=4 Tr (1/2 e2 - 1/4 (e2 -1))	6 9
	$=\frac{1}{4\pi}\left(\frac{1}{2}e^2 - \frac{1}{4}e^2 + \frac{1}{4}\right)$	E LOUIS ACTUAL AND
5 12	$=\pi\left(e^{2}+1\right).$	3x/ -2.3
	$\bar{\chi} = \pi \left(e^2 + 1\right)$	1500
	27 (22-1)	o = 2y
	: \$ e ² +1	8-39
	$\frac{1}{2(e^2-1)}$	



A small ball P of mass m is attached to the midpoint of a light inextensible string of length 4l. The ends of the string are attached to fixed points A and B, where A is vertically above B. Both strings are taut and AP makes an angle of 30° with AB, as shown in Figure 1. The ball is moving in a horizontal circle with constant angular speed ω .

(a) Find, in terms of m, g, l and ω ,

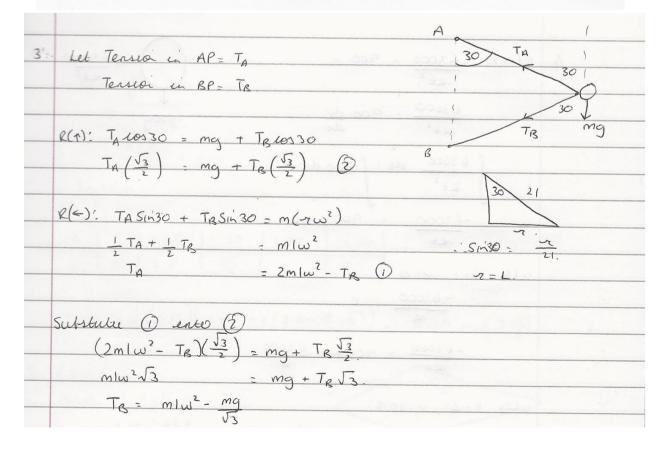
(i) the tension in AP,

(ii) the tension in BP.

(8)

(b) Show that $\omega^2 \geqslant \frac{g\sqrt{3}}{3I}$.

(2)



	2 m/w2	- (m/w² - mg) + mg	ORKE ORICE	
		V3	*	
٥.	$T_{\mathcal{B}} > 0$ $m w^2 - \frac{mq}{\sqrt{3}} > 0$ $ w^2 > 0$ $\sqrt{3}$		73 / B . 7 . 8	
1	m/w2- mg >0	90089 -	V-008 - 00884-1	
	1002 > 9		- V.00P.1	
	万.	4		
	W2 > 9		V = PI - PI	
	ω^2 > $\frac{9}{103}$			
	w2 3 v3 g			

4. A vehicle of mass 900 kg moves along a straight horizontal road. At time t seconds the resultant force acting on the vehicle has magnitude $\frac{63000}{kt^2}$ N, where k is a positive constant. The force acts in the direction of motion of the vehicle. At time t seconds, $t \ge 1$, the speed of the vehicle is t m s⁻¹ and the vehicle is a distance t metres from a fixed point t on the road. When t = 1 the vehicle is at rest at t and when t = 4 the speed of the vehicle is 10.5 m s⁻¹.

(a) Show that
$$v = 14 - \frac{14}{t}$$
 (7)

- (b) Hence deduce that the speed of the vehicle never reaches 14 m s⁻¹.
- (c) Use the trapezium rule, with 4 equal intervals, to estimate the value of x when v = 7 (4)

(1)

4.
$$R(\Rightarrow)$$
: $63000 = 900 a$.

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 $63000 = 900 dv$
 Rt^2
 $63000 dt = 900 dv$
 t^2
 $-63000 = 900 v + c$
 t^2
 t^2

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	-15750 - 900(10.5) - 63000 R.
	47250 - 9450
	R
	R: 5.
	-63000 = 900v - 63000
	- 12600 - 900V - 12600 E.
	14 - 14 = V.
+6.	As t is positive, for large values of T, the velocity i
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4c.	ule V=7 14- 14 = 7.
4c.	ule V=7
4c.	ule V=7 14- 14 = 7.
4c.	$14 - \frac{14}{\epsilon} = 7$ $\therefore 7 : \frac{14}{\epsilon}$
tc.	ule $V=7$ $14 - \frac{14}{E} = 7$
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tc.	
tc.	
tc.	ule $V=7$ $14 - \frac{14}{E} = 7$ $\vdots \frac{14}{E}$ $E = 2$

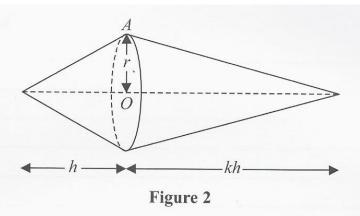
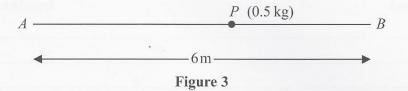


Figure 2 shows a uniform solid spindle which is made by joining together the circular faces of two right circular cones. The common circular face has radius r and centre O. The smaller cone has height h and the larger cone has height kh. The point A lies on the circumference of the common circular face. The spindle is suspended from A and hangs freely in equilibrium with AO at an angle of 30° to the vertical.

Show that
$$k = \frac{4r}{h\sqrt{3}} + 1$$
 (6)

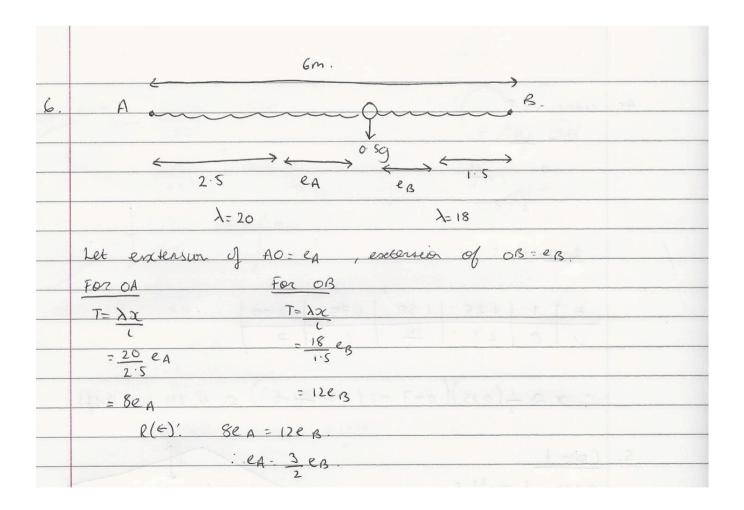
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mass: 1π-2hp	coner core,
= 1 TTr2 Rhp	
Centre = 1/4 h.	h kh
: <u>reh</u> : (nh, 0)	n
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- Jan	
Core 2	1 0.
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Centre: 4h	
= (-1/4 h, 0)	$\frac{h(R^2-1)}{4\pi(R+1)}$
man ratio: 1.	
p (ph) (-11)/1)	V3 = h(-12-1)
$R\left(\frac{Rh}{4}\right) + \left(\frac{-1}{4}h\right)(1) - (R+1)(\bar{z})$	42 +1 - R
$\frac{R^2h - h}{4} = \frac{(R+1)5c}{4}$	73
$\overline{x} = h(x^2 - 1)$ $\overline{y(x+1)}$	33



Two points A and B are 6 m apart on a smooth horizontal floor. A particle P of mass 0.5 kg is attached to one end of a light elastic spring, of natural length 2.5 m and modulus of elasticity 20 N. The other end of the spring is attached to A. A second light elastic spring, of natural length 1.5 m and modulus of elasticity 18 N, has one end attached to P and the other end attached to P0, as shown in Figure 3. Initially P1 rests in equilibrium at the point P1, where P2 is a straight line.

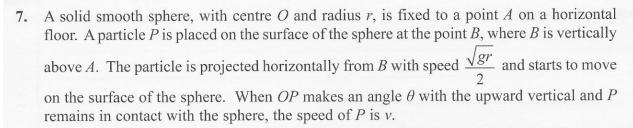
The particle P now receives an impulse of magnitude 6 N s acting in the direction OB and P starts to move towards B.

- (b) Show that P moves with simple harmonic motion about O. (4)
- (c) Find the amplitude of the motion. (4)
- (d) Find the time taken by P to travel 1.2 m from O. (3)



	6= 2.5+1.5+ ea+ eB	
	2 = eA + eB.	
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	2.5	-12(eB-JE)
	= 8(ka+x)	
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	$\frac{48 - 12x - 48 - 8x - 0.5x}{5}$	
	5 5	
	-1100	
	-40x = x	
	. SHM.	

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	6-0-5(v-0)
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	$\omega = 2\sqrt{10}$
	V = aw
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	2510
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	= 1.90 (346).
d.	x: a Sinwt.
	1.2 = 1.90 Sin (T40t)
	V406: 0.68
	t: 0.108 seeonds (3/6)
	The Control of the Co



(a) Show that
$$v^2 = \frac{gr}{4}(9 - 8\cos\theta)$$
. (4)

The particle leaves the surface of the sphere when $\theta = \alpha$.

(b) Find the value of
$$\cos \alpha$$
.

(4)

After leaving the surface of the sphere, P moves freely under gravity and hits the floor at the point C.

Given that $r = 0.5 \,\mathrm{m}$,

(c) find, to 2 significant figures, the distance AC.

(7)

	<u> 192</u> 2.
	Take A to have OPE Let mass=m. B
7.	At B
	PE = mgL $= mg(2r)$
	z 2 mg z.
	$\frac{kE - \frac{1}{2}mv^{2}}{-\frac{1}{2}m(\frac{1}{4}g^{2})}$
	- 1 mg·z.
	100 - 36
	At angle 0
	PE: mgh.
	= mgr(1+coso) KE = 1 mv ²
	Control of the contro
	conservation of energy: 2mgr + 1mgr = mgr + mgr coso +1 mr² 9 gr - grcoso - 1 v² 8 gr - grcoso - 1 v²
	655 (d-8100) = Ns.

76 (2): travally leadly of sphere Mg 1806 - R - M(\frac{\sigma}{2}) 2:0 Mg 1806 : M(\frac{9}{9}, 8000)) Mg 1806 : M(\frac{9}{9}, 8000) Mg 1806 : M(\frac{9}{9}, 8000) Mg 1806 : M(\frac{9}{9}, 8000) Mg 1800 : M(
Mg. Leso. M. (=) Leso. Mg. Leso. M. (=) Mg. L	76. P(K): towards eentre of sphere.	
Mg 1676 : $m\left(\frac{3^{2}}{4^{2}}(4-8600)\right)$ Mg 1676 : $m_{3}\left(9-8100\right)$ 12676 : $q = 8100$ 1268 : $q = 8100$ Vertual conferent : $V \sin x = S \sin x \sqrt{\frac{39}{8}}$ Reget abor ground : $-7 + 7(\frac{7}{4})$ $\frac{7}{8} = \left(\sin x \sqrt{\frac{39}{8}}\right)^{\frac{1}{2}} + \frac{1}{2}g\left(\frac{1}{2}\right)$ 4912 : $\left(\sin x \sqrt{\frac{39}{8}}\right)^{\frac{1}{2}} + \frac{1}{2}g\left(\frac{1}{2}\right)$ 4913 : $\left(\sin x \sqrt{\frac{39}{8}}\right)^{\frac{1}{2}} + \frac{1}{2}g\left(\frac{1}{2}\right)$ 4914 : $\left(\sin x \sqrt{\frac{39}{8}}\right)^{\frac{1}{2}} + \frac{1}{2}g\left(\frac{1}{2}\right)$ 4915 : $\left(\sin x \sqrt{\frac{39}{8}}\right)^{\frac{1}{2}} + \frac{1}{2}g\left(\frac{1}{2}\right)$ 4915 : $\left(\sin x \sqrt{\frac{39}{8}}\right)^{\frac{1}{2}} + \frac{1}{2}g\left(\frac{1}{2}\right)$ 4916 : $\left(\sin x \sqrt{\frac{39}{8}}\right)^{\frac{1}{2}} + \frac{1}{2}g\left(\frac{1}{2}\right)$ 4917 : $\left(\sin x \sqrt{\frac{39}{8}}\right)^{\frac{1}{2}} + \frac{1}{2}g\left(\frac{1}{2}\right)$ 4918 : $\left(\cos x \sqrt{\frac{39}{8}}\right)^{\frac{1}{2}} + \frac{1}{2}g\left(\frac{1}{2}\right)$ 4919 : $\left(\cos x \sqrt{\frac{39}{8}}\right)^{\frac{1}{2}} + \frac{1}{2}g\left(\frac{1}{2}\right)$ 5106 : $\left(\cos x \sqrt{\frac{39}{8}}\right)^{\frac{1}{2}} + \frac{1}{2}g\left(\frac{1}{2}\right)$ 5107 : $\left(\cos x \sqrt{\frac{39}{8}}\right)^{\frac{1}{2}} + \frac{1}{2}g\left(\frac{1}{2}\right)$ 5108 : $\left(\cos x \sqrt{\frac{39}{8}}\right)^{\frac{1}{2}} + \frac{1}{2}g\left(\frac{1}{2}\right)$ 5108 : $\left(\cos x \sqrt{\frac{39}{8}}\right)^{\frac{1}{2}} + \frac{1}{2}g\left(\frac{1}{2}\right)$ 5108 : $\left(\cos x \sqrt{\frac{39}{8}}\right)^{\frac{1}{2}} + \frac{1}{2}g\left(\frac{1}{2}\right)$ 6139 : $\left(\cos x \sqrt{\frac{39}{8}}\right)^{\frac{1}{2}} + \frac{1}{2}g\left(\frac{1}{2}\right)$ 7109 : $\left(\cos x \sqrt{\frac{39}{8}}\right)^{\frac{1}{2}} + \frac{1}{2}g\left(\frac{1}{2}\right)$ 7109 : $\left(\cos x \sqrt{\frac{39}{8}}\right)^{\frac{1}{2}} + \frac{1}{2}g\left(\frac{1}{2}\right)^{\frac{1}{2}}$ 7109 : $\left(\cos$	$Max = R = M\left(\frac{\sqrt{2}}{2}\right)$	
mg was $= m \left(\frac{9^{2}}{4r} \left(9 - 8 \cos \theta \right) \right)$ mg was $= \frac{m}{9} \left(9 - 8 \cos \theta \right)$ 4 $\cos \theta = \frac{9}{9} \cdot 8 \cos \theta$ 11 $\cos \theta = \frac{9}{9} \cdot 8 \cos \theta$ 12 $\cos \theta = \frac{3}{9} \cdot \frac{3}{$		
mg 1096 . mg (9-8 1000) 4100 . q - 8 1000. 1200 . 3 1001 . 3 1	192 (a ema)	
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$\frac{7}{8} \text{ metros}$ $\frac{7}{8} = \left(5 \ln x \sqrt{\frac{39}{8}} \right) + \frac{1}{2} g \left(t^2 \right)$ $4 \cdot 9t^2 + \left(5 \ln x \sqrt{\frac{39}{8}} \right) + \frac{7}{6} = 0$ $t = 0 \cdot 3191710 0.3125544$ $Houzgardal component : Vosix = 5 \cdot \cos x \sqrt{\frac{39}{8}}$ $distance traceled in the tensor of the second of t$		
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