Solomon Practice Paper

Mechanics 3D

Time allowed: 90 mintues

Question	Points	Score
1	7	
2	7	
3	9	
4	10	
5	11	
6	13	
7	18	
Total:	75	

Centre:

Name:

Teacher:

How I can achieve better:

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1. The mechanism for releasing the ball on a pinball machine contains a light elastic spring of natural length 15cm and modulus of elasticity λ. The spring is held compressed to a length of 9 cm by a force of 4.5N.

   (a) Find λ. [3]

   (b) Find the work done in compressing the spring from a length of 9 cm to a length of 5 cm. [4]

   Total: 7

2. A small bead P is threaded onto a smooth circular wire of radius 0.8 m and centre O which is fixed in a vertical plane. The bead is projected from the point vertically below O with speed u ms^{-1} and moves in complete circles about O.

   (a) Suggest a suitable model for the bead. [1]

   (b) Given that the minimum speed of P is 60% of its maximum speed, use the principle of conservation of energy to show that $u = 7$. [6]

Total: 7

3. At time t seconds the acceleration, a ms^{-2}, of a particle is given by

$$a = \frac{4}{(1+t)^3}.$$

When $t = 0$, the particle has velocity 1 ms^{-1} and displacement 3 m from a fixed origin O.

(a) Find an expression for the velocity of the particle in terms of t. [4]

(b) Show that when $t = 3$ the particle is 10.5 m from O. [5]

Total: 9

4. A particle of mass 0.5kg is moving on a straight line with simple harmonic motion. At time $t = 0$ the particle is instantaneously at rest at the point A. It next comes instantaneously to rest 3 seconds later at the point B where $AB = 4$m.

   (a) For the motion of the particle write down [2]

   i. the period,

   ii. the amplitude.

   (b) Find the maximum kinetic energy of the particle in terms of π. [4]

   The point C lies on AB at a distance of 1.2m from B.

   (c) Find the time it takes the particle to travel directly from A to C, giving your answer in seconds correct to 2 decimal places. [4]

Total: 10

5. When a particle of mass M is at a distance of x metres from the centre of the moon, the gravitational force, F N, acting on it and directed towards the centre of the moon is given by

$$F = \frac{(4.90 \times 10^{12})M}{x^2}.$$

A rocket is projected vertically into space from a point on the surface of the moon with initial speed u ms^{-1}. Given that the radius of the moon is (1.74×10^6)m,

(a) show that the speed of the rocket, v ms^{-1}, when it is x metres from the centre of the moon is given by [7]

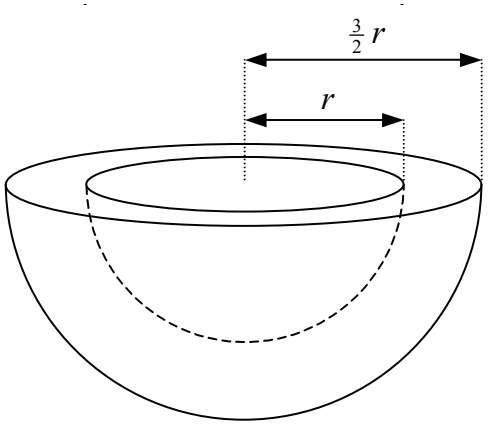
$$v^2 = u^2 + \frac{a}{x} - b,$$

where a and b are constants which should be found correct to 3 significant figures.

(b) Find, correct to 2 significant figures, the minimum value of u needed for the rocket to escape the moon's gravitational attraction. [4]

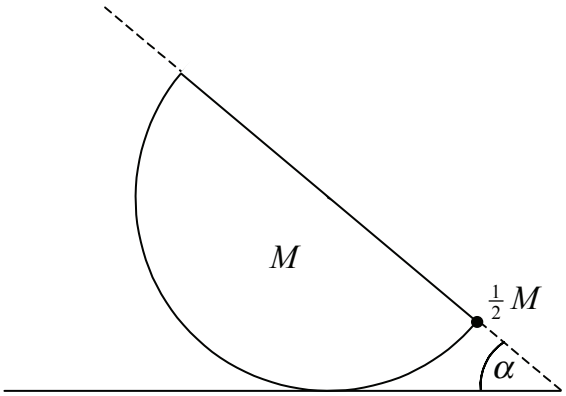
Total: 11

6. Figure shows a bowl formed by removing from a solid hemisphere of radius $\frac{3}{2}r$, a smaller hemisphere of radius r having the same axis of symmetry and the same plane face.



(a) Show that the centre of mass of the bowl is a distance of $\frac{195}{304}$r from its plane face. [7]

The bowl has mass M and is placed with its curved surface on a smooth horizontal plane. A stud of mass $\frac{1}{2}M$ is attached to the outer rim of the bowl.



When the bowl is in equilibrium its plane surface is inclined at an angle α to the horizontal as shown in Figure.

(b) Find $\tan\alpha$. [6]

Total: 13

7. A cyclist is travelling round a circular bend of radius 25m on a track which is banked at an angle of 35° to the horizontal.

   In a model of the situation, the cyclist and her bicycle are represented by a particle of mass 60kg and air resistance and friction are ignored.

   Using this model and assuming that the cyclist is not slipping,

   (a) find, correct to 3 significant figures, the speed at which she is travelling. [5]

   In tests it is found that the cyclist must travel at a minimum speed of 10 ms^{-1} to prevent the bicycle from slipping down the slope. A more refined model is now used with a coefficient of friction between the bicycle and the track of μ.

   Using this model,

   (b) show that $\mu = 0.227$, correct to 3 significant figures, [8]

   (c) find, correct to 2 significant figures, the maximum speed at which the cyclist can travel without slipping up the slope. [5]

Total: 18