Year 12 Circular Motion, Gravity and Equilibrium Practise test

**Section 1 Short response (15 marks)**

1. An athlete is practising throwing the hammer at home with home· made equipment. A cord is tied around a 2.0kg brick. The amateur athlete then whirls the home-made 'hammer' around in a circle a few times and throws it as far as she can in her back yard.



1. At which point should the hammer be released if it is not to damage any windows, walls or fences? A

(1 mark)

1. Explain the Physics principles involved in the motion of the ‘hammer’ both before and after it is released. Hammer moves in a circular motion because it is being pulled continuously towards the centre of the circle. Once released it continues to move in the direction in which it was travelling due to its inertia.

(3 marks)

2. Suppose you are investigating the idea of gravitational force between two objects. If the size of the gravitational force of attraction between the two objects is F when they are placed a distance r apart on the Earth's surface, what is the magnitude (in terms of F) of the gravitational force of attraction between them if:

a) the mass of one object is doubled? .......2F

b) the mass of both objects is halved? .........F/4...........

c) the distance between the two centres of masses is halved? ............4F....

d) the two objects are placed a distance r apart on the Moon's surface? ............F......

(4 marks)

3.a) Three balls (A,B,&C) sit at equilibrium on the shaped surface as pictured.



(a) Name the "type of equilibrium" for the ball in position A. Unstable

(b) Name the "type of equilibrium" for the ball in position B. Stable

(2 marks)

4. The cross-sectional diagrams below show concrete retaining walls (a) and (b) used to retain earth. The earth, particularly when wet, can exert significant force (F as shown on diagram (a)) on the wall and lead to collapse.



1. On diagram (a) superimpose a lever diagram that shows the torque that keeps the wall upright. Clearly label forces, distances and the pivot point. Weight provides CM to balance CM caused by F

Weight

A

(2 marks)

1. State clearly, using the labels from your torque diagram, the mathematical relationship that must exist for the wall to remain upright and not topple over. (1 mark)

∑CM = ∑ACM

Weight x d = F x h where d is distance from A to Weight line of action and H is distance from bottom of wall to F line of action.

(c) Explain why the retaining wall shown as diagram (b) is a more stable structure.

You should give TWO different reasons. (2 marks)

Extra weight in base gives greater clockwise moment.

Weight of soil above base provides additional clockwise moment.

Longer base provides a greater moment arm which produces a larger clockwise moment.

**Section 2 Problem solving (25 marks)**

1. Tarzan plans to cross a river by swinging in a vertical arc using a hanging vine so that his centre of mass is a constant 4.00 m from the point where the vine is attached. If he has a mass of 80.0 kg and the maximum force he can exert with his arms on the vine is 1500 N. What is his maximum speed he can tolerate at the lowest point of his swing?

FT ∑F = FT + Fmg = mv2/r

to centre is positive

 1500 + (- 80x9.8) = mv2/r

 v = 5.98 ms-1

 Fmg

(4 marks)

1. The diagram below shows a 57.5 kg diver preparing to dive. The 4.00 m long board is of uniform density and has a mass of 6.50 kg. The right hand support acts as a pivot point and the board is fixed down to the left hand support as shown.



1. Calculate the force required to "fix" the board to the left-hand support when the diver's mass is 3.00 m out on the diving board.

∑τ = 0 bout A

A

∑CM = ∑ACM

(57. x9.8x3)+(6.5x9.8x1) = F x 1

F =1750 N down

1. How far out on the board would the diver have to be such that the force required to "fix" the board to the left-hand support was reduced to 1.00 kN?

∑τ = 0 bout A

∑CM = ∑ACM

(57.5x9.8xd)+(6.5x9.8x1) = 1000 x 1

d = 1.66 m out from A

(5 marks)

1. A traffic light of mass 30.0kg issuspended from two wires as shown in the diagram. Find the force of tension in each of the two wires. (You may ignore the mass of the wires).

FT2

FT1

(5 marks)

FT2

37◦  cos37 = FT2/Fmg

 FT2 = cos37 x 30 x 9.8

 Fmg  FT2 = 235 N as shown

 sin37 = FT1/Fmg

FT1

 FT1 = sin37 x 30 x 9.8

 FT1 = 177 N as shown

1. An 'Octopus' machine at the Royal Show is capable of revolving twice every 7.00 s. Each of the eight seats moves in a horizontal circle with a diameter of 6.80 m.
2. lf you were riding the 'Octopus', what would your speed be?

v = 2x2πr/t = 4π x 3.4/7

v = 6.10 ms-1

(2 marks)

1. Calculate the maximum horizontal reaction force that the seat would exert on you if you weigh 65.0 kg.

FR = mv2/r = 65x6.12/3.4

FR = 711N towards the centre

 (2 marks)

1. a) Show a full calculation to find the mass of the Sun using the mass of the Earth and the Earth –Sun distance from your data sheet. The Sun exerts a gravitational attraction of 3.55 x 1022 N on the Earth.

F = GMSME/r2

 MS = Fr2/GME = 3.55 x 1022 x (1.5 x1011)2 / (6.67x10-11 x 5.98x1024)

 MS = 2.00x1030 kg

(3 marks)

b) What is the orbital speed of the space shuttle when it is in an orbit at a height of 320 km above the Earth's surface?

mv2/r = GMEm/r2 where r = (RE + 320 000)m

 v = √ GME/r = 7.72 ms-1

(4 marks)

**Section 3 Comprehension (10 marks)**

1. Calculate the Earth's gravitational field strength at Mathilde's position 195 million kilometres from Earth.

g = GMM/r2 where r = RE + 1.95x1011m

g = 1.05 x 10-8 Nkg-1 (2 marks)

1. Assuming Mathilda to be spherical with a diameter of 59.0 km and an average density *(D=mass/volume)* of 2000 kg per cubic metre, calculate an assumed mass of Mathilde. (Volume of a sphere is 4πr3/3).

Mass = D xV = 2000 x 4πr3/3 = 2.15x1017 kg (2 marks)

1. The picture implies that NEAR takes up a circular orbit around Mathilde at a radius of 1200 km, yet both

articles refer to a fly-past. Calculate the maximum possible velocity of NEAR tangental to Mathilde to allow the asteroid to capture and hold the satellite in circular orbit. *(Use the mass of Mathilde from Question 2.)*

mv2/r = GMMm/r2

v = √(6.67x10-11 x 2.15x1017/1.2x106)

v = 3.46ms-1 (2 marks)

1. Could you land on Mathilde's equator?

( If NEAR landed on Mathilde's equator, would the centripetal acceleration produced by Mathilde be

sufficient to allow the probe to "stick" to its rotating surface).

*Assume Mathilde to be spherical and rotating on it's axis* *with a period of* 17.5 *days. Diameter* = *59.0 km.*

Centripetal acceleration needed to hold probe:

ac = v2/r and v = πd/T = 59 000π/(17.5x24x3600)

ac = 0.1232/29 500 = 5.09x10-7ms-2

Centripetal acceleration provided:

g = GMM/r= 486 ms-2(Nkg-1)

Yes, you could land on Mathilde.

(4 marks)