HW 1 on CENTRIPETAL FORCES - SOLUTIONS

1. A rock tied to a string is traveling at a constant speed of 4 m / s in a circle of radius 1.5 m. Calculate the magnitude of the centripetal acceleration of the rock. What is the direction of the acceleration?

$a_c = m\frac{v^2}{r}$ $\qquad$ $a_c = 10.7\ m/s^2$

2. A 1.3 m long fishing line rated as "10 lb test" that can stand a force of 10 lb (44.48 N) is attached to a rock of mass 0.5 kg. Calculate the maximum speed at which the rock can be rotated without breaking the line.

$F_c = m\frac{v^2}{r}$ $\qquad$ $v\ =\ 10.75\ m/s$

3. A rock tied to the end of a string moves in a circle at a constant speed of 2.5 m / s and experiences an acceleration of 4.0 m / s^2. What is the radius of the circle of its motion?

$a_c = m\frac{v^2}{r}$ $\qquad$ $\mathrm{r}\ =\ 1.56\,\mathrm{m}$

4. A rock tied to the end of a string moves in a circle of radius 1.2 m with a constant speed of 3.0 m / s. Calculate the centripetal acceleration of the rock.

$a_c = m\frac{v^2}{r} \quad = 7.5\ m/s^2$

5. Calculate the gravitational attraction between a person of mass 60 kg and a building of mass 10,000 kg when the person is 5 m from the building.

$F = G\frac{m_1 m_2}{r^2} \quad = 1.6 \times 10^{-6} N$

6. A satellite of mass 500 kg is placed in an orbit of radius 5 times the radius of the Earth, i.e. the distance between the satellite and the center of the Earth is equal to 5 Earth radii. Calculate the centripetal force experienced by the satellite. The radius of the Earth is 6.37 x 10^6 m

$F_c = F = G\frac{M_E m}{R^2}$ $\qquad$ $F_{cnew} = G\frac{M_E m}{(5R)^2} = \frac{1}{25}G\frac{M_E}{R^2}\ m = \frac{1}{25}gm = \frac{1}{25} \times 9.80 \times 500$

$F_{cnew} = 197N$ $\qquad$ You may be surprised by how small this force is.

7. The distance from the Earth to the Sun is 1.5 x 10^{11} m (93 million miles), and the time for one complete orbit of the Earth about the Sun is one year. How long would it take for a planet located at twice this distance from the Sun to complete one orbit?

$F_c = F = G\frac{M_S M_E}{R^2}$ $\qquad$ $\frac{F_c}{F_{cnew}} = \frac{G\frac{M_S M_E}{d^2}}{G\frac{M_S M_E}{(2d)^2}} = 4$

$$\frac{F_c}{F_{cnew}} = \frac{M_E \frac{v^2}{d}}{M_E \frac{v_{new}^2}{2d}} = 4 \quad \rightarrow \quad \frac{v^2}{v_{new}^2} = 2 \quad \rightarrow \quad \left(\frac{\frac{2\pi d}{T}}{\frac{2\pi(2d)}{T_{new}}} \right)^2 = 2$$

$$\left(\frac{T_{new}}{2T} \right)^2 = 2 \quad \rightarrow \quad T_{new}^2 = 8T^2 \quad \rightarrow \quad T_{new} = \sqrt{8}\ years = 2.83\ years$$

8. A car of mass 1000 kg travels around a level curve of radius 40 m. If the maximum frictional force that can be exerted upon the car by the road (determined by the coefficient of friction between the tires and the road) is 7000 N how fast can the car travel without "spinning out?"

$$F_{fr} = F_c = m\frac{v^2}{r} \qquad v = 16.7\frac{m}{s} = 37.3\ mi/h$$

9. The mass of Mars is 6.37×10^{23} kg and its radius is 3430 km. Calculate the value of g for Mars

$g = G M_M / r^2$ $\quad g = (4.25 \times 10^{13}) / (1.18 \times 10^{13})\ m / s^2$

$g = 3.60\ m / s^2$

10. The Earth has a mass of 5.98×10^{24} kg, the Moon has a mass of 7.34×10^{22} kg, and the distance from the center of the Earth to the center of the Moon is 3.8×10^5 km. Calculate the gravitational attractive force between the Earth and the Moon.

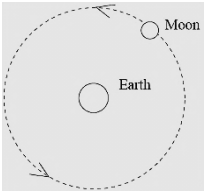
$F = G m_E m_M / r^2$

$F = (6.67 \times 10^{-11}\ N\ m^2/kg^2)(5.98 \times 10^{24}\ kg)(7.34 \times 10^{22}\ kg) / (3.8 \times 10^8\ m)^2$

$F = 2.03 \times 10^{20}\ N$

HW 2 on CENTRIPETAL FORCES

1. The Moon orbits the Earth in a nearly circular orbit at constant speed as shown.

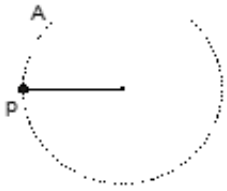


Which of the following diagrams correctly shows the force(s) acting on the Moon in the position shown above?

A. B. C. D.

ANS: B

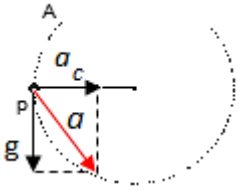
2. A pendulum, consisting of a heavy bob attached to a rigid rod, is released from rest at point A as shown in the diagram below. When the bob is a point p, the rod is horizontal.



Which arrow best indicates the direction of the acceleration of the bob at point p?

A. ← B. ↘ C. ↓ D. →

ANS: B

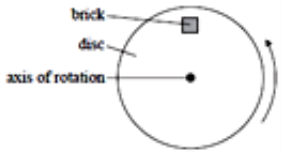


3. Two satellites of equal mass, S_1 and S_2, orbit the Earth. S_1 is orbiting at a distance *r* from the Earth's centre at speed *v*. S_2 orbits at a distance 2*r* from the Earth's centre at speed v/2 . The ratio of the centripetal force on S_1 to the centripetal force on is S_2

A. 1/8 . B. 1/4 . C. 4. D. 8.

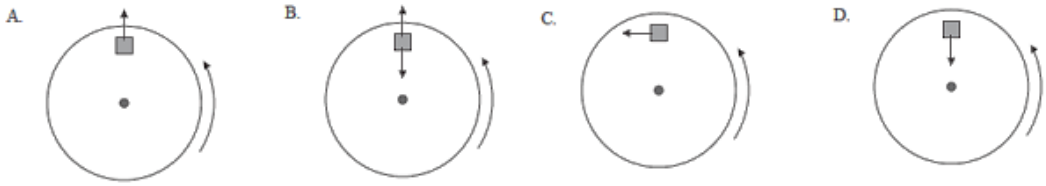
ANS: 8

4. A brick is placed on the surface of a flat horizontal disc as shown in the diagram below.



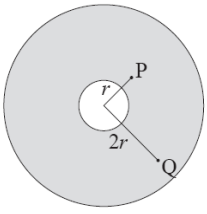
The disc is rotating at constant speed about a vertical axis through its centre. The brick does not move relative to the disc.

Which of the diagrams below correctly represents the **horizontal** force or forces acting on the brick?



ANS: D

5. Two points P and Q are at distances *r* and 2*r* respectively from the centre of a compact disc (CD) as shown.

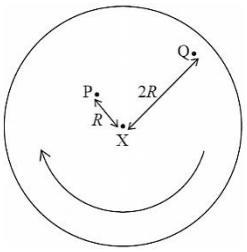


When the disc is rotating about its centre, the ratio of the centripetal accelerations at P and Q is

A. 1/2. B. 1. C. $\sqrt{2}$. D. 2.

ANS: A

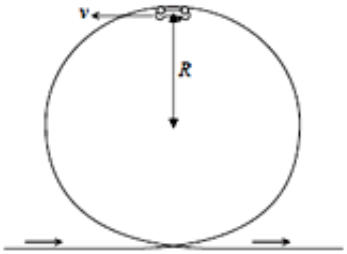
6. Points P and Q are at distances R and 2R respectively from the centre X of a disc, as shown below.



The disc is rotating about an axis through X, normal to the plane of the disc. Point P has linear speed v and centripetal acceleration a. Which one of the following is correct for point Q?

	Linear speed	**Centripetal acceleration**
A.	v	a
B.	v	2a
C.	2v	2a
D.	2v	4a

ANS:C



7. In a fairground ride, a car of mass *M* travels on rails around a vertical loop of effective radius *R*. At the top of the loop, the speed of the car is *v*. The car stays in contact with the rails, as shown below.

The acceleration of free fall is *g*.

Which of the following is the correct expression for the force that the rails exert on the car?

A. $\frac{Mv^2}{R} - Mg$ B. $\frac{Mv^2}{R}$ C. Mg D. $\frac{Mv^2}{R} + Mg$

ANS: A

8. Which of the following can *not* be used as units for the centripetal acceleration of a mass moving in a circular path?

A. rad s^{-2} B. m s^{-2} C. N kg^{-1} D. km h^{-2}

ANS: A

9. An object is moving in a circle of radius r with an initial (linear) speed v. It then accelerates to 2v. The ratio of the final centripetal force to the initial centripetal force is

A. 0·25 B. $\sqrt{2}$ C. 2 D. 4

ANS: D