## Physics 12 - Chapter 3 Quiz          Name:__________________

**A. True/False** (8 marks K/U)

*Indicate whether the sentence or statement is true or false.*

1. A body in Uniform Circular Motion experiences acceleration that is constant in magnitude.

T F

2. Centripetal acceleration is in a direction tangential to the path of the object in motion.

T F

3. At a constant speed, the centripetal acceleration of an object in uniform circular motion is inversely proportional to the orbital radius, yet, at a constant period of revolution, the centripetal acceleration is directly proportional to the orbital radius.

T F

4. The centrpetal force on an object in uniform circular motion is, as required by Newton's first law of motion, directed toward the centre of the circle.

T F

5. Centripetal force is a fundamental force of nature that applies to all objects, both natural and human-made, in circular motion.

T F

6. It is possible for static friction to be the sole force producing centripetal acceleration in a moving object.

T F

7. The International Space Station is an example of an artificial satellite.

T F

8. As the radius of the orbit of a satellite in uniform circular motion around a central body increases, the speed of the satellite decreases.

T F

**B. Multiple Choice** (4 marks K/U)

9. You are whirling a rubber stopper of mass *m,* attached to a string, in a vertical circle at a high constant speed. At the top of the circle, the net force that causes acceleration is:

a. horizontal and greater in magnitude than *mg*

b. horizontal and lower in magnitude than *mg*

c. vertically downward and greater in magnitude than *mg*

d. vertically downward and lower in magnitude than *mg*

e. vertical and equal in magnitude to *mg*

10. At the bottom of the circle for this same rubber stopper, the net force that causes acceleration is:

a. horizontal, and greater in magnitude than *mg*

b. horizontal, and lower in magnitude than *mg*

c. vertically upward, and greater in magnitude than *mg*

d. vertically upward, and lower in magnitude than *mg*

e. vertical, and equal in magnitude to *mg*

11. You now reduce the speed of this stopper, so that the stopper barely makes it over the top of the circle. When the stopper is at its highest point, the net force toward the centre of the circle is:

a. horizontal, and greater in magnitude than *mg*

b. horizontal, and lower in magnitude than *mg*

c. vertically downward, and greater in magnitude than *mg*

d. vertically downward, and lower in magnitude than *mg*

e. vertical, and equal in magnitude to *mg*

12. When the child on the swing in **Figure 1(b)** reaches the lowest position on the swing, the vector in **Figure 1(a)** that gives the direction of the centripetal force is:

a. vector 4

b. vector 10

c. vector 12

d. vector 6

e. vector 8

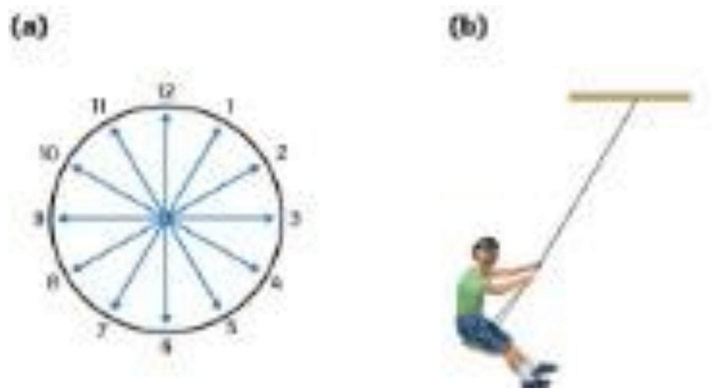


Fig. 1

**C. Problem Solving** (20 marks, C and A)

1. Neptune travels in a nearly circular orbit, of diameter 9.0

1012 m, around the Sun. The mass of Neptune is 1.0

1026 kg. The gravitational force of attraction between Neptune and the Sun has a magnitude of 6.8

1020 N.

(a) What is the speed of Neptune?

(b) Determine Neptune's period of revolution around the Sun in Earth years.

2. A 45.7-kg boy on a swing moves in a circular arc of radius 3.80 m. At the lowest position, the child's speed reaches 2.78 m/s. Determine the magnitude of the tension in each of the two vertical support chains.

3. At a certain distance above Earth's surface, the gravitational force on a certain object is only 2.8% of its value at Earth's surface. Determine this distance, expressing it as a multiple of Earth's radius, rE.

4. Obtain the value of g at the surface of Earth using the motion of the Moon. Assume that the Moon's period around Earth is 27 d 8 h and that the radius of its orbit is 60.1 times the radius (6.38x10^6 m) of Earth.

Solutions:

| | | |
|---|---|---|
| 1. T | 5. F | 9. C |
| 2. F | 6. T | 10. C |
| 3. T | 7. T | 11. E |
| 4. T | 8. T | 12. C |

Problem Solving

1. C/ 1 marks, A/ 4 marks

$$r = \frac{9.0\times10^{12}\text{ m}}{2} = 4.5\times10^{12}\text{ m}$$

$$m_N = 1.0\times10^{26}\text{ kg}$$

$$F_G = 6.8\times10^{20}\text{ N}$$

(a) $F_G = \dfrac{m_N v^2}{r}$

$$v = \sqrt{\frac{F_G r}{m_N}}$$

$$= \sqrt{\frac{(6.8\times10^{20}\text{ N})(4.5\times10^{12}\text{ m})}{1.0\times10^{26}\text{ kg}}}$$

$$v = 5.5\times10^{3}\text{ m/s}$$

The speed of Neptune is $5.5\times10^{3}$ m/s.

(b) $v = \dfrac{2\pi r}{T}$

$$T = \frac{2\pi r}{v}$$

$$= \frac{2\pi(4.5\times10^{12}\text{ m})}{5.5\times10^{3}\text{ m/s}}$$

$$= 5.1\times10^{9}\text{ s}$$

$$T = 1.6\times10^{2}\text{ a}$$

Thus, Neptune's period of revolution around the Sun in Earth years is $1.6\times10^{2}$ a.

2. C / 2 marks, A / 3 marks

$m = 45.7$ kg
$r = 3.80$ m
$v = 2.78$ m/s

Let the positive direction be upward. The tension in each of the two vertical support chains is equal. Since $\Sigma F = 2F_T + (-F_g)$ and $\sum F = \dfrac{mv^2}{r}$, then:

$$\begin{aligned}
2F_T &= \frac{mv^2}{r} - (-mg) \\
&= \frac{(45.7\text{ kg})(2.78\text{ m/s})^2}{3.80\text{ m}} + (45.7\text{ kg})(9.80\text{ m/s}^2) \\
2F_T &= 541\text{ N} \\
F_T &= 2.70 \times 10^2\text{ N}
\end{aligned}$$

The magnitude of the tension in each of the two vertical support chains is $2.70 \times 10^2$ N.

3. C / 1 marks, A / 4 marks

Let $F_1$ be the gravitational force at Earth's surface and $F_2$ be the gravitational force at distance $r$. Thus, $\dfrac{F_2}{F_1} = 0.028$.

$$\begin{aligned}
\frac{F_2}{F_1} &= \frac{\left(\dfrac{Gmm_E}{(r + r_E)^2}\right)}{\left(\dfrac{Gmm_E}{{r_E}^2}\right)} \\
0.028 &= \left(\frac{r_E}{r + r_E}\right)^2 \\
\left(\frac{r_E}{r + r_E}\right) &= 0.17 \\
0.17r &= (1 - 0.17)r_E \\
r &= 5.0r_E
\end{aligned}$$

The required distance above Earth's surface would be 5.0 $r_E$.

4. C / 2 marks, A / 3 marks

$T_M = 27 \text{ d } 8 \text{ h} = 2.3616 \times 10^6 \text{ s}$
$r_E = 6.38 \times 10^6 \text{ m}$
$r_{EM} = 60.1\ r_E$

Consider first that the force that causes the centripetal acceleration of the Moon around Earth is the force of gravity.

$$\Sigma F_M = F_g = ma_c$$

$$\frac{Gm_M m_E}{r_{EM}^2} = \frac{4\pi^2 m_M r_{EM}}{T_M^2}$$

$$m_E = \frac{4\pi^2 r_{EM}^3}{GT_M^2} \quad \text{(Equation 1)}$$

Next consider that the force of universal gravitation exerted by Earth on an object of mass $m$ on Earth's surface equals the object's weight:

$$F_g = mg$$

$$\frac{Gmm_E}{r_E^2} = mg$$

$$\frac{Gm_E}{r_E^2} = g$$

$$m_E = \frac{gr_E^2}{G} \quad \text{(Equation 2)}$$

Equating Equations 1 and 2:

$$\frac{gr_E^2}{G} = \frac{4\pi^2 r_{EM}^3}{GT_M^2}$$

$$g = \left(\frac{4\pi^2}{T_M^2}\right)\left(\frac{r_{EM}^3}{r_E^2}\right)$$

$$= \left(\frac{4\pi^2}{T_M^2}\right)\left(\frac{(60.1 r_E)^3}{r_E^2}\right)$$

$$= \left(\frac{4\pi^2}{T_M^2}\right)(60.1^3) r_E$$

$$= \left(\frac{4\pi^2}{(2.3616\times10^6 \text{ s})^2}\right)(60.1^3)(6.38\times10^6 \text{ m})$$

$$g = 9.80 \text{ m/s}^2$$

The value of $g$ at Earth's surface using the motion of the Moon is $9.80 \text{ m/s}^2$.