PhyzExamples: UCM & Gravity

Physical Quantities • Symbols • Units • Brief Definitions

Radius • R or r • m • Distance from the center of the circle to the center of the object in circular motion. If motion is circular, radius is constant.

Tangential Velocity • v / Tangential Speed • v • m/s • Velocity or speed of an object in circular motion. In uniform circular motion, tangential *speed* is constant while tangential *velocity* is always changing.

Centripetal Force • F_C • N • Force on an object in circular motion directed radially inward (toward the center of the circle).

Gravitational Force • F_G or W • N • Attractive force between two objects with mass (due only to their mass).

Universal Gravitation Constant • G • $N{\cdot}m^2/kg^2$ • $6.67 \times 10^{-11}\ N{\cdot}m^2/kg^2$

Equations

$F_C = mv^2/R$ • centripetal force = mass · tangential speed squared / radius

$F_G = GMm/R^2$ • (Newton's Universal Gravitation) • gravitational force = universal gravitation constant · mass of one object · mass of the other object / radius squared

Smooth Operations Examples

1. What is the force needed to keep a 0.50-kg object moving in a 0.60-m circle at 2.8 m/s?

1. $m = 0.50\ kg \quad R = 0.60\ m \quad v = 2.8\ m/s$
$F_C = ?$
$F_C = mv^2/R$
$F_C = 0.50\ kg \cdot (2.8\ m/s)^2 / 0.60\ m$
$\underline{F_C = 6.5\ N}$

2. What is the mass of an object moving at 4 m/s in a circle having a 3-m radius and experiencing a 24-N centripetal force?

2. $v = 4\ m/s \quad R = 3\ m \quad F_C = 24\ N \quad m = ?$
$F_C = mv^2/R$
$m = F_C R/v^2$
$m = 24\ N \cdot 3\ m / (4\ m/s)^2$
$\underline{m = 4.5\ kg}$

3. What is the gravitational force of the Earth on the moon?

[Numerical values found on Solar System Reference sheet]

3. $M = 5.98 \times 10^{24}\ kg \quad m = 7.36 \times 10^{22}\ kg$
$R = 3.82 \times 10^{8}\ m$
$F_G = GMm/R^2$
$F_G = 6.67 \times 10^{-11}\ N{\cdot}m^2/kg^2 \cdot 5.98 \times 10^{24}\ kg \cdot 7.36 \times 10^{22}\ kg / (3.82 \times 10^{8}\ m)^2$
$\underline{F_G = 2.0 \times 10^{20}\ N}$

4. How far is 80-kg Felix from 60-kg Bertha if they experience an attractive gravitational force of 100 nN?

4. $M = 80\ kg \quad m = 60\ kg \quad F_G = 100 \times 10^{-9}\ N$
$R = ?$
$F_G = GMm/R^2$
$R = \sqrt{(GMm/F_G)}$
$R = \sqrt{(6.67 \times 10^{-11}\ N{\cdot}m^2/kg^2 \cdot 80\ kg \cdot 60\ kg / 100 \times 10^{-9}\ N)}$
$\underline{R = 1.79\ m}$

PhyzReference: Solar System Information

db

ORBITAL CHARACTERISTICS

	Radius		*Period*	*Speed*
	*E+9m**	*AU*	*years*	*m/s*
Mercury	57.9	0.39	0.241	47,900
Venus	108	0.72	0.615	35,000
Earth	150	1.00	1.00	29,800
Mars	228	1.52	1.88	24,100
Jupiter	778	5.19	11.9	13,100
Saturn	1430	9.53	30	9,640
Uranus	2870	19.1	84	6,810
Neptune	4500	30.0	165	5,430

PLANETARY CHARACTERISTICS

	Mass	*Radius*	*Density*	*Gravity*
	*E+24kg**	*E+6m**	*kg/m^3*	*m/s^2*
Mercury	0.334	2.44	5,600	
Venus	4.87	6.1	5,200	
Earth	5.98	6.4	5,520	9.78
Mars	0.640	3.4	3,950	
Jupiter	1902	72	1,310	
Saturn	569	60	704	
Uranus	86.7	25.9	1,210	
Neptune	103	24.8	1,670	

**Note: "E" means "times 10 to the," so 57.9E+9m is 57.9 times 10 to the 9th meters.*

SOL & LUNA: THE SUN AND THE MOON

	Mass	*Radius*	*Density*	*Gravity*
	kg	*m*	*kg/m^3*	*m/s^2*
Sun (Sol)	1.99E+30	6.96E+8	1,410	
Moon (Luna)	7.36E+22	1.74E+6	3,340	

Assignment: Calculate gravity for the planets, the Sun, and the Moon.

Earth-Moon Distance: 3.82E+8m