Session 6: Circular Motion and Gravitation

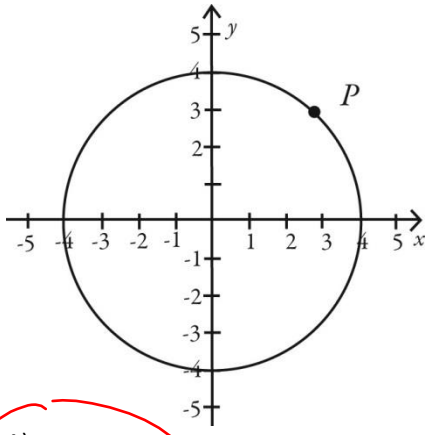
Multiple Choice:

1) If an object travels at a constant speed in a circular path, the acceleration of the object is
A) larger in magnitude the smaller the radius of the circle.
B) smaller in magnitude the smaller the radius of the circle.
C) in the opposite direction of the velocity of the object.
D) in the same direction as the velocity of the object.
E) zero.

• IF AN OBJECT CHANGES DIRECTION, IT ACCELERATES

$a_c = \frac{v^2}{r}$

2) Point *P* in the figure indicates the position of an object traveling at constant speed clockwise around the circle. Which arrow best represents the direction of the acceleration of the object at point *P*?



A)

← ACCELERATION IS ALWAYS DIRECTED TOWARD THE CENTER

B)

C)

D)

E)

3) A string is attached to the rear-view mirror of a car. A ball is hanging at the other end of the string. The car is driving around in a circle, at a constant speed. Which of the following lists gives all of the forces directly acting on the ball? ***Select two answers.***

A) tension,
B) gravity,
C) the centripetal force,
D) friction

← THESE ARE THE ONLY POSSIBILITIES
← JUST A NAME FOR ANOTHER FORCE
← NO CONTACT W/ SURFACE ∴ NO FRICTION

4) A car travels at a steady 40.0 m/s around a horizontal curve of radius 200 m. What is the minimum coefficient of static friction between the road and the car's tires that will allow the car to travel at this speed without sliding?

A) 0.662
B) 1.23
C) 0.736
D) 0.816
E) 0.952

$\Sigma F = ma$

$f = m\frac{v^2}{r}$

$\mu mg = \frac{mv^2}{r}$

$\mu = \frac{v^2}{rg} = \frac{(40)^2}{200(9.8)}$

$\mu = 0.816$

5) A new roller coaster contains a loop-the-loop in which the car and rider are completely upside down. If the radius of the loop is 13.2 m with what minimum speed must the car traverse the loop so that the rider does not fall out while upside down at the top? Assume the rider is not strapped to the car.

A) 12.5 m/s
B) 11.4 m/s
C) 10.1 m/s
D) 14.9 m/s

@ MIN SPEED
$F_N = 0$ → ONLY WEIGHT MAINTAINS CIRCULAR MOTION

$\Sigma F = ma$

$mg = m\frac{v^2}{r}$

$v = \sqrt{rg} = \sqrt{13.2(9.8)} = 11.4 m/s$

6) A baseball is located at the surface of the earth. Which statements about it are correct?

A) The gravitational force on the ball due to the earth is exactly the same as the gravitational force on the earth due to the ball.
B) The ball exerts a greater gravitational force on the earth than the earth exerts on the ball.
C) The earth exerts a much greater gravitational force on the ball than the ball exerts on the earth.
D) The gravitational force on the ball is independent of the mass of the earth.
E) The gravitational force on the ball is independent of the mass of the ball.

NEWTON'S 3RD LAW

7) If the mass of the earth and all objects on it were suddenly doubled, but the size remained the same, the acceleration due to gravity at the surface would become

A) 4 times what it now is.
B) 2 times what it now is.
C) 1/2 of what it now is.
D) the same as it now is.
E) 1/4 of what it now is.

$g_{NOW} = \frac{GM}{r^2}$

$g_{NEW} = \frac{G(2M)}{r^2}$

$= 2 g_{NOW}$

8) Two planets having equal masses are in circular orbit around a star. Planet *A* has a smaller orbital radius than planet *B*. ***Select two answers.***

A) Planet *A* has more kinetic energy than planet *B*. MOVING FASTER
B) Planet *A* has less kinetic energy than planet *B*.
C) Planet *A* has less mechanical energy than planet band planet B.
D) Planet *A* has less mechanical energy than planet band planet B.

ORBITAL SPEED
$F_g = ma$
$\frac{GMm}{r^2} = \frac{mv^2}{r}$
$\frac{GM}{r} = v^2$
$KE = \frac{1}{2}m\left(\frac{GM}{r}\right)$

$E_T = -\frac{GMm}{r} + \frac{1}{2}mv^2$
$E_T = -\frac{GMr}{r} + \frac{1}{2}\frac{GMm}{r}$
$E_T = -\frac{1}{2}\frac{GMm}{r}$

9) The reason an astronaut in an earth satellite feels weightless is that 9

A) the astronaut is falling.
B) this is a psychological effect associated with rapid motion.
C) the astronaut is beyond the range of the earth's gravity.
D) the astronaut's acceleration is zero.
E) the astronaut is at a point in space where the effects of the moon's gravity and the earth's gravity cancel.

THE ASTRONAUT IS IN CONSTANT FREE FALL

10) Because the earth's orbit is slightly elliptical, the earth actually gets closer to the sun during part of the year. When the earth is closer to the sun its orbital speed is

A) the same as when the earth is farthest away from the sun.
B) greater than when the earth is farthest away from the sun.
C) less than when the earth is farthest away from the sun.

CONS OF E ⇒ AS IT FALLS CLOSER IT MOVES FASTER

11) A small planet having a radius of 1000 km exerts a gravitational force of 100 N on an object that is 500 km above its surface. If this object is moved 500 km farther from the planet, the gravitational force on it will be closest to

A) 56 N.
B) 71 N.
C) 50 N.
D) 75 N.
E) 25 N.

$F_1 = \frac{GMm}{r^2}$

$F_2 = \frac{GMm}{\left(\frac{4}{3}r\right)^2} = \frac{9GMm}{16r^2} = \frac{9}{16}F_1$

$F_2 = \frac{9}{16}(100) = 56\,N$

12) Ekapluto is an unknown planet that has two spherical moons in circular orbits. The table summarizes the hypothetical data about the moons. Both moons have low axial spin rates. (G = 6.67 × 10-11 N · m2/kg2)

	Mass	*Radius*	*Orbital radius*	*Orbital period*
Moon A	4.0 × 1020 kg		2.0 × 108 m	4.0 × 106 s
Moon B	1.5 × 1020 kg	2.0 × 105 m	3.0 × 108 m	

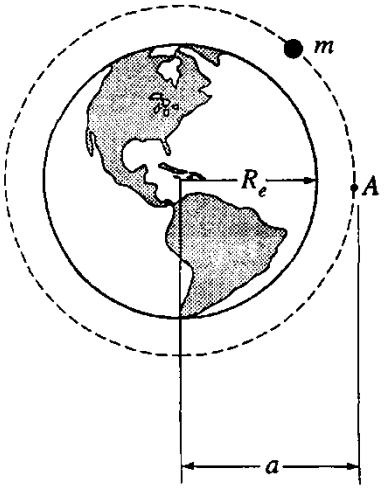
The acceleration due to gravity at the surface of Moon *B* is

A) 0.20 m/s2.
B) 0.25 m/s2.
C) 0.30 m/s2.
D) 0.15 m/s2.
E) 0.10 m/s2.

$g = \frac{GM}{r^2} = \frac{6.67\times10^{-11}(1.5\times10^{20}\,kg)}{(2\times10^{5}\,m)^2}$

$g = 0.25\,m/s^2$

Free Response:



1.

A satellite of mass m is in an elliptical orbit around the Earth, which has mass M_e and radius R_e. The orbit varies from closest approach of a at point A to maximum distance of b from the center of the Earth at point B. At point A, the speed of the satellite is v Assume that the gravitational potential energy $U_g = 0$ when masses are an infinite distance apart. (a) An astronaut in the satellite feels weightless at point A.

i. Determine the acceleration of the satellite.

$a = \frac{GM}{a^2}$

ii. Explain why the astronaut feels weightless at that point.

THE ASTRONAUT HAS A HIGH SIDE WAYS VELOCITY SUCH THAT SHE ACCELERATES TOWARD THE EARTH, BUT CONSTANTLY MISSES, STAYING IN A STATE OF FREE FALL & FEELING WEIGHTLESS.

b. Describe, in a clear, coherent paragraph length response the changes that would occur to the satellite's velocity and total energy if it moved into an orbit with a larger radius.

THE VELOCITY WOULD DECREASE BECAUSE ORBITAL SPEED IS INVERSELY PROPORTIONAL TO THE ROOT OF RADIUS ($V = \sqrt{\frac{GM}{r}}$), BUT THE TOTAL ENERGY WOULD INCREASE BECAUSE ENERGY MUST BE ADDED TO THE SYSTEM TO INCREASE ORBIT.