Physics 621 Unit 2 Test Review Outline

Topics **Circular Motion**
- define centripetal force and identify the effect of the force on a moving body
- identify what centripetal acceleration is measuring
- apply the concepts of tangential speed, period, frequency as they relate to a body undergoing circular motion
- draw or label FBD diagrams for objects undergoing circular motion in horizontal and vertical planes
- draw or label centripetal force, centripetal acceleration, and instantaneous velocity vectors on motion diagrams for objects undergoing circular motion in horiontal and vertical planes
- solve problems involving circular motion in horizontal or vertical planes of motion (working from first priniples with FBD and net force statements)

Planetary and Satellite Motion
- identify the major differences between the geocentric model and heliocentric model as the model of the universe progressed from geocentric (Aristotle) to Ptolemy to heliocentric (Copernicus / Galileo) to combined (Brahe) to today's version (Kepler)
- state, identify, and apply Kepler's Three Laws to planets and satellites
- identify why each of Kepler's three laws was a significant advancement and, at times, very controversial
- convert orbital radii into and out of astronomical units (AU)
- apply Newton's Law of Universal Gravitation to any pairing of bodies (people, objects, planets, etc.)
- solve orbital problems for satellites and planets that equate Newton's Law of Universal Gravitation and the centripetal force equations solving for period, frequency, speed, centripetal acceleration, mass, radii, and altitudes.
- derive a relationship between Kepler's constant and G
- calculate acceleration due to gravity on different celestial bodies or parameters measuring the focus mass including mass and radius
- explain how uniform circular motion is used as an approximation in calculations of orbital parameters, especially when the orbits become more elliptical in nature (role of normal/ perpendicular components of gravitational force)

PHY 621 Chapter 11 and 12 Test Review

Constants:

$G = 6.67 \times 10^{-11}$ N m^2 /kg^2

$M_E = 5.98 \times 10^{24}$ kg	$R_E = 6.38 \times 10^{6}$ m	$T_E = 365.25$ d
M moon $= 7.34 \times 10^{22}$ kg	Rmoon $= 1.74 \times 10^{6}$ m	1 d = 23 h 56 min 4 s (giving 5 s.f.)
M sun $= 1.99 \times 10^{30}$ kg	R sun $= 6.96 \times 10^{8}$ m	1 d = 24 h (giving 2 s.f.)

1. a) What average distance separates the centre of the sun from the centre of the Earth? (Or, it could be worded, what is the mean orbital radius of the Earth?)
   b) What average distance separates the surface of the sun from the surface of the Earth?
   c) What is the tangential speed of the Earth as it orbits the sun?

2. What would be the acceleration due to gravity on the surface of the sun?

3. Jupiter's moon Io orbits Jupiter once every 1.769 days. Its average orbital radius is 4.216×10^{8} m. What is Jupiter's mass?

4. What is the tangential speed of the moon as it orbits Earth at an orbital radius of 3.84×10^{5} km?

5. A stone of mass 284 g is twirled at a constant speed of 12.4 m/s in a horizontal circle of radius 0.850 m.
   a) What is the frequency at which the stone is being twirled?
   b) What is the horizontal component of tension in the string? FBD required.
   c) Why is not important for us to use the resultant tension in the string a rock being twirled in a horizontal circle? (Theory.)

6. You are driving a 1654 kg car on a level road surface and start to round a curve at 77 km/h. If the radius of curvature is 129 m, what must be the minimum coefficient of static friction for rubber-on-asphalt so that you can safely make the turn? FBD required.

7. A motorcycle stunt rider want to do a loop-the-loop within a vertical circular track. If the radius of the circular track is 10.0 m, what is the minimum speed must the motorcyclist maintain to stay on the track? FBD required.

8. If a planet orbits the sun with a mean radius of 2.0×10^{11} m, what is its orbital period?

9. The moon has an orbital period of approximately 27.3 days and a mean orbital radius of 3.90×10^{5} km from the center of the Earth. What is the mean orbital radius for an artificial satellite that has an orbital period of 88.5 minutes?

10. Two bowling balls each have a mass of 6.8 kg. They are located next to one another with their centers 21.8 cm apart. What gravitational force do they exert on each other?

11. At what altitude must a probe orbit around the moon in order to have an orbital period of 118 minutes?

12. What angle, measured from the horizontal, must a banked turn have to allow a car to move at 108 km/h without relying on friction force to a make turn with a radius of curvature of 125 m ?

13. A stone of mass 284 g is twirled in a vertical circle of radius 0.850 m.
    a) What is the tension in the string if the stone is moving 12.4 m/s at the top of the circle? (FBD required.)
    b) What is the tension in the string if the stone is moving 12.4 m/s at the bottom of the circle? (FBD required.)
    c) What is the maximum frequency the stone can be twirled if the string will break if the tension force exceeds 65 N?

14. A lead ball is released on a ramp. At the bottom of the ramp is a vertical circular loop of radius 25.0 cm. When the ball is rolling at the top of the loop, it has a speed of 2.75 m/s. The track is exerting a normal force of 4.388 N down on the ball. What is the mass of the lead ball?

Answers:

1a) 1.50×10^{11} m
b) 1.49×10^{11} m
c) 2.98×10^{4} m/s

2. 2.74×10^{2} m/s^2 [to centre of sun]

3. 1.90×10^{27} kg

4. 1.02×10^{3} m/s

5. a) 2.32 Hz
b) 51.4 N [to centre]

6. 0.362

7. 9.90 m/s

8. 4.9×10^{7} s

9. 6.70×10^{3} km

10. 6.5×10^{-8}N[towards each other]

11. 1×10^{2} km

12. 36.3 °

13. a) - 48.6 N [up]
b) 54.2 N [up]
c) 2.6 Hz

14. 0.215 kg