Name: _____Answer Key_____ Date: _____
Honors Physics Test #5H Review

Universal Gravitation & Circular Motion

1. Read Chapter 7

2. Terms to know: universal gravitation, linear speed, rotational speed, centripetal acceleration, centripetal force, uniform circular motion, cycle, universal gravitational constant, gravitational field strength.

3. What is Newton's law of universal gravitation?
   Every object in the universe is attracted to every other object in the universe.
4. What happens to the gravitation force of attraction between two masses when:
   a) the distance between the two masses is doubled?
      Quartered

   b) the distance between the two masses is halved?
      Quadrupled

   c) the mass of both objects is doubled?
      Quadrupled

   d) the mass of one object is halved?
      Halved

5. Explain how what feels like a centrifugal force is really a centripetal force. Remember to use Newton's Laws appropriately. Provide 3 real world examples of this feeling.

   You are continuing in a straight line motion, due to Newton's first law. There is an outside force acting on which is pushing or pulling you and forcing you to move in a circular path. It feels to you like you are being thrust to the outside of the circle, but really you are being directed inwards toward the center.

   Turning a corner in a car, Turning a corner on a roller coaster, spinning around on a whirly amusement park ride, water skiing – jump the wake, merry-go-round

6. Answer the following questions about g's.

   a. What are the two names for "g"?

      Acceleration due to gravity
      Gravitational field strength

   b. What are the two units for "g"?

      m/s^2 & N/kg

   c. What are the two formulas for "g"?

      $g = F_g/m$
      $g = Gm/r^2$

   d. What is the name and value of "G"?
      Universal Gravitational Constant
      $6.67 \times 10^{-11}\ Nm^2/kg^2$

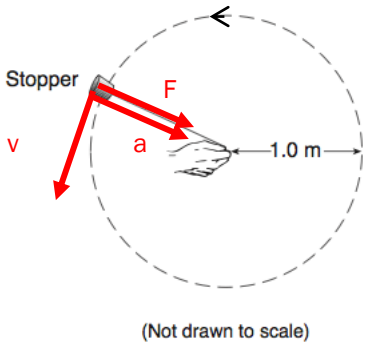
Directions: Read each question carefully and record your answers in the space provided. Be sure to show all work! Answers should be in significant figures. You will be graded on proper use of the GUESS method. **These will be the same directions on the test. Practice the GUESS method now.**

7. A 3400 kg car is parked 23 meters away from a tractor that has a mass of 5.6 x 10^6 kg. What is the force of gravitational attraction between the two vehicles?

$$F_G = \frac{Gm_1m_2}{r^2} = \frac{(6.67\times10^{-11}\ \frac{N\cdot m^2}{kg^2})(5.6\times10^6\ kg)(3400\ kg)}{(23\ m)^2} = 0.0024\ N\ \text{toward}$$

8. A student in lab twirls a rubber stopper on a 1.0 m string around in a circle overhead. It revolves 15 times in 3.74 seconds and has a mass of 7.2 kg.

   a. Draw and label the velocity, acceleration, and force vectors for the rubber stopper in the position shown on the diagram below.



(Not drawn to scale)

Velocity is tangential.

Force and acceleration always point IN on a circle.

   b. Calculate its period.

$$T = \frac{t_{total}}{\#\ \text{revolutions}} = \frac{3.74\ s}{15\ \text{rev}} = .249\ s$$

Sig figs match the total time

   c. Calculate its speed.

$$v = \frac{2\pi r}{T} = \frac{2\pi(1.0\ m)}{0.249\ s} = 25\ m/s$$

Distance is Circumference

   d. Calculate its centripetal acceleration.

$$a_c = \frac{v^2}{r} = \frac{(25\ \frac{m}{s})^2}{1.0\ m} = 630\ \tfrac{m}{s^2}\ \text{in}$$

Acceleration always points IN on a circle

   e. Calculate the centripetal force acting on it.

$$F_c = ma_c = 7.2\ kg(630\ \tfrac{m}{s^2}) = 4500\ N\ \text{in}$$

Force always points IN on a circle

9. A 2.00 kg mass is being swung in a circle of radius 2.00 m at a constant speed of 4.00 m/s.
   a. What is the period of the object?

$$T = \frac{2\pi r}{v} = \frac{2\pi(2.00\text{ m})}{(4.00\ \frac{m}{s})} = 3.14\text{ s}$$

   b. What is the magnitude of the tension that is needed to keep the object moving in a circle?

$$F_c = ma_c = \frac{mv^2}{r} = \frac{2.00\text{ kg}\,(4.00\ \frac{m}{s})^2}{2.00\text{ m}} = 16.0\text{ N}$$

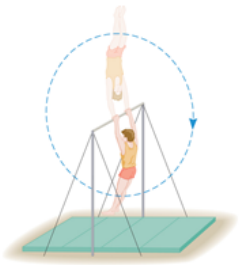
"Magnitude of..." means no direction

10. A force of 3.4 newtons is needed to turn the handle of a 0.15 meter long wrench. Calculate the magnitude of the torque applied.

$$\tau = Fr = (3.4N)(0.15m) = 0.51Nm$$

Honors Equation – need to memorize

11. How much force does this 55 kilogram gymnast need to hold onto the bar as they swing through the bottom of their swing at 3.4 meters per second? Assume their center of mass is approximately 0.80 meter from their outstretched hands.



$F_{net} = F_c = \frac{mv^2}{r}$ $\quad F_A - F_g = \frac{mv^2}{r}$ $\quad F_A = \frac{mv^2}{r} + mg$

$F_A = \frac{(55\text{ kg})(3.4\text{ m/s})^2}{0.80\text{ m}} + (55\text{ kg})(9.81\text{ m/s}^2)$

$F_T = 1334\text{ N} = 1300\text{ N}$

1.3×10^3 N

12. As the mass of a body increases, its gravitational force of attraction on the Earth

(A) Increases (B) Decreases (C) Remains the Same

$F_g = mg$

13. The magnitude of the gravitational force of attraction between the Earth and the Moon is approximately

(A) 6.7×10^{41} N (B) 1.9×10^{20} N (C) 7.8×10^{28} N (D) 6.0×10^{24} N

$F_g = \frac{Gm_1m_2}{r^2}$

$F_g = \frac{(6.67\times10^{-11}\ \frac{Nm^2}{kg^2})(7.35\times10^{22}\text{kg})(5.98\times10^{24}\text{ kg})}{(3.84\times10^{8}\text{ m})^2}$

14. Gravitational force F exists between point objects A and B separated by a distance R. If the mass of A is doubled and the distance R is tripled, what is the new gravitational force?

(A) $\frac{9}{2}F$ (B) $\frac{3}{2}F$ (C) $\frac{2}{3}F$ (D) $\frac{2}{9}F$

$F_g = \frac{Gm_1m_2}{r^2} = \frac{1\cdot2\cdot1}{3^2} = \frac{2}{9}$

15. As a cart travels around a horizontal circular track, the cart *must* undergo a change in

(A) weight (B) velocity (C) inertia (D) speed

Direction changes

16. An amusement park ride moves a rider at a constant speed of 14 meters per second in a horizontal circular path of radius 10. meters. What is the rider's centripetal acceleration in terms of g, the acceleration due to gravity?

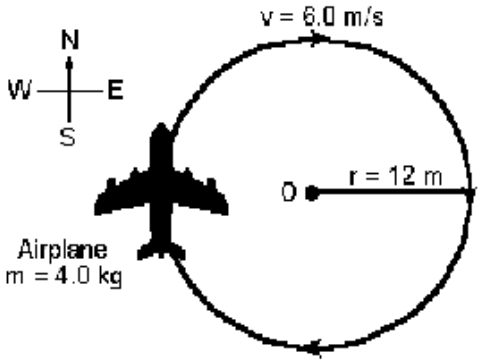
(A) 0g (B) 1g (C) 2g (D) 3g

$a_c = \frac{v^2}{r} = \frac{(14\,\frac{m}{s})^2}{10.m} = 19.6\,\frac{m}{s^2}$ in

$\frac{19.6}{9.81} = 2g$ (How many "g=9.81" is the acceleration?)

Questions 17 through 19 refer to the following:

A 4.0 kilogram model airplane travels in a horizontal circular path of radius 12 meters at a constant speed of 6.0 meters per second.



17. At the position shown, what is the direction of the net force acting on the airplane?

(A) east (B) west (C) north (D) south

Force always points IN on a circle

18. What is the magnitude of the centripetal acceleration of the airplane?

(A) 0.50 m/s^2 (B) 2.0 m/s^2 (C) 3.0 m/s^2 (D) 12 m/s^2

$a_c = \frac{v^2}{r} = \frac{(6.0\,\frac{m}{s})^2}{12m}$

19. If the speed of the airplane is doubled and the radius of the path remains unchanged, the magnitude of the centripetal force acting on the airplane will be

(A) half as much
(B) one-fourth as much
(C) twice as much
(D) four times as much

$F_c = \frac{mv^2}{r} = \frac{1 \cdot 2^2}{1}$

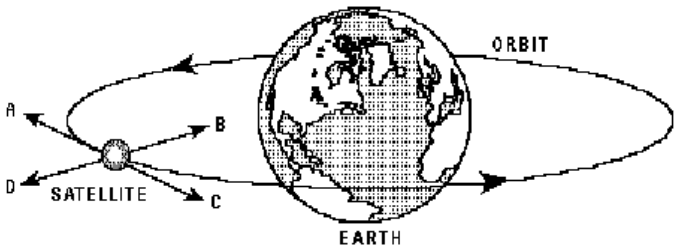
20. A motorcycle travels around a flat circular track. If the speed of the motorcycle increased, the force required to keep it in the same circular path

(A) Increases (B) Decreases (C) Remains the Same

$F_c = \frac{mv^2}{r}$

21. A satellite is moving at constant speed in a circular orbit around the Earth, as shown in the diagram below.

Force always points IN on a circle

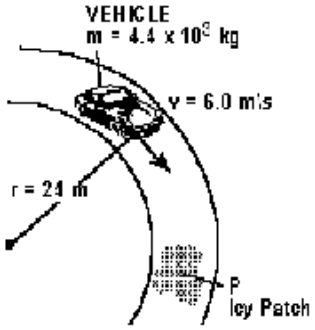


The net force acting on the satellite is directed toward point

(A) A (B) B (C) C (D) D

Questions 22 and 23 refer to the following:

A vehicle travels at a constant speed of 6.0 meters per second around a horizontal circular curve with a radius of 24 meters. The mass of the vehicle is 4.4 x 10^3 kilograms. An icy patch is located at point P on the curve.

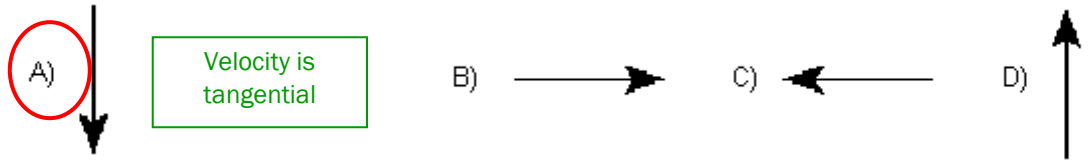


$F_c = \frac{mv^2}{r} = \frac{(4.4\times10^3 kg)(6.0\,\frac{m}{s})^2}{24m}$

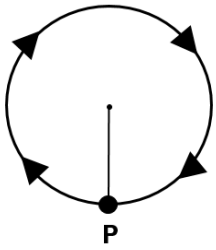
22. What is the magnitude of the frictional force that keeps the vehicle on its circular path?

(A) 1.1 x 10^3 N (B) 6.6 x 10^3 N (C) 4.3 x 10^4 (D) 6.5 x 10^4 N

23. On the icy patch of pavement, the frictional force on the vehicle is zero. What arrow best represents the direction of the vehicle's velocity when it reaches icy patch P?



Questions 24 through 26 refer to the following diagram:



24. What is the direction of the velocity of the ball at point P?

(A) → (B) ← (C) ↓ (D) ↑ (E) ←→

25. What is the direction of the acceleration of the ball at point P?

(A) → (B) ← (C) ↓ (D) ↑ (E) ←→

26. What is the direction of the net force acting on the ball at point P?

(A) → (B) ← (C) ↓ (D) ↑ (E) ←→

27. If the Earth were compressed in such a way that its mass remained the same and its diameter halved, what would be the acceleration due to gravity at the surface of Earth?

(A) g / 4 (B) g / 2 (C) g (D) 2g (E) 4g

Questions 28 through 30 refer to the following:

Two masses m_1 and m_2 are separated by a distance R so that there is a gravitational force F between them. The following choices refer to the gravitational force on m_1 due to m_2.

28. What happens to the magnitude of the force on m_1 if the mass of m_2 is doubled?

(A) Quadrupled (B) Doubled (C) Remains the same (D) Halved (E) Quartered

29. What happens to the magnitude of the force on m_1 if the distance between the centers of the masses is doubled?

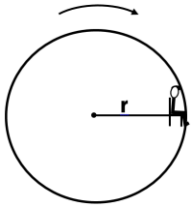
(A) Quadrupled (B) Doubled (C) Remains the same (D) Halved (E) Quartered

30. What happens to the magnitude of the force of m_1 if the distance between the centers of the masses is halved?

(A) Quadrupled (B) Doubled (C) Remains the same (D) Halved (E) Quartered

Questions 31 through 33 refer to the following information:

A 30 kg child sits on the edge of a carnival ride at a radius of 2 m. The ride makes 2 revolutions in 4 s.



31. The period of the revolution is

(A) ½ rev/s (B) ½ s (C) 2 rev/s (D) 2 s (E) 4 s

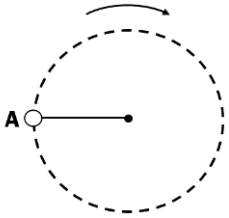
32. The speed of the child is most nearly

(A) 4 m/s (B) 6 m/s (C) 24 m/s (D) 120 m/s (E) 360 m/s

33. The centripetal force acting on the child is most nearly

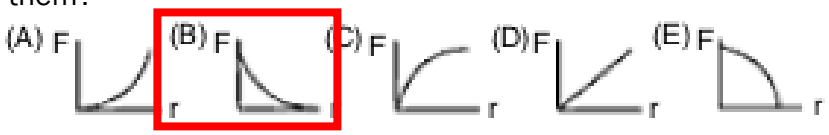
(A) 30 N (B) 180 N (C) 300 N (D) 540 N (E) 4,320 N

34. A ball is spun around on a string as shown in the figure above. If the string were suddenly cut when the ball is at point A, the subsequent motion of the ball would be



(A) To the right (B) To the left (C) To the top of the page (D) To the bottom of the page (E) Up and to the left

35. Two stars are separated by a distance *r* and are moving away from each other. Which of the graphs below best represents the gravitational force between the stars as a function of *r*, the distance between them?



36. Which of the following are means of maximizing the torque of a force applied to a rotating object?

I. Maximize the magnitude of the applied force.
II. Apply the force as close as possible to the axis of rotation.
III. Apply the force perpendicular to the displacement vector between the axis of rotation and the point of applied force

(A) I only (B) II only (C) I and II only (D) I and III only (E) I, II, and III

37. Two objects rest on a seesaw. The first object has a mass of 3 kg and rests 10 m from the pivot. The other rests 1 m from the pivot. What is the mass of the second object if the seesaw is in equilibrium?

(A) 0.3 kg (B) 3 kg (C) 10 kg (D) 30 kg (E) 50 kg

38. Torque

(A) is the vector product of force and lever arm displacement
(B) is a scalar and has no direction associated with it
(C) is always equal to force
(D) is always greater for shorter lever arms
(E) must always equal zero

Answers:
7. 0.0024 N toward
8. a. See sheet in classroom
b. 0.249 s
c. 25 m/s
d. 630 m/s² in
e. 4500 N in
9. a. 3.14 s
b. 16.0 N
10. 0.51 Nm
11. 1300 N
12. A
13. B
14. D
15. B
16. C
17. A
18. C
19. D
20. A
21. B
22. B
23. A
24. B
25. D
26. D
27 E
28. B
29. E
30. A
31. D
32. B
33. D
34. C
35. B
36. D
37. D
38. A