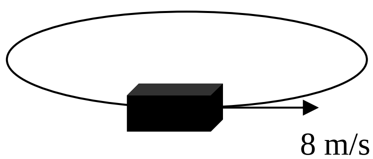
Centripetal Forces Practice: Work <u>only</u> problems I, II and IV for Unit 6.

<u>Problem I</u>

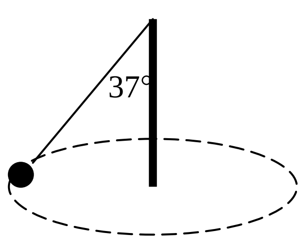
A 500 gram electric car is tied to the end of a lightweight, 1.4 m long string. The other end of the string is tied to a peg in the middle of a table. The electric car is turned on and runs in a circular track around the peg at a speed of 8 m/s.



1. The car accelerates at ___ m/s^2.
   A) 13   B) 24   C) 35   D) 46
2. The period of revolution for the car is ___ seconds.
   A) 1.1   B) 1.6   C) 2.1   D) 2.6
3. The car completes ___ rev / second.
   A) 0.38   B) 0.48   C) 0.63   D) 0.91
4. The car has an angular frequency of ___ radians / second.
   A) 2.4   B) 3.0   C) 3.9   D) 5.7
5. The tension in the string that turns the car is ___ Newtons.
   A) 12   B) 17.5   C) 23   D) 28.5

<u>Problem II</u>

A 5 Kg bowling ball is connected to the end of a 2 meter long wire. The opposite end of the wire is attached to a tall pole. The ball is given a push to form a conical pendulum with the wire forming an angle of 37° from the vertical. Use $g = 10\ m/s^2$.



6. The radius of the circular path traced out by the bowling ball is ___ m.
   A) 1.0   B) 1.2   C) 1.6   D) 2.0
7. The tension in the wire is ___ N.
   A) 40   B) 50   C) 63   D) 75
8. The ball travels along the circular path at a speed of ___ m/s.
   A) 3.0   B) 3.5   C) 4.0   D) 4.5
9. The net force acting on the ball is due to the combination of the tension and gravity. The net force of the ball has a value of ___ N.
   A) 0   B) 25   C) 38   D) 50
10. The direction of the net force at the instant shown in the figure is ___.
    A) ←   B) ↑   C) →   D) ↓

<u>Problem III</u>

A 50 Kg child rides in a Ferris wheel at the fair. The wheel has a radius of 6 meters and turns at 2 radians / second. Since the seats are swiveled the normal force from the seat is always upright.

11. A rider will experience an acceleration of ___ m/s^2.
    A) 6   B) 12   C) 18   D) 24
12. At the bottom of the ride the seat exerts an upward force of ___N.
    A) 700   B) 1200   C) 1700   D) 2200
13. At the top of the ride the seat exerts an upward, normal force of ___N.
    A) 700   B) 1200   C) 1700   D) 2200
14. The rider is at the midpoint between top and bottom. The <u>back</u> of the seat exerts a normal force toward the center of ___ N.
    A) 700   B) 1200   C) 1700   D) 2200
15. When a rider is at the same position described in 14 the <u>bottom</u> of the seat exerts an upward force of ___N.
    A) 500   B) 700   C) 1200   D) 1500

Continued on next page

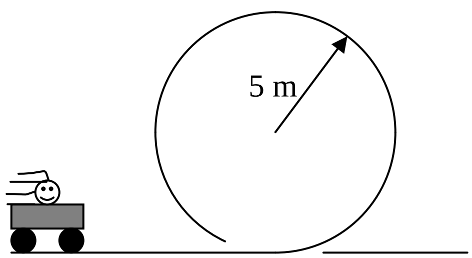
Problem IV

A 900 Kg car with new tires has a static coefficient of friction of $\mu = 0.84$. The car wishes to take a flat curve of 39 m radius at maximum speed without slipping.

16. The normal force acting on the car while in the turn is ___ N.
    A) 7560 B) 9000 C) 10710 D) 4500
17. The maximum friction available to turn the car is ___N.
    A) 7560 B) 9000 C) 10710 D) 4500
18. The maximum safe speed to make the turn is ___ m/s.
    A) 16 B) 18 C) 20 D) 22
19. To make the turn at the same speed without friction the curve should be banked to an angle of ___°.
    A) 33 B) 40 C) 46 D) 51
20. The new normal force for a car in the banked turn of item #19 is ___N.
    A) 10770 B) 11700 C) 12890 D) 14340

Problem V

The same 50 Kg child from problem III is now riding in a cart on a roller coaster. The child is riding along flat rails on the ground at 17 m/s. The cart and child encounter a vertical, circular loop of radius 5m. As the cart moves through the loop the normal force from the cart is always pushing inward on the child.



21. The speed of the child halfway between top and bottom of loop is ___ m/s.
    A) 9.7 B) 11.7 C) 13.7 D) 15.7
22. The normal force on the child at this point is ___ N.
    A) 1280 B) 1480 C) 1680 D) 1880
23. The speed of the child at the top of the loop is ___ m/s.
    A) 9.4 B) 11.4 C) 13.4 D) 15.4
24. The normal force acting on the child at the top of the loop is ___ N.
    A) 190 B) 290 C) 390 D) 490
25. The minimum speed the child can have at the top of the loop without falling out of the cart is ___ m/s.
    A) 4.1 B) 5.1 C) 6.1 D) 7.1

Answers

1. D
2. A
3. D
4. D
5. C
6. B
7. C
8. A
9. C
10. C
11. D
12. C
13. A
14. B
15. A
16. B
17. A
18. B
19. B
20. B
21. C
22. D
23. A
24. C
25. D

Solutions to this work can be found at the end of this file, page 7?

Continued on next page ☞

Part II: Gravity Practice Test **$G = 6.67$ E – 11 N m^2 / Kg^2**

Problem I

A planet has a mass of 8 E+24 Kg and a radius of 6.8 E+6 m.

1. The gravitational acceleration at the surface of the planet is ___ m/s^2.
2. A fast working gopher digs a hole until it is only 3.4 E+6 m from the center of the planet. What is the gravitational acceleration at the bottom of the gopher hole?
3. Where does the gopher weigh more, on the surface or in the hole?
4. A hard jumping kangaroo jumps from the surface of the planet and reaches a height of 2.1 E+6 m above the surface of the planet. What is the gravitational acceleration at the top of the jump?
5. Where does the kangaroo have more mass, on the surface or at the top of the jump?

Problem II

A 40 Kg space probe is sent to map the surface of a moon of another planet. The mass of the moon is 7 E+ 23 Kg and the radius is 3 E+6 m. The probe is parked in a circular orbit 200,000 m above the surface.

6. The acceleration of the satellite in this orbit is ___ m/s^2.
7. The speed of the probe in this orbit is ___ meters/sec.
8. The time to complete one orbit is ___ minutes.
9. If an 80 Kg probe were to be parked in the same orbit would it have to travel faster, slower or at the same speed since it has twice the mass?

Problem III

A planet similar to Earth has a mass of 6 E +24 Kg and a radius of 6.4 E+6 m. It turns once on its axis every 18 hours however.

10. The orbital period of a geo-synchronous orbit about this planet is ___ seconds.
11. The orbital radius of a geo-synchronous orbit about this planet is ___ meters.
12. The orbital speed of a geo-synchronous satellite about this planet is ___ m.
13. The acceleration of a satellite in geo-synchronous orbit is ___ m/s^2.
14. A 500 Kg satellite in this geo-synchronous orbit weighs ___ N.

Problem IV

Also be sure that you know each of Kepler's Laws of Planetary motion and can match the number of the law with a description or consequence. Also be able to match the names of Newton, Galileo, Kepler, Copernicus, Tycho and Einstein* with their contributions of our understanding of gravity.

Einstein's contribution - improved Newton's Law of Gravity to more accurately reflect what is really happening. We will discuss the details later!

Problem I

1. $g = G M / R^2 = G (8E+24)/(6.8E+6)^2$
   $g = 11.5 \text{ m/s}^2$
2. $g_< = (r / R) g_{SUR} = (3.4e6/6.8e6)*11.5$
   $= 5.8 \text{ m/s}^2$
3. Maximum weight is on the surface. Jumping up or digging down will reduce the weight value.
4. $g = G M /(r^2) = G (8E+24)/(8.9E+6)^2$
   $g = 6.7 \text{ m/s}^2$
5. The mass is the same everywhere. Mass does not change if you jump up or dig down.

Problem II (r = 3E6m + 2E5m)

6. $g = G M / r^2 = G (7E+23)/(3.2E+6)^2$
   $g = 4.56 \text{ m/s}^2$

7. $v_{orb} = \sqrt{(rg)} = 3820 \text{ m/s}$
8. $\tau = 2\pi r \div v_{orb} = 88$ minutes
9. Satellites at the same orbital radius travel at the same speed independent of the mass of the satellite. If on the other hand you were to double the mass of the planet all values of the satellite will change.

Problem III

10. $\tau = 18$ hours = 64,800 seconds
11. Use $r^3 = (GM/ 4\pi^2) \tau^2 = 4.26E22 \text{ m}^3$
    $r = 3.49 \text{ E+7 m}$
12. $v_{orb} = 2\pi r / \tau = 3386 \text{ m/s}$
13. $a = v^2 / r = 0.328 \text{ m/s}^2$
    or $g = G M / r^2$
14. W = mg = 500*0.328 = 164 N

A second practice test for the gravity portion of your next test appears on the following pages.

Gravity Practice Test #2 $G = 6.67\ E\ {-11}\ Nm^2/Kg^2$

<u>Problem #1</u>

A planet has a mass of 9E24 Kg and a radius of 8.4E6m. Determine the gravitational acceleration due the planet at each of the following locations.

1. Acceleration at the surface is ___m/s^2.
   A) 5.5 B) 6.5 C) 7.5 D) 8.5
2. Acceleration at 3E6 m from the center of the planet is ___ m/s^2.
   A) 3.0 B) 4.0 C) 5.0 D) 6.0
3. Acceleration at 2E6 m above the surface is ___ m/s^2.
   A) 5.6 B) 6.6 C) 7.6 D) 8.6

<u>Problem #2</u>

A planet has a mass of 8E23 Kg and a radius of 4E6 m. A 300 Kg satellite is placed in a circular orbit 100 km above the surface of the planet in order to avoid atmospheric drag.

4. The satellite's weight is ___N.
   A) 0 B) 300 C) 952 D) 3000
5. The orbital velocity of the satellite is ___ km/sec.
   A) 3.6 B) 4.6 C) 5.6 D) 6.6
6. The orbital period for the satellite is ___ minutes.
   A) 90 B) 100 C) 110 D) 120
7. In order to escape from the orbit and travel to another planet the satellite's speed must change to a new value of ___ km/sec.
   A) 4.5 B) 5.1 C) 5.7 D) 6.3

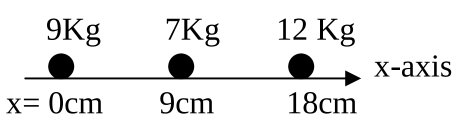
<u>Problem #3</u>

A planet has a mass of 5.7E26 Kg and a radius of 6.0E7m. The planet completes one rotation every 10 hours. A satellite is placed in a geosynchronous orbit about this planet.

8. The orbital period for the satellite is ___E+4 seconds.
   A) 2.6 B) 3.6 C) 4.6 D) 5.6
9. The distance from the center of the planet to the satellite is ___E+8m.
   A) 1.1 B) 2.2 C) 3.3 D) 4.4
10. The orbital velocity of the satellite is ___ km/sec.
    A) 5.8 B) 12.1 C) 18.8 D) 23.7
11. The satellite has an altitude of ___E+7m.
    A) 4.8 B) 5.4 C) 6.0 D) 6.6
12. The satellite has an acceleration of ___m/s^2.
    A) 2.2 B) 3.3 C) 4.4 D) 5.5

<u>Problem #4</u>

Three very small, dense spheres are placed on the x-axis as shown in the figure below. Masses are above each sphere with coordinates below each sphere. Consider only the gravitational forces among the spheres.



13. The net force on the 9 Kg sphere is ___E-7 Newtons to the right.
    A) 5.2 B) 6.3 C) 7.4 D) 8.5
14. The net force on the 12 Kg sphere is ___E-7Newtons to the left.
    A) 6.7 B) 7.5 C) 8.3 D) 9.1
15. The magnitude of the net force on the 7 Kg sphere is ___E-7Newtons.
    A) 1.7 B) 2.3 C) 3.4 D) 4.5
16. If only the 7 Kg sphere is allowed to move freely it would most likely
    A) roll to the left.
    B) roll to the right.
    C) remain stationary.

Solutions to Practice Test B

1. $g_{SUR} = GM/R^2 = 8.5$ m/s^2 **[D]**
2. $g = g_S$ (r/R) for inside a planet so
$g = 8.5$ (3~~E6~~/8.4~~E6~~) = 3.0 m/s^2**[A]**
3. r = R + altitude
= 8.4E6 + 2E6 = 10.4E6 m
$g = GM/r^2 = 5.6$ m/s^2 **[A]**

4. $W = GMm/r^2$ = 952N **[C]**
where r = 4.1E6m
5. $v = \sqrt{(GM/r)}$ = 3607 m/s or
3.607 km/sec **[A]**
6. $\tau = 2\pi r / v$ = 7141 = 119 min **[D]**
7. $V_{ESC} = V_{ORB} \sqrt{2}$ = 5.1 km/sec **[B]**
8. τ = 10 hrs(3600 sec/hr)
= 3.6E4 s **[B]**
9. $r^3 = \tau^2 GM/ (4\pi^2)$ = 1.2 E24 m^3 so
r = 1.08E8 m. **[A]**
10. $v = 2\pi r/ \tau$ = 18800 m/s
= 18.8 km/s **[C]**
11. Altitude = r – R = 1.08E8 – 6.0E7
= 4.8 E 7 m **[A]**
12. $a_C = v^2/r = (18800)^2$/1.08E8 = 3.27
m/s^2 or you could use the approach like in solution to #3. **[B]**
13. The force on the 9 Kg ball is from the other two using $F = Gm_1m_2 / r^2$.
$F = G*9*(7/0.09^2 + 12/0.18^2)$ =
F = 7.4E-7 N **[C]**
14. The force on the 12 Kg ball is from the other two using $F = Gm_1m_2 / r^2$.
$F = G*12*(7/0.09^2 + 9/0.18^2)$ =
F = 9.1E-7 N **[C]**
15. The force on the 7 Kg ball is from the other two using $F = Gm_1m_2 / r^2$.
$F = G*7*(12/0.09^2 – 9/0.09^2)$ =
F = 1.7E-7 N **[A]**
16. The 7 Kg ball will roll towards the heavier object which is the 12 Kg ball. **[B]**

The following shows the solutions to all of the centripetal forces problems from the very first worksheet.

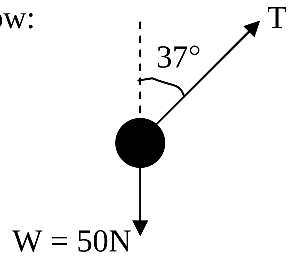
Solutions to Centripetal Forces Practice Test

Problem #1

1. Use $a_C = v^2/r = 8^2/1.4 = 45.7$ m/s^2
2. Use d = vt or $2\pi r = v\tau$ so the period is $\tau = 2\pi$(1.4m)/(8m/s) = 1.1 sec
3. Frequency is $f = 1/\tau$ = 0.91 Hz
4. $\omega = 2\pi f$ or $\omega = 2\pi/\tau$ = 5.7 radians/s
5. Tension is the only force acting along the radius and thus is equal to the centripetal force; $T = mv^2/r = ma$.
T = 0.5Kg(45.7m/s^2) = 22.9 N

Problem #2

The forces acting on the ball are shown below:



6. Radius = 2.0m sin(37°) = 1.2m
7. $\Sigma F_{\perp}$ = Tcos(37) – 50 = 0; T = 63N
8. ΣF_R = Tsin(37) – 0 = mv^2/r;
63N(sin37) = $5v^2/1.2$; v = 3 m/s
9. From Newton's 2nd Law, $F_{NET} = ma$ or $F_{NET} = mv^2/r = 5(3^2)/1.2$ = 37.5N. You could also recognize the net force by realizing that the up/down forces will add to zero leaving only Tsin37 as an unbalanced part.
10. The net force points towards the center of the circle for an object curving at constant speed.

Problem #3

11. Use $v = r\omega = 6m(2s^{-1}) = 12$ m/s; Now $a_C = v^2/r = 12^2/ 6 = 24$ m/s^2.
12. $\Sigma F_R = N - mg = mv^2/r$; $N – 500N = 50(12^2)/6m$; $N = 1700N$
13. $\Sigma F_R = mg - N = mv^2/r$; $500N – N = 50(12^2)/6m$; $N = -700N$ Since the normal force is -700N we must conclude that the seat pushes in instead of out. There better be a bar or strap to keep the rider in the ride.
14. $\Sigma F_R = N - 0 = mv^2/r$; $N=50(12^2)/6m$; $N = 1200N$
15. $\Sigma F_{TAN} = N – 500N = 0$. Here the forces add to zero because the rider is moving at a constant speed. N = 500N. I would not be too troubled about this concept tomorrow.

Problem #4

16. $\Sigma F_\perp = N – 9000N = 0$; $N = 9000N$.
17. Use $F_f = \mu N = 0.84(9000N) = 7560N$
18. But friction acts along the radius so $\Sigma F_{RAD} = F_f = mv^2/r$ so that $7560 = 900v^2/39$ or v = 18 m/s
19. From the notes it can be shown that μ on a flat curve is the same as tan θ for a banked curve. 0.84 = tan θ or θ is 40 degrees.
20. $\Sigma F_\perp = N\cos(40) – 9000 = 0$; N = 11750 N

Problem #5

21. Use conservation of energy, where $v_f^2 = v_o^2 + 2g(h_o – h_f)$. So the speed is $v = \sqrt{(17^2 + 20(-5))} = 13.7$ m/s.
22. $\Sigma F_R = N - 0 = mv^2/r$; $N=50(13.7^2)/5m$; N = 1890N
23. Use conservation of energy, where $v_f^2 = v_o^2 + 2g(h_o – h_f)$. So the speed is $v = \sqrt{(17^2 + 20(-10))} = 9.4$ m/s.
24. $\Sigma F_R = N + mg = mv^2/r$; $N+500 =50(9.4^2)/5m$; N = 390N
25. $v \geq \sqrt{(rg)}$ or $v \geq \sqrt{(50)} = 7.1$ m/s