PLANETARY DATA

Planet	Mass (kg)	Mean Distance from Sun (m)	Radius (m)	Period (days)
Sun	**1.99×10^{30}**		**6.970×10^8**	
Mercury	3.30×10^{23}	5.791×10^{10}	2.439×10^6	87.97
Venus	4.87×10^{24}	1.082×10^{11}	6.052×10^6	224.70
Earth	**5.98×10^{24}**	**1.496×10^{11}**	**6.378×10^6**	365.26
Mars	6.42×10^{23}	2.279×10^{11}	3.398×10^6	686.98
Jupiter	1.90×10^{27}	7.783×10^{11}	7.149×10^7	4,332.71
Saturn	5.69×10^{26}	1.429×10^{12}	6.027×10^7	10,759.50
Uranus	8.69×10^{25}	2.870×10^{12}	2.556×10^7	30,685.00
Neptune	1.02×10^{26}	4.497×10^{12}	2.476×10^7	60,190.00
Pluto	1.32×10^{22}	5.900×10^{12}	1.160×10^6	90,550

NATURAL SATELLITES

Moon	Orbits	Mass (kg)	Mean Distance from Planet (m)	Radius (m)	Period (days)
Ganymede	Jupiter	1.48×10^{23}	1.070×10^9	2.631×10^6	7.15
Callisto	Jupiter	1.08×10^{23}	1.883×10^9	2.400×10^6	16.69
Io	Jupiter	8.93×10^{22}	4.22×10^8	1.815×10^6	1.77
Europa	Jupiter	4.80×10^{22}	6.71×10^8	1.569×10^6	3.55
Titan	Saturn	1.35×10^{23}	1.222×10^9	2.575×10^6	15.95
Triton	Neptune	2.14×10^{22}	3.55×10^8	1.353×10^6	-5.88
Moon	**Earth**	**7.35×10^{22}**	**3.84×10^8**	**1.738×10^6**	27.32

II

01. A car traveling at 80.0 km/h rounds a circular curve of radius 95.0 m. What is the car's centripetal acceleration?

02. A ball in a roulette wheel makes 85 revolutions in 45.0 s before falling. If the radius of the wheel is 57.5 cm, what is the average centripetal acceleration of the ball?

03. If a coin is placed 5.00 cm from the center of a 45 rpm record, what is the centripetal acceleration of the coin when the record reaches its rated speed?

04. A bicycle tire is making 12.5 revolutions per minute. If the diameter of the tire is 68.0 cm, what centripetal acceleration would a point on the outer edge of the tire experience?

05. A car tachometer indicates the flywheel is spinning at 2200 rpm. The flywheel is 35.0 cm in diameter.
    a.) what is the centripetal acceleration of a point on the edge of the wheel?
    b.) what is the centripetal acceleration of a point on the wheel that is halfway between the center and the edge of the wheel?

06. A jet plane traveling at 1800 km/h pulls out of a dive by moving in an arc of radius 4.00 km. What is the plane's acceleration in g's?

07. A child on a merry-go-round experiences a centripetal acceleration of 5.25 m/s^2. The wooden horse on which the child sits is 6.25 m from the center of the rotating disk.
    a.) What is the linear speed of the child?
    b.) What is the frequency (in rpm's) of the child?

08. Calculate the centripetal acceleration of the earth in its orbit around the sun. Assume the earth's orbit is a circle with a radius of 1.50 x 10^{11} m.

09. The hammer throw is an Olympic sport in which the contestant twirls a steel cord attached to a "weight" (mass) called the hammer and releases the cord so the hammer is "thrown" across a field. The length of the hammer is 1.195-1.215 m and the mass is 7.256 kg while the diameter of the head is 11 cm. The throwing circle is 2.135 m in diameter. If the cord is swung in a radius of 2.65 m and the hammer experiences a final centripetal acceleration of 211 m/s^2, what is the frequency (rpm's) of the contestant as he releases the hammer?

10. One aspect of training for an astronaut involves experiencing and enduring extreme accelerations. To achieve this a device that rotates in a circle was designed. The astronaut is strapped into a chair in a spherical chamber. This chamber is attached to a motor in the center of the room by a metallic, multiple-poled structure I will call the arm. If the arm is 4.50 m long and the astronaut is to experience an acceleration of 5g's, calculate the following.
    a.) What is the linear speed of the spherical chamber?
    b.) What frequency (in rpm's) must the motor generate to achieve this acceleration?

ANSWERS: **01.** 5.21 m/s^2 **02.** 81.0 m/s^2 **03.** 1.11 m/s^2 **04.** 0.582 m/s^2
05. a.) 9.29 x 10^3 m/s^2 b.) 4.64 x 10^3 m/s^2 **06.** 6.39g's   **07.** a.) 5.73 m/s   b.) 8.75 rpm   **08.** 5.95 x 10^{-3} m/s^2
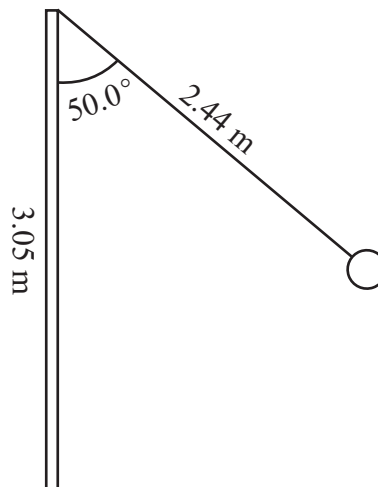**09.** 85.2 rpm's   **10.** a.) 14.8 m/s   b.) 31.5 rpm's

I

01. A 6.35-kg object is twirled in a circle of radius 18.3 m at a speed of 12.5 m/s. What is the centripetal force?

02. A 1.35-kg ball in a roulette wheel makes 85 revolutions in 45.0 s before falling. If the radius of the roulette wheel is 57.5 cm, what is the average centripetal force on the ball?

II-Horizontal Circular Motion

03. A 0.453-kg ball, attached to the end of a cord, is rotated in a circle with a radius of 1.25 m on a frictionless horizontal surface. If the cord will break when the tension in it exceeds 57.5 N, what is the maximum speed the ball can have?

04. A 1250-kg car traveling at 40.0 km/h rounds a flat curve of radius 87.5 m. What is the minimum coefficient of friction between the tires and the road surface that is necessary to make this turn?

05. A coin is placed 11.5 cm from the axis of a rotating turntable of variable speed. The speed of the turntable is slowly increased. The coin remains fixed at the same location on the turntable until it reaches a rate of 38.5 rpm, at which point the coin slides off. What is the coefficient of friction between the coin and the turntable?

06. On an icy day a car approaches a flat curve with a radius of 68.2 m. If the coefficient of friction between the tires and ice is 0.13, what is the maximum speed that the car should make the turn?

07. A tetherball apparatus consists of a 2.44-m (8-foot) cord attached to an inflated 0.426-kg (15-ounce) ball at one end, while the other end is attached to the top of a vertical pole that is about 3.05 m (10 feet) tall. A game is begun by swinging the ball in a horizontal circle. If it takes 2.5136 s to complete the first revolution, and the cord makes an angle of 50.0° with the vertical, what is the tension in the cord. See the diagram below.

08. In a "Rotor-ride" at a carnival, riders are pressed against the inside wall of a vertical cylinder 2.50 m in radius rotating at 0.40 revolutions per second when the floor drops out. What minimum coefficient of friction is needed so a person won't slip down?

Problem 07

50.0°

2.44 m

3.05 m

ANSWERS: **01.** 54.2 N   **02.** 109 N   **03.** 12.6 m/s   **04.** 0.14   **05.** 0.19   **06.** 9.32 m/s   **07.** 6.49 N   **08.** 0.62
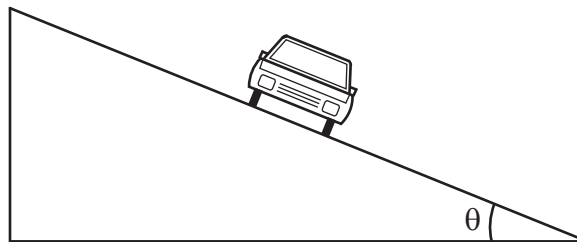
II-Vertical Circular Motion

09. A roller coaster enters a vertical circle with a radius of curvature of 9.25 m.
    a.) What is the minimum speed that the roller coaster must have at the top so the passengers do not fall out?
    b.) Assuming uniform circular motion, what is the force the tracks experience at the bottom (mass = 2000 kg)?

10. A ball is tied to the end of a string that is 1.65 m long and is rotated in a vertical circle at a constant speed.
    a.) What is the minimum speed needed to maintain this circular motion throughout the path?
    b.) If the ball has a mass of 0.375 kg, what is the maximum tension in the string?

11. A 0.335-kg ball, tied to one end of a string, is cleverly rotated at a uniform rate of 3.25 m/s in a vertical circle of radius 82.5 cm.
    a.) Calculate the tension in the string when the ball is at the top of its path.
    b.) Calculate the tension in the string when the ball is at the bottom of its path.

III-Banked Curves

12. A curve, with a radius of 60.0 m, is to be constructed for a car traveling 60.0 km/h. See diagram below.
    a.) What angle is needed for proper banking?
    b.) If the curve is banked at the angle determined in part a.) above, what minimum coefficient of friction is needed for a car to round this curve at 90.0 km/h?

13. What must be the coefficient of static friction for a car rounding a curve of radius 68.6 m at 92.3 km/h if it is properly banked for 55.0 km/h? See diagram below.

Problem 12 and 13

Chapter 4
Circular Motion and Gravitation
4.3 Universal Gravitation   Homework #30

Refer to the table of "Planetary Data" on Homework #26 **in this chapter.**

I

01. Calculate the gravitational force between a 55.3-kg woman and a 87.5-kg man if they are _____.
    a.) 20.0 m apart   b.) 0.300 m apart (from center to center)

02. What is the force of gravity on a 1250-kg spacecraft that is two earth radii **ABOVE** the earth's surface?

03. Calculate the acceleration due to gravity on the surface of _____.
    a.) Jupiter   b.) the moon

04. Calculate the acceleration due to gravity on the surface of _____, a moon of Jupiter.
    a.) Io   b.) Europa

05. A hypothetical planet has the same radius as earth but a mass that 2½ that of earth. Calculate the acceleration due to gravity on this planet.

06. A hypothetical planet has the same mass as earth but a radius that 2½ that of earth. Calculate the acceleration due to gravity on this planet.

II

07. A hypothetical planet has a mass 100 times that of earth and a radius 20 times that of earth. Calculate the acceleration due to gravity on this planet's surface.

08. What is the distance from the earth's center to a point outside the earth where the gravitational acceleration due to earth is $\frac{1}{25}$ that of its value at the earth's surface?

09. At the surface of a certain planet, the acceleration due to gravity is 2.0 m/s^2. A 5.0 kg copper ball is transported to this planet. Find _____.
    a.) the mass of the ball on earth   b.) the mass of the ball on this planet
    c.) the weight of the ball on earth   d.) the weight of the ball on this planet

10. Calculate the value of the acceleration due to gravity at _____.
    a.) 3200 m above the earth's surface   b.) 3200 km above the earth's surface

11. Given the acceleration due to gravity at the surface of Mars is 0.378 that of earth and Mars' radius is 3400 km, determine the mass of Mars.

III

12. Four 6.00-kg balls are placed at the corners of a rectangle of dimensions 0.800 m x 1.200 m. Calculate the force of gravity on one sphere due to the other three.

13. If the mass of the earth were doubled, but it kept the same density and spherical shape. How would the weight of an object change at the earth's surface?

ANSWERS: **01.** a.) 8.07 x 10^{-10} N   b.) 3.59 x 10^{-6} N   **02.** 1361 N   **03.** a.) 24.8 m/s^2 b.) 1.62 m/s^2
04. a.) 1.81 m/s^2 b.) 1.30 m/s^2 **05.** 24.5 m/s^2 **06.** 1.57 m/s^2 **07.** 2.45 m/s^2 **08.** 3.19 x 10^7 m
09. a.) 5.0 kg   b.) 5.0 kg   c.) 49 N   d.) 10 N   **10.** a.) 9.79 m/s^2 b.) 4.35 m/s^2 **11.** 6.42 x 10^{23} kg
12. 5.12 x 10^{-9} N (Angle = 30.9° or 59.1°)
13. Each object's current weight would increase by approximately 1.26 times

Chapter 4
Circular Motion and Gravitation
4.4 Satellite Motion and Apparent Weightlessness   Homework #31

Refer to the table of "Planetary Data" on Homework #26 **in this chapter.**

I

01. What is the apparent weight of a 52.5-kg woman in an elevator that moves _____?
    a.) with a constant upward speed of 6.50 m/s
    b.) with a constant downward speed of 6.50 m/s?
    c.) with an upward acceleration of $\frac{1}{4}g$
    d.) with an downward acceleration of $\frac{1}{4}g$

02. What is the _____ of a satellite that is 3200 km above the earth's surface?
    a.) speed   b.) period

03. What is the _____ of a satellite that is 3200 km above Callisto's surface? (Callisto is a moon of Jupiter)
    a.) speed   b.) period

II

04. A 112.5-kg businessman carries a 4.25-kg briefcase onto an elevator. The elevator begins to move causing the briefcase to have an apparent weight of 35.0 N.
    a.) What is the acceleration of the elevator?   b.) What force does the floor feel at that moment?
    c.) What is the net force acting on the businessman

05. A satellite is to be placed in an orbit such that it is to remain over the same geographical point on the equator of the earth.
    a.) What must be the height of this satellite above the earth's surface?
    b.) What must be the speed of this satellite?

06. What is the apparent weight of an 82.5-kg astronaut 3800 km from the center of the earth's moon in a space vehicle moving at _____ toward the moon's surface? (Include magnitude and direction)
    a.) constant velocity of 125 m/s
    b.) accelerating toward the moon at 0.0750 m/s^2
    c.) accelerating toward the moon at 3.25 m/s^2

07. A space station is designed so that astronauts can enjoy long-term residence of several months or years. To simulate gravity, the space station would be a large circular tube (like a bicycle tire) with a diameter of 200 m.
    a.) On what part of the structure would people walk?
    b.) With what linear speed would the space station have to be rotating to exactly simulate gravity here on earth?
    c.) Studies show that making more than two rpm's causes dizziness and nausea. How could the space station be redesigned so that astronauts can live comfortably while still experiencing earth-like gravitational simulation?

III

08. A roller coaster goes into a vertical circle of diameter 18.5 m and takes 5.25 s to complete the loop. Assuming uniform circular motion, calculate the ratio of a person's apparent weight to their actual weight when they are at the _____.
    a.) top   b.) bottom

ANSWERS: **01.** a.) 515 N   b.) 515 N   c.) 643 N   d.) 386 N   **02.** a.) 6453 m/s   b.) 2.59 h (9328 s)
03. a.) 1134 m/s   b.) 8.62 h (31,023 s)   **04.** a.) -1.56 m/s^2 b.) 962 N   c.) -176 N
05. a.) 3.59 x 10^7 m   b.) 3.07 x 10^3 m/s   **06.** a.) 28.0 N   b.) 21.9 N   c.) -240 N
07. a.) on the inside of the outermost wall of the tube   b.) 31.3 m/s   c.) Diameter > 447 m
08. a.) 0.352 (this is not a safe roller coaster)   b.) 2.35

4.5 Kepler's Laws   Homework #32

Refer to the table of "Planetary Data" on <u>Homework #26</u> **in this chapter.**

I

01. Calculate the length of a Venusian year. Show work!!!

02. What is the period of a satellite of Jupiter that is orbiting 5.65×10^8 m from its center? Show work!!!

03. What is the radius of orbit of a satellite of Saturn if it takes 6.25 days to complete an orbit? Show work!!!

04. Calculate the length of a Neptunian year. Show work!!!

05. Calculate the period of a communications satellite of the earth that is at an altitude of 3200 km. Show work!!!

06. What is the altitude of a satellite that remains over the same geographical point on the equator of the earth. Show work!!!

07. How old would you be on Pluto? Show work!!! (Answer on bottom assumes an age of 17 earth years)

08. How far is Mercury from the sun? Show work!!!

ANSWERS: **01.** 225 days (0.615 yrs)   **02.** 2.74 days   **03.** 6.54×10^8 m   **04.** 165 yrs
05. 2.58 hrs (0.108 days)   **06.** 3.60×10^7 m   **07.** 25.0 days old (0.0685 yrs)   **08.** 5.79×10^{10} m

01. It is sometimes said that water is removed from clothes in the spin cycle of a washer by centrifugal force throwing the water outward. Is this correct? Explain!!!
02. Will the acceleration of a car be the same when it travels around a sharp curve at 60 km/h as when it travels around a gentle curve at the same speed? Explain!!!
03. Suppose a car moves at a constant speed along a mountain road. At what place does it exert the greatest and least forces on the road: (a) at the top of the hill, (b) at a dip between two hills, (c) on a level stretch near the bottom of the hill. Explain!!!
04. Describe all the forces acting on a child on a merry-go round.
05. A bucket of water can be whirled in a vertical circle without the water spilling out even at the top of the circle when the bucket is upside down. Explain!!!
06. Does an apple exert a gravitational force on the earth? If so, how large a force? Consider an apple (a) attached to a tree, and (b) falling. Explain!!!
07. If the earth's mass were suddenly to double, in what ways would the moon's orbit change? Explain!!!
08. Describe how careful measurements of the variation of g in the vicinity of an ore deposit might be used to estimate the amount of ore present.
09. When will your apparent weight be greatest, as measured by a scale in a moving elevator: when the elevator (a) accelerates downward, (b) accelerates upward, (c) is in freefall, (d) moves upward at a constant speed? In which cases would your apparent weight be the least? When would it be the same as when you are on the ground? Explain!!!
10. The sun is directly below us at midnight, in line with the earth's center. Are we then heavier at midnight due to the sun's gravitational force on us than at noon? Explain!!!
11. If you were in a satellite orbiting the earth, how might you cope with walking, drinking, or putting a pen on a table?
12. An antenna loosens and becomes detached from a satellite in a circular orbit around the earth. Describe the antenna's motion subsequently. If it will land on the earth, describe where; if not, describe how it could be made to land on the earth.
13. Astronauts who spend long periods in outer space could be adversely affected by weightlessness. One way to simulate gravity is to shape the space station like a bicycle wheel that rotates, with the astronauts walking on the inside of the "tire." Explain how this simulates gravity. Consider (a) how objects fall, (b) the force we feel on our feet, and (c) any other aspects of gravity of which you can think.
14. People sometimes ask, "What keeps a satellite up in its orbit around the earth?" How would you respond?
15. Explain why a person running experiences "freefall" or "apparent weightlessness" between steps.
16. The sun's gravitational pull on the earth is much larger than the moon's. Yet the moon is mainly responsible for tides. Explain!!!
17. The earth moves faster in its orbit around the sun in winter than in summer. Is it closer to the sun in the summer or winter? Does this affect the seasons? Explain!!!