Exam

Name_____

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

1) Is it possible for an object moving with a constant speed to accelerate? Explain.
   A) Yes, if an object is moving it can experience acceleration
   B) No, an object can accelerate only if there is a net force acting on it.
   C) Yes, although the speed is constant, the direction of the velocity can be changing.
   D) No, if the speed is constant then the acceleration is equal to zero.

   Answer: C

2) Consider a particle moving with constant speed such that its acceleration of constant magnitude is always perpendicular to its velocity.
   A) It is moving in a parabola.
   B) It is moving in a straight line.
   C) It is moving in a circle.
   D) None of the above is definitely true all of the time.

   Answer: C

3) An object moves in a circular path at a constant speed. Compare the direction of the object's velocity and acceleration vectors.
   A) Both vectors point in the same direction.
   B) The vectors are perpendicular.
   C) The vectors point in opposite directions.
   D) The question is meaningless, since the acceleration is zero.

   Answer: B

4) When an object experiences uniform circular motion, the direction of the acceleration is
   A) is directed toward the center of the circular path.
   B) in the opposite direction of the velocity vector.
   C) in the same direction as the velocity vector.
   D) is directed away from the center of the circular path.

   Answer: A

5) Consider a particle moving with constant speed such that its acceleration of constant magnitude is always perpendicular to its velocity.
   A) It is moving in a circle.
   B) It is moving in a parabola.
   C) It is moving in a straight line.
   D) None of the above is definitely true all of the time.

   Answer: A

6) What type of acceleration does an object moving with constant speed in a circular path experience?
   A) linear acceleration
   B) free fall
   C) constant acceleration
   D) centripetal acceleration

   Answer: D

7) What force is needed to make an object move in a circle?
A) weight B) centripetal force C) kinetic friction D) static friction

Answer: B

8) When an object experiences uniform circular motion, the direction of the net force is
A) is directed toward the center of the circular path.
B) in the same direction as the motion of the object.
C) is directed away from the center of the circular path.
D) in the opposite direction of the motion of the object.

Answer: A

9) A roller coaster car is on a track that forms a circular loop in the vertical plane. If the car is to just maintain contact with track at the top of the loop, what is the minimum value for its centripetal acceleration at this point?
A) 0.5g downward B) g upward C) g downward D) 2g upward

Answer: C

10) A roller coaster car (mass = M) is on a track that forms a circular loop (radius = r) in the vertical plane. If the car is to just maintain contact with the track at the top of the loop, what is the minimum value for its speed at that point?
A) $(2rg)^{1/2}$ B) $(rg)^{1/2}$ C) rg D) $(0.5rg)^{1/2}$

Answer: B

11) A pilot executes a vertical dive then follows a semi-circular arc until it is going straight up. Just as the plane is at its lowest point, the force on him is
A) less than mg, and pointing down. B) more than mg, and pointing down.
C) less than mg, and pointing up. D) more than mg, and pointing up.

Answer: D

12) A coin of mass m rests on a turntable a distance r from the axis of rotation. The turntable rotates with a frequency of f. What is the minimum coefficient of static friction between the turntable and the coin if the coin is not to slip?
A) $(4\pi^2f^2r)/g$ B) $(4\pi f^2r)/g$ C) $(4\pi^2fr^2)/g$ D) $(4\pi fr^2)/g$

Answer: A

13) A car goes around a curve of radius r at a constant speed v. What is the direction of the net force on the car?
A) toward the curve's center B) away from the curve's center
C) toward the back of the car D) toward the front of the car

Answer: A

14) A car goes around a curve of radius r at a constant speed v. Then it goes around the same curve at half of the original speed. What is the centripetal force on the car as it goes around the curve for the second time, compared to the first time?
A) twice as big B) one-fourth as big C) half as big D) four times as big

Answer: B

15) A car goes around a curve of radius r at a constant speed v. Then it goes around a curve of radius 2r at speed 2v. What is the centripetal force on the car as it goes around the second curve, compared to the first?
A) twice as big B) four times as big C) one-fourth as big D) one-half as big

Answer: A

16) A car of mass m goes around a banked curve of radius r with speed v. If the road is frictionless due to ice, the car can still negotiate the curve if the horizontal component of the normal force on the car from the road is equal in magnitude to

A) mg. B) mg/2. C) mv^2/r. D) $\tan[v^2/(rg)]$.

Answer: C

17) Two horizontal curves on a bobsled run are banked at the same angle, but one has twice the radius of the other. The safe speed (no friction needed to stay on the run) for the smaller radius curve is v. What is the safe speed on the larger radius curve?

A) approximately 0.707v
B) approximately 1.41v
C) 2v
D) 0.5v

Answer: B

18) The banking angle in a turn on the Olympic bobsled track is not constant, but increases upward from the horizontal. Coming around a turn, the bobsled team will intentionally "climb the wall," then go lower coming out of the turn. Why do they do this?

A) to reduce the g-force on them
B) to give the team better control, because they are able to see ahead of the turn
C) to prevent the bobsled from turning over
D) to take the turn at a faster speed

Answer: D

19) Is it possible for an object moving around a circular path to have both centripetal and tangential acceleration?

A) No, an object can only have one or the other at any given time.
B) Yes, this is possible if the speed is constant.
C) Yes, this is possible if the speed is changing.
D) No, because then the path would not be a circle.

Answer: C

20) The gravitational force between two objects is proportional to

A) the distance between the two objects.
B) the square of the product of the two objects.
C) the square of the distance between the two objects.
D) the product of the two objects.

Answer: D

21) The gravitational force between two objects is inversely proportional to

A) the distance between the two objects.
B) the product of the two objects.
C) the square of the distance between the two objects.
D) the square of the product of the two objects.

Answer: C

22) Two objects attract each other gravitationally. If the distance between their centers is cut in half, the gravitational force

A) is cut to one fourth.
B) is cut in half.
C) quadruples
D) doubles.

Answer: C

23) Two objects, with masses m_1 and m_2, are originally a distance r apart. The gravitational force between them has magnitude F. The second object has its mass changed to $2m_2$, and the distance is changed to r/4. What is the magnitude of the new gravitational force?

A) 16F B) 32F C) F/32 D) F/16

Answer: B

24) Two objects, with masses m_1 and m_2, are originally a distance r apart. The magnitude of the gravitational force between them is F. The masses are changed to $2m_1$ and $2m_2$, and the distance is changed to 4r. What is the magnitude of the new gravitational force?

A) F/4 B) F/16 C) 16F D) 4F

Answer: A

ESSAY. Write your answer in the space provided or on a separate sheet of paper.

25) State Newton's law of universal gravitation.

Answer: Every particle in the universe attracts every other particle with a force that is proportional to the product of their masses and inversely proportional to the square of the distances between them. This force acts along the line joining the two particles.

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

26) Compared to its mass on the Earth, the mass of an object on the Moon is

A) the same. B) more. C) less. D) half as much.

Answer: A

27) The acceleration of gravity on the Moon is one-sixth what it is on Earth. An object of mass 72 kg is taken to the Moon. What is its mass there?

A) 72 N B) 72 kg C) 12 kg D) 12 N

Answer: B

28) As a rocket moves away from the Earth's surface, the rocket's weight

A) depends on how fast it is moving. B) remains the same.
C) decreases. D) increases.

Answer: C

29) A spaceship is traveling to the Moon. At what point is it beyond the pull of Earth's gravity?

A) when it is closer to the Moon than it is to Earth B) when it gets above the atmosphere
C) when it is half-way there D) It is never beyond the pull of Earth's gravity.

Answer: D

30) Suppose a satellite were orbiting the Earth just above the surface. What is its centripetal acceleration?

A) equal to g B) smaller than g
C) larger than g D) Impossible to say without knowing the mass.

Answer: A

31) A hypothetical planet has a mass of half that of the Earth and a radius of twice that of the Earth. What is the acceleration due to gravity on the planet in terms of g, the acceleration due to gravity at the Earth?

A) g B) g/4 C) g/8 D) g/2

Answer: C

32) The acceleration of gravity on the Moon is one-sixth what it is on Earth. The radius of the Moon is one-fourth that of the Earth. What is the Moon's mass compared to the Earth's?

A) 1/96 B) 1/16 C) 1/24 D) 1/6

Answer: A

33) Two planets have the same surface gravity, but planet B has twice the radius of planet A. If planet A has mass m, what is the mass of planet B?

A) m B) 1.41m C) 0.707m D) 4m

Answer: D

34) Two planets have the same surface gravity, but planet B has twice the mass of planet A. If planet A has radius r, what is the radius of planet B?

A) 1.41r B) 0.707r C) 4r D) r

Answer: A

35) Consider a small satellite moving in a circular orbit (radius r) about a spherical planet (mass M). Which expression gives this satellite's orbital velocity?

A) $(GM/r)^{1/2}$ B) $(GM/r^2)^{1/2}$ C) GM/r^2 D) $v = GM/r$

Answer: A

36) Satellite A has twice the mass of satellite B, and rotates in the same orbit. Compare the two satellite's speeds.

A) The speed of B is half the speed of A.
B) The speed of B is one-fourth the speed of A.
C) The speed of B is twice the speed of A.
D) The speed of B is equal to the speed of A.

Answer: D

37) A person is standing on a scale in an elevator accelerating downward. Compare the reading on the scale to the person's true weight.

A) zero
B) greater than their true weight
C) equal to their true weight
D) less than their true weight

Answer: D

38) Who was the first person to realize that the planets move in elliptical paths around the Sun?

A) Einstein B) Copernicus C) Brahe D) Kepler

Answer: D

39) The speed of Halley's Comet, while traveling in its elliptical orbit around the Sun,

A) is zero at two points in the orbit.
B) increases as it nears the Sun.
C) decreases as it nears the Sun.
D) is constant.

Answer: B

40) Let the average orbital radius of a planet be r. Let the orbital period be T. What quantity is constant for all planets orbiting the Sun?

A) T/R B) T/R^2 C) T^3/R^2 D) T^2/R^3

Answer: D

41) A planet is discovered to orbit around a star in the galaxy Andromeda, with the same orbital diameter as the Earth around our Sun. If that star has 4 times the mass of our Sun, what will the period of revolution of that new planet be, compared to the Earth's orbital period?

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

Answer: B

42) The average distance from the Earth to the Sun is defined as one "astronomical unit" (AU). An asteroid orbits the Sun in one-third of a year. What is the asteroid's average distance from the Sun?

A) 5.2 AU
B) 0.19 AU
C) 2.1 AU
D) 0.48 AU

Answer: D

ESSAY. Write your answer in the space provided or on a separate sheet of paper.

43) State Kepler's laws.

Answer: Kepler's first law: The path of each planet about the Sun is an ellipse with the Sun at one focus.
Kepler's second law: Each planet moves so that an imaginary line drawn from the Sun to the planet sweeps out equal areas in equal periods of time.
Kepler's third law: The ratio of the squares of the periods of any two planets revolving about the Sun is equal to the ratio of the cubes of their mean distances from the Sun.

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

44) List the four fundamental forces in nature.

A) gravitational, normal, kinetic friction, static friction
B) gravitational, normal, tension, friction
C) gravitational, electromagnetic, strong nuclear, weak nuclear
D) gravitational, electromagnetic, contact, nuclear

Answer: C

45) An object moves with a constant speed of 30 m/s on a circular track of radius 150 m. What is the acceleration of the object?

A) zero
B) 5.0 m/s^2
C) 6.0 m/s^2
D) 0.17 m/s^2

Answer: C

46) The maximum speed around a level curve is 30.0 km/h. What is the maximum speed around a curve with twice the radius? (Assume all other factors remain unchanged.)

A) 45.0 km/h
B) 60.0 km/h
C) 120 km/h
D) 42.4 km/h

Answer: D

47) What is the centripetal acceleration of a point on the perimeter of a bicycle wheel of diameter 70 cm when the bike is moving 8.0 m/s?

A) 2.1×10^2 m/s^2
B) 2.7×10^2 m/s^2
C) 1.8×10^2 m/s^2
D) 91 m/s^2

Answer: C

48) A point on a wheel rotating at 5.00 rev/s is located 0.200 m from the axis. What is the centripetal acceleration?

A) 0.050 m/s^2
B) 198 m/s^2
C) 1.35 m/s^2
D) 48.0 m/s^2

Answer: B

49) How many revolutions per minute must a circular, rotating space station of radius 1000 m rotate to produce an artificial gravity of 9.80 m/s^2?

A) 0.75 rpm B) 0.65 rpm C) 0.95 rpm D) 0.85 rpm

Answer: C

50) A motorcycle has a mass of 250 kg. It goes around a 13.7 m radius turn at 96.5 km/h. What is the centripetal force on the motorcycle?

A) 4.31×10^4 N B) 2.95×10^3 N C) 719 N D) 1.31×10^4 N

Answer: D

51) A 0.50-kg mass is attached to the end of a 1.0-m string. The system is whirled in a horizontal circular path. If the maximum tension that the string can withstand is 350 N. What is the maximum speed of the mass if the string is not to break?

A) 19 m/s B) 26 m/s C) 700 m/s D) 13 m/s

Answer: B

52) A stone, of mass m, is attached to a strong string and whirled in a vertical circle of radius r. At the exact top of the path the tension in the string is 3 times the stone's weight. The stone's speed at this point is given by

A) $(2gr)^{1/2}$. B) 2gr. C) $(gr)^{1/2}$. D) $2(gr)^{1/2}$.

Answer: D

53) A stone, of mass m, is attached to a strong string and whirled in a vertical circle of radius r. At the exact bottom of the path the tension in the string is 3 times the stone's weight. The stone's speed at this point is given by

A) $2(gr)^{1/2}$. B) $(2gr)^{1/2}$. C) 2gr. D) $(gr)^{1/2}$.

Answer: B

54) A jet plane flying 600 m/s experiences an acceleration of 4g when pulling out of the dive. What is the radius of curvature of the loop in which the plane is flying?

A) 640 m B) 9200 m C) 1200 m D) 7100 m

Answer: B

55) A pilot makes an outside vertical loop (in which the center of the loop is beneath him) of radius 3200 m. At the top of his loop he is pushing down on his seat with only one-half of his normal weight. How fast is he going?

A) 5.0 m/s B) 625 m/s C) 25 m/s D) 125 m/s

Answer: D

56) The maximum force a pilot can stand is about seven times his weight. What is the minimum radius of curvature that a jet plane's pilot, pulling out of a vertical dive, can tolerate at a speed of 250 m/s?

A) 4.25 m B) 911 m C) 1060 m D) 3.64 m

Answer: C

57) A car traveling 20 m/s rounds an 80-m radius horizontal curve with the tires on the verge of slipping. How fast can this car round a second curve of radius 320 m? (Assume the same coefficient of friction between the car's tires and each road surface.)

A) 80 m/s B) 20 m/s C) 40 m/s D) 160 m/s

Answer: C

58) A car is negotiating a flat curve of radius 50 m with a speed of 20 m/s. The centripetal force provided by friction is 1.2×10^4 N. What is the mass of the car?

A) 1500 kg B) 2000 kg C) 500 kg D) 1000 kg

Answer: A

59) A car goes around a flat curve of radius 50 m at a speed of 14 m/s. What must be the minimum coefficient of friction between the tires and the road for the car to make the turn?

A) 0.40 B) 0.60 C) 0.20 D) 0.80

Answer: A

60) A car is moving with a constant speed v around a level curve. The coefficient of friction between the tires and the road is 0.40. What is the minimum radius of the curve if the car is to stay on the road?

A) $2v^2/g$ B) $2.5v^2/g$ C) $0.40v^2/g$ D) v^2/g

Answer: B

61) What minimum banking angle is required for an Olympic bobsled to negotiate a 100-m radius turn at 35 m/s without skidding? (Ignore friction.)

A) 61° B) 51° C) 31° D) 41°

Answer: B

62) A horizontal curve on a bobsled run is banked at a 45° angle. When a bobsled rounds this curve at the curve's safe speed (no friction needed to stay on the run), what is its centripetal acceleration?

A) 2.0 g B) 0.5 g C) 1.0 g D) none of the above

Answer: C

63) A frictionless curve of radius 100 m, banked at an angle of 45°, may be safely negotiated at a speed of

A) 22 m/s. B) 31 m/s. C) 67 m/s. D) 44 m/s.

Answer: B

64) A curve of radius 80 m is banked at 45°. Suppose that an ice storm hits, and the curve is effectively frictionless. What is the safe speed with which to take the curve without either sliding up or down?

A) 7.8×10^2 m/s B) 9.4 m/s

C) 28 m/s D) The curve cannot be taken safely.

Answer: C

ESSAY. Write your answer in the space provided or on a separate sheet of paper.

65) A 175-kg ball on the end of a string is revolving uniformly in a horizontal circle of radius 0.500 m. The ball makes 2.00 revolutions in a second.

(a) Determine the speed of the ball.

(b) Determine the ball's centripetal acceleration.

(c) Determine the force a person must exert on opposite end of the string.

Answer: (a) 6.28 m/s

(b) 79.0 m/s^2

(c) 13.8 N

66) Starting from rest in the pit area, a race car accelerates at a uniform rate to a speed of 45 m/s in 15 s, moving on a circular track of radius 500 m.
(a) Calculate the tangential acceleration.
(b) Calculate the radial acceleration when the instantaneous speed is equal to 30 m/s.

Answer: (a) 3.0 m/s^2
(b) 1.8 m/s^2

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

67) The hydrogen atom consists of a proton of mass 1.67×10^{-27} kg and an orbiting electron of mass 9.11×10^{-31} kg. In one of its orbits, the electron is 5.3×10^{-11} m from the proton. What is the mutual attractive force between the electron and proton?
A) 3.6×10^{-47} N B) 5.4×10^{-47} N C) 1.8×10^{-47} N D) 7.0×10^{-47} N

Answer: A

68) What is the gravitational force on a 70-kg person standing on the Earth, due to the Moon? The mass of the Moon is 7.36×10^{22} kg and the distance to the Moon is 3.82×10^{8} m.
A) 0.0024 N B) 0.00024 N C) 0.024 N D) 0.24 N

Answer: A

69) The gravitational attractive force between two masses is F. If the masses are moved to half of their initial distance, what is the gravitational attractive force?
A) F/2 B) F/4 C) 4F D) 2F

Answer: C

70) For a spacecraft going from the Earth toward the Sun, at what distance from the Earth will the gravitational forces due to the Sun and the Earth cancel?
Earth's mass: $M_e = 5.98 \times 10^{24}$ kg
the Sun's mass: $M_S = 1.99 \times 10^{30}$ kg
Earth-Sun distance: $r = 1.50 \times 10^{11}$ m
A) 2.60×10^{8} m B) 1.30×10^{10} m C) 2.60×10^{10} m D) 1.30×10^{8} m

Answer: A

71) The mass of the Moon is 7.4×10^{22} kg and its mean radius is 1.75×10^{3} km. What is the acceleration due to gravity at the surface of the Moon?
A) 2.8×10^{6} m/s^2 B) 0.80 m/s^2 C) 1.6 m/s^2 D) 9.80 m/s^2

Answer: C

72) An astronaut goes out for a "space-walk" at a distance above the Earth equal to the radius of the Earth. What is her acceleration due to gravity?
A) g B) g/2 C) zero D) g/4

Answer: D

73) The radius of the Earth is R. At what distance above the Earth's surface will the acceleration of gravity be 4.9 m/s^2?
A) 1.00 R B) 1.41 R C) 0.50 R D) 0.41 R

Answer: D

74) A satellite encircles Mars at a distance above its surface equal to 3 times the radius of Mars. The acceleration of gravity of the satellite, as compared to the acceleration of gravity on the surface of Mars, is

A) the same.
B) one-third as much.
C) one-sixteenth as much.
D) zero.

Answer: C

75) At a distance of 14000 km from some planet's center, the acceleration of gravity is 32 m/s^2. What is the acceleration of gravity at a point 28000 km from the planet's center?

A) 8.0 m/s^2
B) 128 m/s^2
C) 16 m/s^2
D) cannot be determined from the information given

Answer: A

76) An object weighs 432 N on the surface of the Earth. The Earth has radius r. If the object is raised to a height of 3r above the Earth's surface, what is its weight?

A) 432 N
B) 48 N
C) 0 N
D) 27 N

Answer: D

77) By how many newtons does the weight of a 100-kg person change when he goes from sea level to an altitude of 5000 m? (The mean radius of the Earth is 6.38×10^6 m.)

A) 3.6 N
B) 1.6 N
C) 2.6 N
D) 0.6 N

Answer: B

78) The Earth has radius r. A satellite of mass 100 kg is at a point 3r above the Earth's surface. What is the satellite's weight?

A) 9000 N
B) 110 N
C) 61 N
D) 16000 N

Answer: C

79) A spherically symmetric planet has four times the Earth's mass and twice its radius. If a jar of peanut butter weighs 12 N on the surface of the Earth, how much would it weigh on the surface of this planet?

A) 36 N
B) 24 N
C) 6.0 N
D) 12 N

Answer: D

ESSAY. Write your answer in the space provided or on a separate sheet of paper.

80) During a lunar eclipse, the Moon, Earth, and Sun all lie on the same line, with the Earth between the Moon and the Sun. The Moon has a mass of 7.36×10^{22} kg; the Earth has a mass of 5.98×10^{24} kg; and the Sun has a mass of 1.99×10^{30} kg. The separation between the Moon and the Earth is given by 3.84×10^8 m; the separation between the Earth and the Sun is given by 1.496×10^{11} m.
(a) Calculate the force exerted on the Earth by the Moon.
(b) Calculate the force exerted on the Earth by the Sun.
(c) Calculate the net force exerted on the Earth by the Moon and the Sun.

Answer: (a) 1.99×10^{20} N, toward the Moon
(b) 3.55×10^{22} N, toward the Sun
(c) 3.53×10^{22} N, toward the Sun

81) A 2.10-kg brass ball is transported to the Moon.
(a) Calculate the acceleration due to gravity on the Moon. The radius of the Moon is 1.74×10^6 m and the mass of the Moon is 7.35×10^{22} kg.
(b) Determine the mass of the brass ball on the Earth and on the Moon.
(c) Determine the weight of the brass ball on the Earth.
(d) Determine the weight of the brass ball on the Moon.

Answer: (a) 1.62 m/s^2
(b) 2.10 kg, 2.10 kg
(c) 20.6 N
(d) 3.40 N

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

82) A satellite is in a low circular orbit about the Earth (i.e., it just skims the surface of the Earth). What is the speed of the satellite? (The mean radius of the Earth is 6.38×10^6 m.)
A) 7.9 km/s B) 5.9 km/s C) 8.9 km/s D) 6.9 km/s

Answer: A

83) A satellite is in a low circular orbit about the Earth (i.e., it just skims the surface of the Earth). How long does it take to make one revolution around the Earth? (The mean radius of the Earth is 6.38×10^6 m.)
A) 85 min B) 89 min C) 81 min D) 93 min

Answer: A

84) A satellite is in circular orbit 230 km above the surface of the Earth. It is observed to have a period of 89 min. What is the mass of the Earth? (The mean radius of the Earth is 6.38×10^6 m.)
A) 5.0×10^{24} kg B) 6.5×10^{24} kg C) 6.0×10^{24} kg D) 5.5×10^{24} kg

Answer: C

85) Europa, a moon of Jupiter, has an orbital diameter of 1.34×10^9 m, and a period of 3.55 days. What is the mass of Jupiter?
A) 1.83×10^{27} kg B) 1.89×10^{27} kg C) 1.87×10^{27} kg D) 1.85×10^{27} kg

Answer: B

86) The innermost moon of Jupiter orbits the planet with a radius of 422×10^3 km and a period of 1.77 days. What is the mass of Jupiter?
A) 1.5×10^{27} kg B) 1.9×10^{27} kg C) 1.3×10^{27} kg D) 1.7×10^{27} kg

Answer: B

87) Two moons orbit a planet in nearly circular orbits. Moon A has orbital radius r, and moon B has orbital radius 4r. Moon A takes 20 days to complete one orbit. How long does it take moon B to complete an orbit?
A) 160 days B) 80 days C) 320 days D) 20 days

Answer: A

88) The planet Jupiter is 7.78×10^{11} m from the Sun. How long does it take for Jupiter to orbit once about the Sun? (The distance from the Earth to the Sun is 1.50×10^{11} m.)
A) 6 yr B) 3 yr C) 1 yr D) 12 yr

Answer: D

89) It takes the planet Jupiter 12 years to orbit the Sun once. What is the average distance from Jupiter to the Sun? (The distance from the Earth to the Sun is 1.5×10^{11} m.)

A) 9.7×10^{11} m B) 3.9×10^{11} m C) 7.9×10^{11} m D) 5.2×10^{11} m

Answer: C

ESSAY. Write your answer in the space provided or on a separate sheet of paper.

90) Will the acceleration of a car be the same when the car travels around a sharp curve at a constant 60 km/h as when it travels around a gentle curve at the same speed? Explain.

Answer: The centripetal acceleration for an object moving in circular motion is inversely proportional to the radius of the curve, given a constant speed. So for a gentle curve (which means a large radius), the acceleration is smaller, while for a sharp curve (which means a small radius), the acceleration is larger.

91) 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.

Answer: For the water to remain in the bucket, there must be a centripetal force forcing the water to move in a circle along with the bucket. That centripetal force gets larger with the tangential velocity of the water, since $F_R = mv^2/r$. The centripetal force at the top of the motion comes from a combination of the downward force of gravity and the downward normal force of the bucket on the water. If the bucket is moving faster than some minimum speed, the water will stay in the bucket. If the bucket is moving too slow, there is insufficient force to keep the water moving in the circular path, and it spills out.

92) Why do airplanes bank when they turn? How would you compute the banking angle given its speed and radius of the turn?

Answer: Airplanes bank when they turn because in order to turn, there must be a force that will be exerted towards the center of a circle. By tilting the wings, the lift force on the wings has a non-vertical component which points toward the center of the curve, providing the centripetal force. The sum of vertical forces must be zero for the plane to execute a level turn. The horizontal component of the lifting force must provide the centripetal force to move the airplane in a circle.

93) A girl is whirling a ball on a string around her head in a horizontal plane. She wants to let go at precisely the right time so that the ball will hit a target on the other side of the yard. When should she let go of the string?

Answer: She should let go of the string when the ball is at a position where the tangent line to the circle at the ball's location, when extended, passes through the target's position. That tangent line indicates the direction of the velocity at that instant, and if the centripetal force is removed, then the ball will follow that line horizontally.

94) Which pulls harder gravitationally, the Earth on the Moon, or the Moon on the Earth? Which accelerates more?

Answer: The gravitational pull is the same in each case, by Newton's third law. To find the acceleration of each body, the gravitational pulling force is divided by the mass of the body. Since the Moon has the smaller mass, it will have the larger acceleration.

95) When will your apparent weight be the greatest, as measured by a scale in a moving elevator: when the elevator (a) accelerates downward, (b) accelerates upward, (c) is in free fall, (d) moves upward at constant speed? In which case would your weight be the least? When would it be the same as when you are on the ground?

Answer: The apparent weight (the normal force) would be largest when the elevator is accelerating upward. The apparent weight would be the least when in free fall, because there the apparent weight is zero. When the elevator is moving with constant speed, your apparent weight would be the same as it is on the ground.

96) The mass of Pluto was not known until it was discovered to have a moon. Explain how this discovery enabled an estimate of Pluto's mass.

Answer: Let the mass of Pluto be M, the mass of the moon be m, the radius of the moon's orbit be R, and the period of the moon's orbit be T. Then Newton's second law for the moon orbiting Pluto will be $F = \frac{GmM}{R^2}$. If that moon's orbit is a circle, then the form of the force must be centripetal, and so $F = \frac{mv^2}{R}$. Equate these two expressions for the force on the moon, and substitute the relationship for a circular orbit that $v = \frac{2\pi R}{T}$.

$$\frac{GmM}{R^2} = \frac{mv^2}{R} = \frac{4\pi^2 mR}{T^2} \rightarrow M = \frac{4\pi^2 R^3}{GT^2}.$$

Thus a value for the mass of Pluto can be calculated knowing the period and radius of the moon's orbit.

97) Suppose the space shuttle is in orbit 400 km from the Earth's surface, and circles the Earth about once every 90 minutes. Find the centripetal acceleration of the space shuttle in its orbit. Express your answer in terms of g, the gravitational acceleration at the Earth's surface.

Answer: 0.9 g

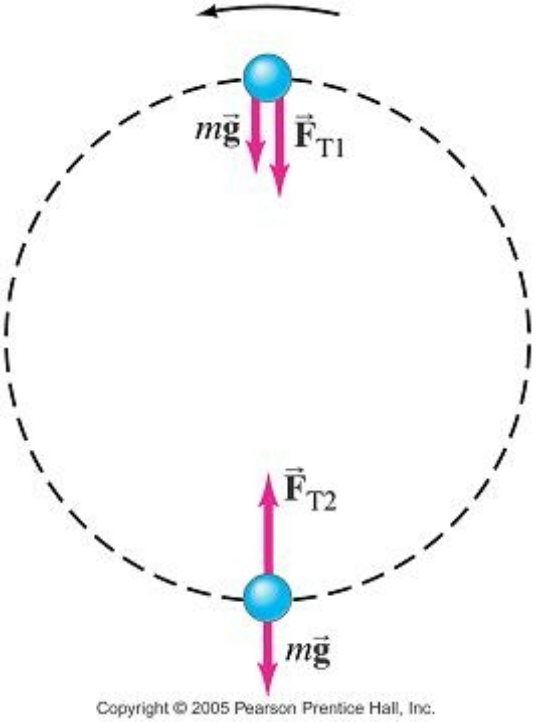

FIGURE 5-33

98) A ball on the end of a string is revolved at a uniform rate in a vertical circle of radius 72.0 cm, as shown in Fig. 5-33. If its speed is 4.00 m/s and its mass is 0.300 kg, calculate the tension in the string when the ball is (a) at the top of its path, and (b) at the bottom of its path.

Answer: (a) 3.73 N
(b) 9.61 N

99) A 0.45-kg ball attached to the end of a horizontal cord, is rotated in a circle of radius 1.3 m on a frictionless horizontal surface. If the cord will break when the tension in it exceeds 75 N, what is the maximum speed the ball can have?

Answer: 15 m/s

100) A coin is placed 11.0 cm from the axis of a rotating turntable of variable speed. When the speed of the turntable is slowly increased, the coin remains fixed on the turntable until a rate of 36 rpm is reached and the coin slides off. What is the coefficient of static friction between the coin and the turntable?

Answer: 0.16

101) A bucket of mass 2.00 kg is whirled in a vertical circle of radius 1.10 m. At the lowest point of its motion the tension in the rope supporting the bucket is 25.0 N. (a) Find the speed of the bucket. (b) How fast must the bucket move at the top of the circle so that the rope does not go slack?

Answer: (a) 1.7 m/s
(b) 3.3 m/s

102) A 1200-kg car rounds a curve of radius 67 m banked at an angle of 12°. If the car is traveling at 95 km/h, will a friction force be required? If so, how much and in what direction?

Answer: A frictional force of 9.8×10^3 N down the plane is needed to provide the necessary centripetal force to round the curve at the specified speed.

103) A car at the Indianapolis 500 accelerates uniformly from the pit area, going from rest to 320 km/h in a semicircular arc with a radius of 220m. Determine the tangential and radial acceleration of the car when it is halfway through the turn, assuming constant tangential acceleration. If the curve were flat, what would the coefficient of static friction have to be between the tires and the road to provide this acceleration with no slipping or skidding?

Answer: $a_{tan} = 5.72$ m/s^2; $a_R = 18.0$ m/s^2; $\mu_S = 1.9$

104) Calculate the acceleration due to gravity on the Moon. The Moon's radius is 1.74×10^6 m and its mass is 7.35×10^{22} kg.

Answer: 1.62 m/s^2

105) Two objects attract each other gravitationally with a force of 2.5×10^{-10} N when they are 0.25 m apart. Their total mass is 4.0 kg. Find their individual masses.

Answer: 3.9 kg and 0.10 kg

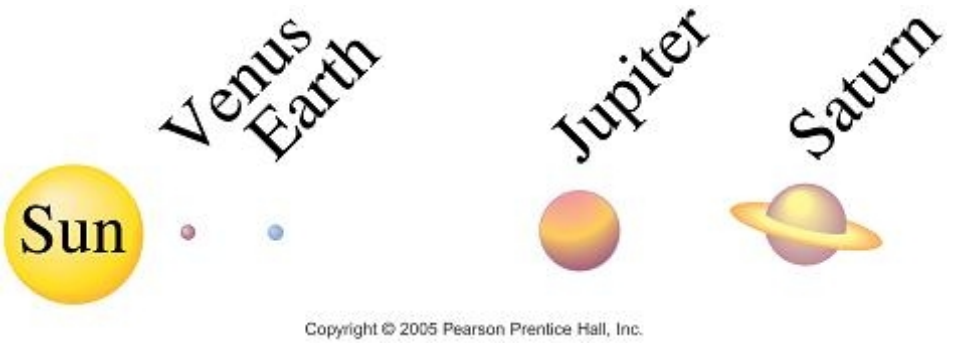

FIGURE 5-38 (Not to scale.)

106) Every few hundred years most of the planets line up on the same side of the Sun. Calculate the total force on the Earth due to Venus, Jupiter, and Saturn, assuming all four planets are in a line (Fig. 5-38). The masses are $M_V = 0.815M_E$, $M_J = 318M_E$, $M_S = 95.1M_E$, and their mean distances from the Sun are 108, 150, 778, and 1430 million km, respectively. What fraction of the Sun's force on the Earth is this?

Answer: 9.56×10^{17} N, toward the right; 2.71×10^{-5}

107) Given that the acceleration of gravity at the surface of Mars is 0.38 of what it is on Earth, and that Mars' radius is 3400 km, determine the mass of Mars.

Answer: 6.4×10^{23} kg

108) During an *Apollo* lunar landing mission, the command module continued to orbit the Moon at an altitude of about 100 km. How long did it take to go around the Moon once?

Answer: 7.08×10^{3} s

109) The rings of Saturn are composed of chunks of ice that orbit the planet. The inner radius of the rings is 73,000 km, while the outer radius is 170,000 km. Find the period of an orbiting chunk of ice at the inner radius and the period of a chunk at the outer radius. Compare your numbers with Saturn's mean rotation period of 10 hours and 39 minutes. The mass of Saturn is 5.7×10^{26} kg.

Answer: inner radius 2.0×10^{4} s, outer radius 7.1×10^{4} s

Saturn's rotation period (day) is 10 hr 39 min which is about 3.8×10^{4} s. Thus the inner ring will appear to move across the sky "faster" than the sun (about twice per Saturn day), while the outer ring will appear to move across the sky "slower" than the sun (about once every two Saturn days).

110) What will a spring scale read for the weight of a 55 kg woman in an elevator that moves (a) upward with constant speed of 6.0 m/s, (b) downward with constant speed of 6.0 m/s, (c) upward with acceleration of 0.33 *g*, (d) downward with acceleration 0.33 *g*, and (e) in free fall?

Answer: (a) 5.4×10^{2} N
(b) 5.4×10^{2} N
(c) 7.2×10^{2} N
(d) 3.6×10^{2} N
(e) 0 N

111) Our Sun rotates about the center of the Galaxy ($M_G \approx 4 \times 10^{41}$ kg) at a distance of about 3×10^{4} lightyears (1 ly = 3×10^{8} m/s × 3.16×10^{7} s/y × 1 y). What is the period of our orbital motion about the center of the Galaxy?

Answer: 2×10^{8} y

112) Determine the mass of the Earth from the known period and distance of the Moon.

Answer: 5.98×10^{24} kg

113) Determine the mean distance from Jupiter for each of Jupiter's moons, using Kepler's third law. Use the distance of Io and the periods given in the Table below. Compare to the values in the Table.

TABLE principal Moons of Jupiter

Moon	Mass (kg)	Period (Earth days)	Mean distance from Jupiter (km)
Io	8.9×10^{22}	1.77	422×10^{3}
Europa	4.9×10^{22}	3.55	671×10^{3}
Ganymede	15×10^{22}	7.16	1070×10^{3}
Callisto	11×10^{22}	16.7	1883×10^{3}

Answer: $r_{Europa} = 671 \times 10^{3}$ km, $r_{Ganymede} = 1070 \times 10^{3}$ kg, $r_{Callisto} = 1880 \times 10^{3}$ km
The agreement with the data in the table is excellent.