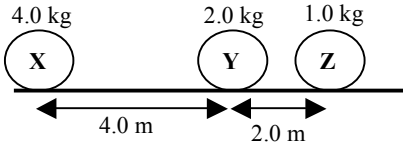
Unit 5: Circular Motion and Gravitation

Please Note that the gravitational potential energy questions are located in Unit 4 (Energy etc.)

Multiple Choice Portion

1. What is the centripetal acceleration of the moon towards the earth?
   a. 1.23×10^{-6} m/s^2
   b. 2.70×10^{-3}m/s^2
   c. 1.62 m/s^2
   d. 9.8 m/s^2

2. Three balls are placed in line on a horizontal surface, as shown in the figure below. What is the magnitude of the net gravitational force exerted on Y due to X and Z?

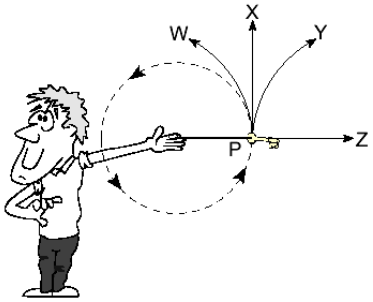


   a. 6.7×10^{-11}N
   b. 1.9×10^{-11} N
   c. 1.0×10^{-11}N
   d. zero

3. Two bodies of equal mass exert a gravitational force F_1 on each other when they are separated by distance d. What is the new force F_2 exerted if the mass is doubled and the distance between them is doubled?
   a. $F_2 = 0.5\ F_1$
   b. $F_2 = F_1$
   c. $F_2 = 2F_1$
   d. $F_2 = 4F_1$

4. What is the relationship between the speed *v* of a planet and the distance *R* from its sun?
   a. *v* increases as *R* decreases
   b. *v* decreases as *R* decreases
   c. *v* does not change as *R* changes
   d. *v* is directly proportional to *R*

5. The diagram shows a student "twirling" a car key in a circular path on the end of a string. If the string snaps at P, which path will the keys follow?



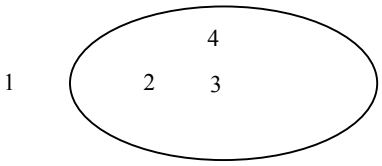
   a. W
   b. X
   c. Y
   d. Z

6. For a given planet in a given elliptical orbit, how does its speed v depend on its distance d from the sun?
   a. as *d* increases, *v* increase
   b. as *d* increases, *v* decreases
   c. *v* is constant even if *d* varies
   d. *v* varies throughout its orbit, but is independent of *d*

7. What is the gravitational force exerted by the sun on a person of mass 72 kg standing on the surface of the earth?
   a. 2.3×10^{8} N
   b. 710 N
   c. 0.42 N
   d. 1.3×10^{-6} N

8. A certain spherical planet, which is not rotating, has a radius of 6.36×10^{5} m and a mass of 1.89×10^{21}-kg. At what minimum speed would a vehicle travelling along its surface just begin to leave the ground?
   a. 445 m/s
   b. 630 m/s
   c. 19 800 m/s
   d. it depends on the mass of the vehicle

9. The curved line in the below diagram represents the path of a planet around star. In relation to this path, at what point is the star located



   a. 1
   b. 2
   c. 3
   d. 4

10. What is the centripetal force required to keep a 0.10 kg mass moving in a circular path of radius 1.0 m with period of 0.010 s?
    a. 3.9×10^{-1}N
    b. 3.9×10^{3} N
    c. 1.3×10^{4} N
    d. 3.9×10^{4} N

11. Why might a car skid as it negotiates a sharp corner?
    a. too much mass
    b. insufficient mass
    c. insufficient frictional forces
    d. too large of coefficient of friction

12. The ratio of F to m_1m_2/d^2 in Newton's law of universal gravitation is
    a. equal to the gravitational constant
    b. equal to the acceleration due to gravity
    c. equal to the centripetal acceleration of the two masses
    d. proportional to the area swept out in given time by the radius vector joining the masses

13. An athlete runs, at a constant speed, around a circle of radius 5.0 m in 12 s. What are the athlete's speed and acceleration?

	SPEED	MAGNITUDE OF ACCELERATION
a.	0. 42 m/s	0.22 m/s^2
b.	0. 42 m/s	1. 4 m/s^2
c.	2.6 m/s	0.22 m/s^2
d.	2.6 m/s	1. 4 m/s^2

14. What is the centripetal acceleration of car moving at a constant speed of 12.5 m/s around radius of 200.0 m?
    a. 3.13 x $10^{-4}m/s^2$
    b. 6.25 x $10^{-2}m/s^2$
    c. 7.81 x $10^{-1}m/s^2$
    d. zero

15. An object is revolving in a circle with period T. Its centripetal acceleration is $\mathbf{a_c}$. If the same object is made to revolve in circle with the same radius but a period of 2T, what is the new acceleration?
    a. 4 $\mathbf{a_c}$
    b. 2 $\mathbf{a_c}$
    c. $\mathbf{a_c}$ /2
    d. $\mathbf{a_c}$ /4

16. An object is moving in a circular path at a constant speed. If the radius of the path is tripled while the speed remains same, by what factor will the centripetal force on the object be multiplied?
    a. $\frac{1}{9}$
    b. $\frac{1}{3}$
    c. 3
    d. 9

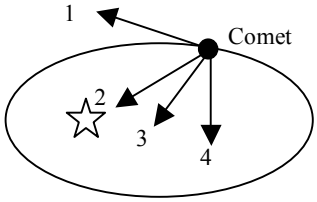
17. What is the acceleration due to gravity at the surface of a planet whose mass is 1.88 x 10^{21} kg and whose radius is 4.34 x 10^5 m?
    a. 3.08 x $10^{-3}m/s^2$
    b. 0.666 m/s^2
    c. 9.80 m/s^2
    d. 2.89 x 10^5 m/s^2

18. A spacecraft circling a planet has period of 1.8 hr. If the radius of its orbit is doubled, what will its period be?
    a. 2.9 hr
    b. 3.6 hr
    c. 5.1 hr
    d. 14 hr

19. Two sacks contain 10 oranges each. Which of the following changes alone could double the gravitational force between the sacks?
    a. add 10 oranges to each sack
    b. add 20 oranges to each sack
    c. add 10 oranges to one of the sacks only
    d. add 20 oranges to one of the sacks only

20. What is the period of an object orbiting a planet at a constant distance of 7.0 x 10^7 m from the planet centre, in an orbit where the acceleration due to gravity is 4.0 m/s^2?
    a. 4.2 x 10^3 s
    b. 1.5 x 10^4 s
    c. 2.6 x 10^4 s
    d. 6.9 x 10^5 s

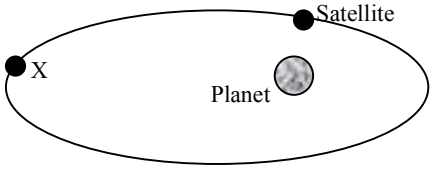
21. In the diagram below shows the elliptical orbit of a comet about the sun. Which arrow represents the direction of the net force on the comet in the position shown?



    a. 1
    b. 2
    c. 3
    d. 4

22. An object travelling in a uniform circular motion at speed v has a centripetal force F acting on it. If its speed is doubled and the radius remains constant, the new centripetal is
    a. F
    b. 2F
    c. 2F
    d. 4F

23. A satellite orbits a planet as shown below



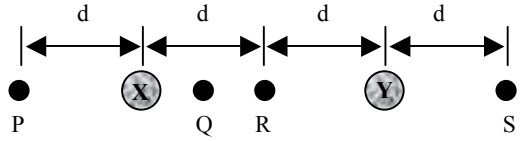
Which one of the following best describes the speed and magnitude of acceleration of the satellite at position X?

	Speed	Magnitude of Acceleration
a	Minimum	Minimum
b	Minimum	Maximum
c	Maximum	Minimum
d	Maximum	maximum

24. An object moves in circle of radius 8.5 m with a period of 7.2 s. If the centripetal force needed for this motion is 36 N, what is the mass of the object?
    a. 5.6 kg
    b. 6.5×10^{-1} kg
    c. 2.3×10^{2} kg
    d. 2.0×10^{3} kg

25. A 1.8×10^{3} kg satellite orbits the earth in a circle of radius 3.2×10^{7} m. What is the gravitational field strength at this radius?
    a. 3.0×10^{-21} N/kg
    b. 3.9×10^{-1} N/kg
    c. 9.8 N/kg
    d. 6.7×10^{2} N/kg

26. A spaceship can be located, relative to the planets X and Y at points P, Q, R and S.



    At which point will the magnitude of the net force of gravity acting on the spaceship be the smallest?
    a. P
    b. Q
    c. R
    d. S

27. The average distance of the planet Saturn from the sun is 9.54 times the average distance of the Earth from the sun. What is the period of Saturn's orbit in Earth years?
    a. 4.50 years
    b. 9.54 years
    c. 29.5 years
    d. 91.0 years

28. A 900-kg car travels at a constant speed in a horizontal circle with radius 61 m with period of 15 s. What is the centripetal force on the car?
    a. 0.0 N
    b. 11 N
    c. 8.8×10^{3} N
    d. 9.6×10^{3} N

29. Two objects are separated by 2.3 m. One of the objects is 8.0 kg. The force of gravitational attraction between them is 5.0×10^{-10} N. What is the mass of the second object?
    a. 0.20 kg
    b. 0.50 kg
    c. 2.2 kg
    d. 5.0 kg

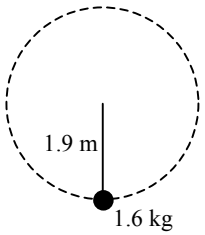
30. The radius of an asteroid orbit around the sun is 4.0 times the radius of Earth's orbit around the Sun. What is the orbital period of the asteroid?
    a. 2.5 years
    b. 4.0 years
    c. 8.0 years
    d. 16 years

31. Which one of the following best describes an object in uniform circular motion?

	Magnitude of Acceleration	Magnitude of Velocity
a	Constant	Constant
b	Constant	Changing
c	Changing	Constant
d	Changing	Changing

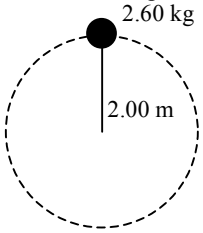
32. The force of gravity on an object at the Moon's surface is 400 N. At what distance from the centre of the Moon will the force of gravity on this object be 100 N?
    a. 1.74×10^{6} m
    b. 2.46×10^{6} m
    c. 3.48×10^{6} m
    d. 6.96×10^{6} m

33. The diagram below shows a 1.6 kg air puck on the end of a string. The puck is moving in a horizontal circular path of radius 1.9 m



    If the tension in the string is 150 N, what is the period of revolution of the puck?
    a. 0.89 s
    b. 0.95 s
    c. 1.1 s
    d. 1.4s

34. A 2.60 kg object, at one end of a rod of negligible mass, is moving at a constant speed in a vertical circle of radius 2.00 m at a frequency 0.800 Hz.



    When the object is at the top of the circle, as shown above, what is the tension in the rod?
    a. 25.5 N
    b. 106 N
    c. 131 N
    d. 157 N

35. A child is riding on a merry-go-round which is rotating at a constant rate. Which of the following describes the child's speed, velocity, and magnitude of acceleration?

	Speed	Velocity	Magnitude of Acceleration
a	constant	constant	constant
b	constant	changing	constant
c	changing	constant	changing
d	changing	changing	changing

36. A satellite is travelling around the Earth in an orbit of radius 4.47 $x10^7$ m. What is the mass of the satellite if it experiences a gravitational force of 3.00 $x10^3$ N?
    a. 4.37 $x10^1$ kg
    b. 3.06 $x10^2$ kg
    c. 2.14 $x10^3$ kg
    d. 1.50 $x10^4$ kg

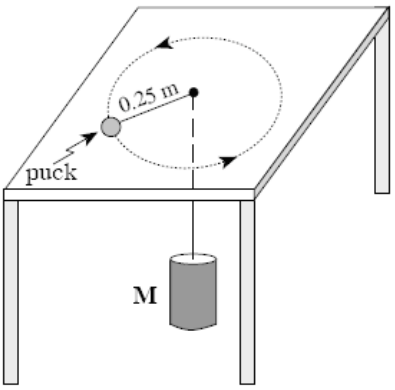
37. A circular space station of radius 120 m is to be rotated so that its astronauts experience an effect similar to that of a gravitational field. If the field is to be 5.0 m/s^2 at this radius, what should be the period of rotation of the space station?
    a. 3.2 x 10^{-1} s
    b. 3.1 x 10^1 s
    c. 5.1 x 10^3 s
    d. 8.6 x 10^4 s

38. On Earth, the maximum speed without skidding for a car on a level circular curved track of radius 40 m is 15 m/s. This car and track are then transported to another planet for the Indy Galactic 500. The maximum speed without skidding is now 8.4 m/s. What is the value of the acceleration due to gravity on this other planet?
    a. 1.8 m/s^2
    b. 3.1 m/s^2
    c. 4.3 m/s^2
    d. 5.5 m/s^2

39. The gravitational force of attraction between the Sun and an asteroid travelling in an orbit of radius 4.14 x 10^{11} m is 4.62 x 10^{17} N. What is the mass of the asteroid?
    a. 1.45 x 10^9 kg
    b. 4.08 x 10^9 kg
    c. 4.71 x 10^{16} kg
    d. 6.00 x 10^{20} kg

40. The orbital radius of Mars around the Sun is 1.52 times that of Earth's orbital radius. In Earth years, what is the period of revolution for Mars in this orbit?
    a. 0.66 years
    b. 1.5 years
    c. 1.9 years
    d. 3.5 years

41. A 0.055 kg puck is attached to a 0.150 kg mass **M** by a cord that passes through a hole in a frictionless table, as shown. The puck travels in a circular path of radius 0.25 m.

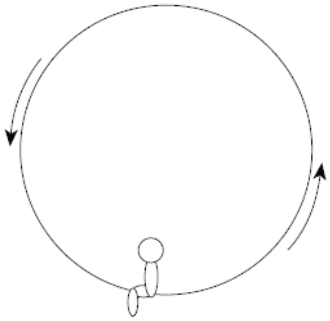


What is the speed of the puck?
    a. 0.61 m/s
    b. 0.95 m/s
    c. 1.6 m/s
    d. 2.6 m/s

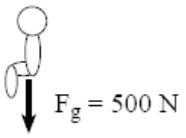
42. A satellite orbits a planet of mass 4.0 x 10^{25} kg at a velocity of 5.8 x 10^3 m/s. What is the radius of this orbit?
    a. 6.4 x 10^6m
    b. 7.9 x 10^7m
    c. 1.6 x 10^8m
    d. 1.2 x 10^{19}m

43. A 120 kg astronaut stands on the surface of an asteroid of radius 600 m. The astronaut leaves the surface with 15 J of kinetic energy and reaches a maximum height of 300 m above the surface. What is the mass of the asteroid?
    a. 5.6 x 10^{11} kg
    b. 2.2 x 10^{12} kg
    c. 3.4 x 10^{12} kg
    d. 5.1 x 10^{12} kg

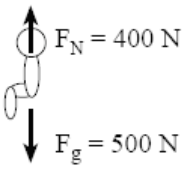
44. A 500 N child travels in a circular path on a Ferris wheel. Which free body diagram **best** shows the forces which could act on the child as she passes the lowest point?



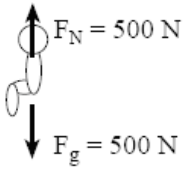
a.



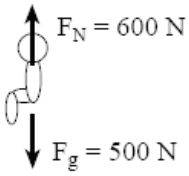
b.



c.



d.

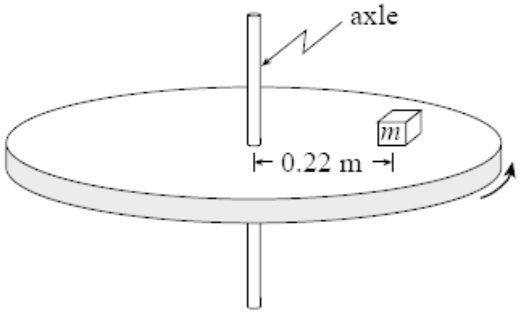


45. Find the gravitational force of attraction between a 75 kg physics student and her 1 500 kg car when their centres are 10 m apart.
    a. 7.5×10^{-8} N
    b. 7.5×10^{-7} N
    c. 740 N
    d. 1.5×10^{3} N

46. A spacecraft of mass m is launched from the surface of a planet of mass M and radius r. Upon which of the variables, m, M and r, does the spacecraft's escape velocity depend?
    a. m and r
    b. M and r
    c. m and M
    d. m, M and r

47. What is the gravitational field strength at the surface of a star of mass 4.8×10^{31}kg and radius 2.7×10^{8}m?
    a. 9.8 N/kg
    b. 4.4×10^{4} N/kg
    c. 4.9×10^{6} N/kg
    d. 1.2×10^{13} N/kg

48. An object of mass ***m*** is on a horizontal rotating platform. The mass is located 0.22 m from the axle and makes one revolution every 0.74 s.



The friction force needed to keep the mass from sliding is 13 N. What is the object's mass?
    a. 0.82 kg
    b. 1.3 kg
    c. 2.7 kg
    d. 5.2 kg

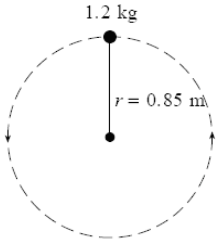
49. A 1 500 kg spaceship circles a planet once every 4.0×10^{5} s with an orbital radius of 3.6×10^{7}m.What is the mass of this planet?
    a. 2.0×10^{11} kg
    b. 1.2×10^{12} kg
    c. 1.7×10^{23} kg
    d. 2.6×10^{26} kg

50. What is the centripetal acceleration of a satellite having an orbital period of 6.1×10^{3} s while in a circular orbit of radius 7.2×10^{6} m?
    a. 0 m/s^2
    b. 5.2 m/s^2
    c. 7.6 m/s^2
    d. 9.8 m/s^2

51. Two satellites, **X** and **Y**, are placed in orbit around a planet. Satellite **X** has a period of revolution of 3.6×10^{5} s and an orbital radius of 7.5×10^{8} m. If the orbital radius of satellite **Y** is 3.0×10^{9} m, what is its orbital period?
    a. 9.1×10^{5} s
    b. 1.4×10^{6} s
    c. 2.9×10^{6} s
    d. 5.2×10^{7} s

52. A certain planet has a mass of 3.3×10^{23} kg and a radius of 2.6×10^{6}m. What is the acceleration due to gravity on the surface of this planet?
    a. 0.54 m/s^2
    b. 3.3 m/s^2
    c. 4.0 m/s^2
    d. 9.8 m/s^2

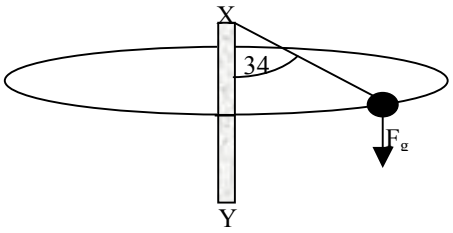
53. A 1.2 kg mass on the end of a string is rotated in a vertical circle of radius 0.85 m.



If the speed of the mass at the top of the circle is 3.6 m/s, what is the tension in the string at this location?

a. 6.5 N
b. 12 N
c. 18 N
d. 30 N

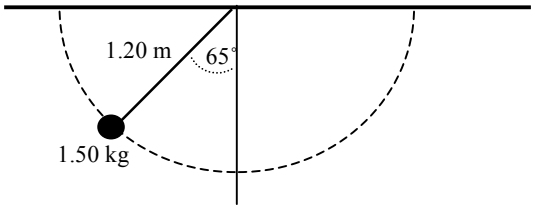
54. The diagram shows an 8.0 kg object attached to a cord, moving in a horizontal circular path around the vertical pole XY. The angle between the pole and cord is 34.0º. What is the centripetal force acting on the 8.0 kg mass



a. 6.6 N
b. 18 N
c. 53 N
d. 140 N

Written

1. A planet of mass 1.88 x 10^{21} kg has a moon of mass 4.56 x 10^{19} kg. The distance between their centre is 3.94 x 10^{8} m. How far from the centre of the planet (along the line joining the planet and the moon) is the net gravitational field strength, due to the two bodies, equal to zero?
2. A satellite is put into orbit with a radius of 1.2 x 10^{4} m. If the satellite takes 1.75 h to orbit once what is the mass of the planet about which it is orbiting?
3. The diagram below shows the oscillation of a simple pendulum of mass 1.50 kg. At point P, the speed of the pendulum is 4.20 m/s. What is the force of tension in the pendulum cord at this point?



4. A satellite is put into circular orbit at a height of 1.1 x 10^{6} m above the surface of a spherical celestial object whose radius is 1.1 x 10^{6} m. If the satellite takes 240 min to revolve once, what is the gravitational field strength at the surface of the celestial object?
5. A roller coaster track is set up on a planet of mass 6.37 x 10^{23} kg and radius of 3.43 x 10^{6} m. The track is a vertical circle with a radius of 8.5 m. What minimum speed must the roller coaster have when upside down at the top of the track if the passengers are not to fall out?
6. A 1350 kg vehicle travels around a level curve (R = 45 m & the μ= 0.82). What is the maximum speed the vehicle can travel at without slipping?
7. A car travels at a constant speed in a circular path of 120 m radius. It completes one circuit in 23 s. If the ground is level, what is the minimum coefficient of friction between the tires and the road?
8. A 63 kg student is on a 15 m diameter Ferris wheel rotating at a constant rate with a period of 18 s. What force does the seat exert on the student at the bottom of the circle?
9. A 0.13 kg puck is moving in a circular path on a horizontal air table where friction is negligible. The centripetal force is provided by a cord 0.68 m long attached in the centre of the air table. If the tension in the cord is 2.5 N, what is the speed of the puck?

Answers

Multiple Choice

1. b	2. d	3. b	4. a	5. b	6. b	7. c	8. a	9. b	10. d	11. c
12. a	13. d	14. c	15. d	16. b	17. b	18. c	19. c	20. c	21. b	22. d
23. a	24. a	25. b	26. c	27. c	28. d	29. d	30. c	31. a	32. c	33. b
34. b	35. b	36. d	37. b	38. b	39. d	40. c	41. d	42. b	43. c	44. d
45. a	46. b	47. b	48. a	49. c	50. c	51. c	52. b	53. a	54. c	

Written

1. 3.42 x 10^{8} m
2. 2.5 x 10^{16} kg
3. 35 N
4. 1.7 N/kg
5. 5.53 m/s
6. 19.0 m/s
7. 0.914
8. 676 N
9. 3.6 m/s

