**Universal Law of Gravitation Problems (from Nelson Physics 12)**

4. Ganymede, one of Jupiter's moons discovered by Galileo in 1610, has a mass of 1.48×10^{23} kg. What is the magnitude of Ganymede's gravitational field strength at a point in space 5.55×10^3 km from its centre?

5. Determine the total gravitational field strength (magnitude and direction) of the Earth and Moon at the location of the spacecraft in the diagram to the right:
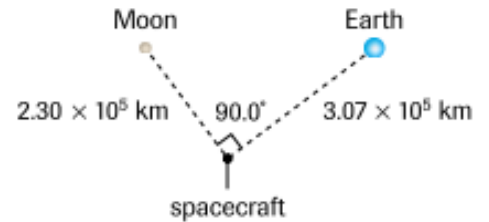
6. Mercury has both a surface gravitational field strength and a diameter 0.38 times the corresponding Earth values. Determine Mercury's mass.

7. A satellite in a circular orbit around Earth has a speed of 7.15×10^3 m/s. Determine, in terms of Earth's radius,
      (a) the distance the satellite is from Earth's centre
      (b) the altitude of the satellite

8. Tethys, one of Saturn's moons, travels in a circular orbit at a speed of 1.1×10^4 m/s. Calculate
      (a) the orbital radius in kilometres
      (b) the orbital period in Earth days

9. Using the mass of the Sun (1.99×10^{30} kg) and the period of revolution of Venus (1.94×10^7 s) around the Sun, determine the average Sun-Venus distance.

Answers

4. 0.318 N/kg
5. 4.23×10^{-3} N/kg [1.26° from the spacecraft-to-Earth line]
6. 3.3×10^{23} kg
7 a) 7.80×10^6 m

7 b) $1.22 r_E$
8 a) 3.1×10^5 km
8 b) 2.1 days
9. 1.08×10^{11} m

Coulomb's Law, Electric Field Strength Problems (from Nelson Physics 12)

4. Two small, oppositely charged conducting spheres experience a mutual electric force of attraction of magnitude 1.6×10^{-2} N. What does this magnitude become if each sphere is touched with its identical, neutral mate, the initially neutral spheres are taken far away, and the separation of the two initially charged spheres is doubled?

5. What is the distance between two protons experiencing a mutually repelling force of magnitude 4.0×10^{-11} N?

6. One model of the structure of the hydrogen atom consists of a stationary proton with an electron moving in a circular path around it. The orbital path has a radius of 5.3×10^{-11} m. The masses of a proton and an electron are 1.67×10^{-27} kg and 9.1×10^{-31} kg, respectively.
      (a) Calculate the electrostatic force between the electron and the proton.

(b) Calculate the gravitational force between them.
(c) Which force is mainly responsible for the electron's circular motion?
(d) Calculate the speed and period of the electron in its orbit around the proton.

7. Two point charges, $+4.0 \times 10^{5}$ C and -1.8×10^{5} C, are placed 24 cm apart. What is the force on a third small charge, of magnitude -2.5×10^{6} C, if it is placed on the line joining the other two,
     (a) 12 cm outside the originally given pair of charges, on the side of the negative charge?
     (b) 12 cm outside the originally given pair of charges, on the side of the positive charge?
     (c) midway between the originally given pair of charges?

11. Three small, negatively charged spheres are located at the vertices of an equilateral triangle. The magnitudes of the charges are equal. Sketch the electric field in the region around this charge distribution, including the space inside the triangle.

12. A small test charge of $+1.0$ µC experiences an electric force of 6.0×10^{6} N to the right.
     (a) What is the electric field strength at that point?
     (b) What force would be exerted on a charge of -7.2×10^{4} C located at the same point, in place of the test charge?

13. What are the magnitude and direction of the electric field strength 1.5 m to the right of a positive point charge of magnitude 8.0×10^{-3} C?

$q_1 = -2.0 \times 10^{-5}$ C $q_2 = 8.0 \times 10^{-6}$ C
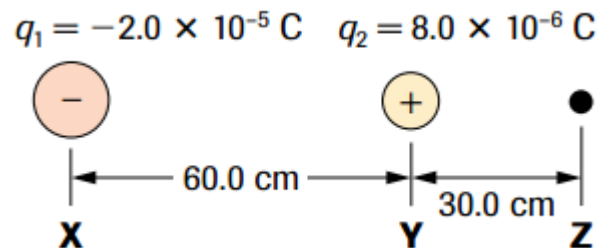
14. What are the magnitude and direction of the electric field strength at point Z in the diagram on the right?

$\leftarrow$ 60.0 cm $\rightarrow$ 30.0 cm

X   Y   Z

Answers

4. 1.0×10^{-3} N	5. 2.4×10^{-9} m	6. a) 8.2×10^{-8} N
6. b) 3.6×10^{-47} N	6. d) 2.2×10^{6} m/s, 1.5×10^{-16} s	
7. a) 21 N [right]	7. b) 59 N [right]	7. c) 91 N [left]
12. a) 6.0 N/C [right]	12. b) 4.3×10^{-3} N [left]	13. 3.2×10^{7} N/C [right]
14. 5.8×10^{5} N/C [right]		

Parallel Plates Problems (from Nelson Physics 12)

15. A ping-pong ball of mass 3.0×10^{-4} kg hangs from a light thread 1.0 m long, between two vertical parallel plates 10.0 cm apart (Figure 3). When the potential difference across the plates is 420 V, the ball comes to equilibrium 1.0 cm to one side of its original position.
     (a) Calculate the electric field strength between the plates.
     (b) Calculate the tension in the thread.
     (c) Calculate the magnitude of the electric force deflecting the ball.
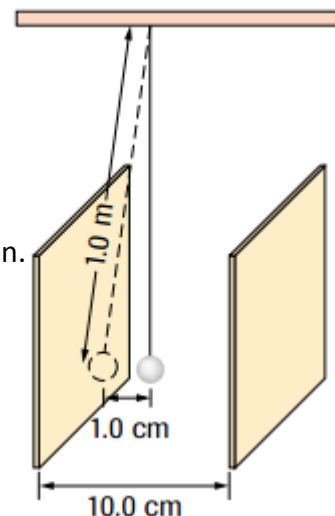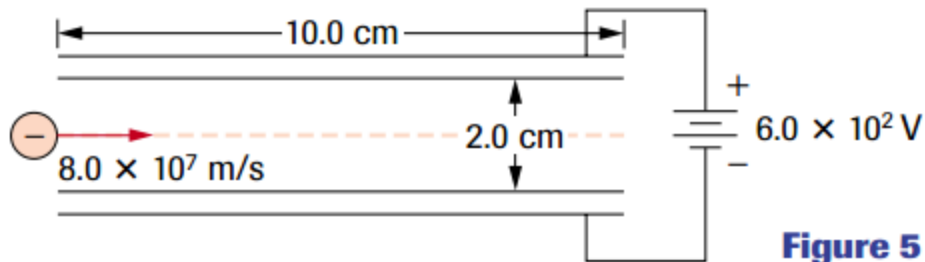   (d) Calculate the charge on the ball.

1.0 m

1.0 cm

10.0 cm

Figure 3

23. What is the magnitude of the electric field between two large parallel plates 2.0 cm apart if a potential difference of 450 V is maintained between them?

24. What potential difference between two parallel plates, at a separation of 8.0 cm, will produce an electric field strength of magnitude 2.5 x 10^3 N/C?

26. Assume that a single, isolated electron is fixed at ground level. How far above it, vertically, would another electron have to be so that its mass would be supported against gravitation by the force of electro-static repulsion between them?

27. An oil droplet of mass 2.6 x 10^{-15} kg, suspended between two parallel plates 0.50 cm apart, remains stationary when the potential difference between the plates is 270 V. What is the charge on the oil droplet? How many excess or deficit electrons does it have?

28. A metallic table tennis ball of mass 0.10 g has a charge of 5.0 x 10^{-6} C. What potential difference, across a large parallel plate apparatus of separation 25 cm, would be required to keep the ball stationary?

35. An electron enters a parallel plate apparatus 10.0 cm long and 2.0 cm wide, moving horizontally at 8.0 x 10^7 m/s, as in Figure 5. The potential difference between the plates is 6.0 x 10^2 V. Calculate
     (a) the vertical deflection of the electron from its original path
     (b) the velocity with which the electron leaves the parallel plate apparatus

Figure 5

Answers
15. (a) 4.2 x 10^3 N/C (b) 2.9 x 10^{-3} N (c) 2.9 x 10^{-5} N   (d) 6.9 x 10^{-9} C
23. 2.3 x 10^4 N/C   24. 2.0 x 10^2 V   26. 5.1 m
27. 4.7 x 10^{-19} C, 3 electrons   28. 49 V
35. (a) 0.41 cm   (b) 8.0 x 10^7 m/s [4.7° up from the right]

Magnetic Force Problems (from Nelson Physics 12)

3. A horizontal east–west wire carries a westward current. A beam of positively charged particles is shot directly down at the wire from above. In what direction will the particles be deflected?

4. A charged particle is moving in a circular path under the influence of a uniform magnetic field. Describe how the path would change in response to each of the following factors, considered separately:

       (a) The strength of the magnetic field is increased.

       (b) An electric field is added, in the same direction as the magnetic field.

       (c) The magnetic field is removed.

6. A straight wire 15 cm long, with a current of 12 A, lying at right angles to a uniform magnetic field, experiences a magnetic force of magnitude 0.40 N. What is the magnitude of the magnetic field?

7. A conductor 45 cm long, with a mass of 15 g, lies in a horizontal position at a 90° angle to a uniform horizontal magnetic field of magnitude 0.20 T. What must the current in the conductor be if the magnetic force is to support the weight of the conductor?

8. Calculate the magnitude and direction of the force on an electron moving horizontally westward at 3.2×10^6 m/s through a uniform magnetic field of 1.2 T directed horizontally southward.

9. An α particle of charge $+3.2 \times 10^{-19}$ C and mass 6.7×10^{-27} kg first accelerates from a negatively charged plate through a hole in a parallel positive plate. The plates have a potential difference of 1.2×10^3 V between them. If the α particle enters a uniform magnetic field of magnitude 0.25 T at 90° when passing through the positive plate, calculate the magnetic force.

16. What is the charge-to-mass ratio of a particle accelerated to 6.0×10^6 m/s, moving in a circular path of radius 1.8 cm perpendicular to a uniform magnetic field of magnitude 3.2×10^{-2} T?

17. A proton, of mass 1.67×10^{-27} kg, moves in a circle in the plane perpendicular to a uniform magnetic field of magnitude 1.8 T. The radius of curvature is 3.0 cm. What is the speed of the proton?

18. A singly ionized atom ($q = +e$) moves at 1.9×10^4 m/s perpendicular to a uniform magnetic field of magnitude 1.0×10^{-3} T. The radius of curvature is 0.40 m. What is the mass of the ion?

19. A singly ionized U-235 atom of mass 3.9×10^{-25} kg is accelerated from one charged plate to another whose potential difference of 1.0×10^5 V between them.

       (a) Calculate its maximum speed.

       (b) What is the radius of the path it would take if injected at this speed and at 90° into a uniform magnetic field of magnitude 0.10 T?

Answers

6. 0.22 T	7. 1.6 A	8. 6.1×10^{-13} N [down]	9. 2.7×10^{-14} N
10. 9.6×10^{-6} T [S]	16. 1.0×10^{10} C/kg	17. 5.2×10^6 m/s	18. 3.4×10^{-27} kg
19. (a) 2.9×10^5 m/s	(b) 7.1 m		