



LEPHIAN

ANSWERS

CHAPTER 1

- 1.1** 6×10^{-3} N (repulsive)
- 1.2** (a) 12 cm
(b) 0.2 N (attractive)
- 1.3** 2.4×10^{39} . This is the ratio of electric force to the gravitational force (at the same distance) between an electron and a proton.
- 1.5** Charge is not created or destroyed. It is merely transferred from one body to another.
- 1.6** Zero N
- 1.8** (a) 5.4×10^6 N C⁻¹ along OB
(b) 8.1×10^{-3} N along OA
- 1.9** Total charge is zero. Dipole moment = 7.5×10^{-8} C m along z-axis.
- 1.10** 10^{-4} N m
- 1.11** (a) 2×10^{12} , from wool to polythene.
(b) Yes, but of a negligible amount ($= 2 \times 10^{-18}$ kg in the example).
- 1.12** (a) 1.5×10^{-2} N
(b) 0.24 N
- 1.13** Charges 1 and 2 are negative, charge 3 is positive. Particle 3 has the highest charge to mass ratio.
- 1.14** (a) $30 \text{ Nm}^2/\text{C}$, (b) $15 \text{ Nm}^2/\text{C}$
- 1.15** Zero. The number of lines entering the cube is the same as the number of lines leaving the cube.
- 1.16** (a) 0.07 μC
(b) No, only that the net charge inside is zero.
- 1.17** 2.2×10^5 N m²/C
- 1.18** 1.9×10^5 N m²/C
- 1.19** (a) -10^3 N m²/C; because the charge enclosed is the same in the two cases.
(b) -8.8 nC
- 1.20** -6.67 nC
- 1.21** (a) 1.45×10^{-3} C
(b) 1.6×10^8 Nm²/C
- 1.22** 10 $\mu\text{C}/\text{m}$
- 1.23** (a) Zero, (b) Zero, (c) 1.9 N/C

CHAPTER 2

- 2.1 10 cm, 40 cm away from the positive charge on the side of the negative charge.
- 2.2 2.7×10^6 V
- 2.3 (a) The plane normal to AB and passing through its mid-point has zero potential everywhere.
(b) Normal to the plane in the direction AB.
- 2.4 (a) Zero
(b) 10^5 N C⁻¹
(c) 4.4×10^4 N C⁻¹
- 2.5 96 pF
- 2.6 (a) 3 pF
(b) 40 V
- 2.7 (a) 9 pF
(b) 2×10^{-10} C, 3×10^{-10} C, 4×10^{-10} C
- 2.8 18 pF, 1.8×10^{-9} C
- 2.9 (a) $V = 100$ V, $C = 108$ pF, $Q = 1.08 \times 10^{-8}$ C
(b) $Q = 1.8 \times 10^{-9}$ C, $C = 108$ pF, $V = 16.6$ V
- 2.10 1.5×10^{-8} J
- 2.11 6×10^{-6} J

CHAPTER 3

- 3.1 30 A
- 3.2 17 Ω, 8.5 V
- 3.3 1027 °C
- 3.4 2.0×10^{-7} Ωm
- 3.5 0.0039 °C⁻¹
- 3.6 867 °C
- 3.7 Current in branch AB = (4/17) A,
in BC = (6/17) A, in CD = (-4/17) A,
in AD = (6/17) A, in BD. = (-2/17) A, total current = (10/17) A.
- 3.8 11.5 V; the series resistor limits the current drawn from the external source. In its absence, the current will be dangerously high.
- 3.9 2.7×10^4 s (7.5 h)

CHAPTER 4

- 4.1 $\pi \times 10^{-4}$ T $\approx 3.1 \times 10^{-4}$ T
- 4.2 3.5×10^{-5} T

- 4.3 4×10^{-6} T, vertical up
 4.4 1.2×10^{-5} T, towards south
 4.5 0.6 N m^{-1}
 4.6 8.1×10^{-2} N; direction of force given by Fleming's left-hand rule
 4.7 2×10^{-5} N; attractive force normal to A towards B
 4.8 $8\pi \times 10^{-3} \text{ T} \approx 2.5 \times 10^{-2} \text{ T}$
 4.9 0.96 N m
 4.10 (a) 1.4, (b) 1
 4.11 4.2 cm
 4.12 18 MHz
 4.13 (a) 3.1 Nm, (b) No, the answer is unchanged because the formula $\tau = N I A \times B$ is true for a planar loop of any shape.

CHAPTER 5

- 5.1 0.36 JT^{-1}
 5.2 (a) \mathbf{m} parallel to \mathbf{B} ; $U = -mB = -4.8 \times 10^{-2} \text{ J}$; stable.
 (b) \mathbf{m} anti-parallel to \mathbf{B} ; $U = +mB = +4.8 \times 10^{-2} \text{ J}$; unstable.
 5.3 0.60 JT^{-1} along the axis of the solenoid determined by the sense of flow of the current.
 5.4 $7.5 \times 10^{-2} \text{ J}$
 5.5 (a) (i) 0.33 J (ii) 0.66 J
 (b) (i) Torque of magnitude 0.33 J in a direction that tends to align the magnitude moment vector along \mathbf{B} . (ii) Zero.
 5.6 (a) 1.28 A m^2 along the axis in the direction related to the sense of current via the right-handed screw rule.
 (b) Force is zero in uniform field; torque = 0.048 Nm in a direction that tends to align the axis of the solenoid (i.e., its magnetic moment vector) along \mathbf{B} .
 5.7 (a) 0.96 g along S-N direction.
 (b) 0.48 G along N-S direction.

CHAPTER 6

- 6.1 (a) Along qrpq
 (b) Along prq, along yzx
 (c) Along yzx
 (d) Along zyx
 (e) Along xry
 (f) No induced current since field lines lie in the plane of the loop.

- 6.2 (a) Along adcd (flux through the surface increases during shape change, so induced current produces opposing flux).
 (b) Along a'd'c'b' (flux decreases during the process)
- 6.3 $7.5 \times 10^{-6} \text{ V}$
- 6.4 (1) $2.4 \times 10^{-4} \text{ V}$, lasting 2 s
 (2) $0.6 \times 10^{-4} \text{ V}$, lasting 8 s
- 6.5 100 V
- 6.6 (a) $1.5 \times 10^{-3} \text{ V}$, (b) West to East, (c) Eastern end.
- 6.7 4H
- 6.8 30 Wb

CHAPTER 7

- 7.1 (a) 2.20 A
 (b) 484 W
- 7.2 (a) $\frac{300}{\sqrt{2}} = 212.1 \text{ V}$
 (b) $10\sqrt{2} = 14.1 \text{ A}$
- 7.3 15.9 A
- 7.4 2.49 A
- 7.5 Zero in each case.
- 7.6 $1.1 \times 10^3 \text{ s}^{-1}$
- 7.7 2,000 W
- 7.8 (a) 50 rad s^{-1}
 (b) 40Ω , 8.1 A
 (c) $V_{Lrms} = 1437.5 \text{ V}$, $V_{Crms} = 1437.5 \text{ V}$, $V_{Rrms} = 230 \text{ V}$

$$V_{LCrms} = I_{rms} \left(\omega_0 L - \frac{1}{\omega_0 C} \right) = 0$$

CHAPTER 8

- 8.1 (a) $C = \epsilon_0 A / d = 8.00 \text{ pF}$

$$\frac{dQ}{dt} = C \frac{dV}{dt}$$

$$\frac{dV}{dt} = \frac{0.15}{8 \times 10^{-12}} = 1.87 \times 10^{10} \text{ V s}^{-1}$$

- (b) $i_d = \epsilon_0 \frac{d}{dt} \Phi_E$. Now across the capacitor $\Phi_E = EA$, ignoring end corrections.

$$\text{Therefore, } i_d = \epsilon_0 A \frac{dE}{dt}$$

Now, $E = \frac{Q}{\epsilon_0 A}$. Therefore, $\frac{dE}{dt} = \frac{i}{\epsilon_0 A}$, which implies $i_d = i = 0.15 \text{ A}$.

- (c) Yes, provided by 'current' we mean the sum of conduction and displacement currents.

8.2 (a) $I_{\text{rms}} = V_{\text{rms}} \omega C = 6.9 \mu\text{A}$

- (b) Yes. The derivation in Exercise 8.1(b) is true even if i is oscillating in time.

(c) The formula $B = \frac{\mu_0}{2\pi} \frac{r}{R^2} i_d$

goes through even if i_d (and therefore B) oscillates in time. The formula shows they oscillate in phase. Since $i_d = i$, we have

$B_0 = \frac{\mu_0}{2\pi} \frac{r}{R^2} i_0$, where B_0 and i_0 are the amplitudes of the oscillating magnetic field and current, respectively. $i_0 = \sqrt{2} I_{\text{rms}} = 9.76 \mu\text{A}$. For $r = 3 \text{ cm}$, $R = 6 \text{ cm}$, $B_0 = 1.63 \times 10^{-11} \text{ T}$.

8.3 The speed in vacuum is the same for all: $c = 3 \times 10^8 \text{ m s}^{-1}$.

8.4 \mathbf{E} and \mathbf{B} in x - y plane and are mutually perpendicular, 10 m.

8.5 Wavelength band: 40 m - 25 m.

8.6 10^9 Hz

8.7 153 N/C

8.8 (a) 400 nT, $3.14 \times 10^8 \text{ rad/s}$, 1.05 rad/m, 6.00 m.

(b) $\mathbf{E} = \{ (120 \text{ N/C}) \sin[(1.05 \text{ rad/m})x - (3.14 \times 10^8 \text{ rad/s})t] \} \hat{\mathbf{j}}$

$\mathbf{B} = \{ (400 \text{ nT}) \sin[(1.05 \text{ rad/m})x - (3.14 \times 10^8 \text{ rad/s})t] \} \hat{\mathbf{k}}$

8.9 Photon energy (for $\lambda = 1 \text{ m}$)

$$= \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{1.6 \times 10^{-19}} \text{ eV} = 1.24 \times 10^{-6} \text{ eV}$$

Photon energy for other wavelengths in the figure for electromagnetic spectrum can be obtained by multiplying approximate powers of ten. Energy of a photon that a source produces indicates the spacings of the relevant energy levels of the source. For example, $\lambda = 10^{-12} \text{ m}$ corresponds to photon energy = $1.24 \times 10^6 \text{ eV} = 1.24 \text{ MeV}$. This indicates that nuclear energy levels (transition between which causes

γ -ray emission) are typically spaced by 1 MeV or so. Similarly, a visible wavelength $\lambda = 5 \times 10^{-7}$ m, corresponds to photon energy = 2.5 eV. This implies that energy levels (transition between which gives visible radiation) are typically spaced by a few eV.

- 8.10** (a) $\lambda = (c/\nu) = 1.5 \times 10^{-2}$ m
 (b) $B_0 = (E_0/c) = 1.6 \times 10^{-7}$ T
 (c) Energy density in **E** field: $u_E = (1/2)\epsilon_0 E^2$
 Energy density in **B** field: $u_B = (1/2\mu_0)B^2$

Using $E = cB$, and $c = \frac{1}{\sqrt{\mu_0\epsilon_0}}$, $u_E = u_B$