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 $= 7.5 \times 10^{-8}$ 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) 30Nm^2/C, (b) 15 Nm^2/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 m^2/C

1.18 1.9×10^{5} N m^2/C

1.19 (a) -10^{3} N m^2/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} Nm^2/C

1.22 10 μC/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 = 1.08×10^{-8} C

(b) Q = 1.8×10^{-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 $\simeq 3.1 \times 10^{-4}$ 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 $8\pi \times 10^{-3}$ T $\simeq 2.5 \times 10^{-2}$ 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 $\boldsymbol{\tau} = N\,I\,\mathbf{A} \times \mathbf{B}$ is true for a planar loop of any shape.

Chapter 5

5.1 0.36 JT^{-1}

5.2 (a) **m** parallel to **B**; $U = -mB = -4.8 \times 10^{-2}$ J: stable.

(b) **m** anti-parallel to **B**; $U = +mB = +4.8 \times 10^{-2}$ 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 7.5×10^{-2} 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 **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 **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 7.5×10^{-6} V

6.4 (1) 2.4×10^{-4} V, lasting 2 s

(2) 0.6×10^{-4} V, lasting 8 s

6.5 100 V

6.6 (a) 1.5×10^{-3} 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) $\dfrac{300}{\sqrt{2}} = 212.1\,\text{V}$

(b) $10\sqrt{2} = 14.1\,\text{A}$

7.3 15.9 A

7.4 2.49 A

7.5 Zero in each case.

7.6 125 s^{-1}; 25

7.7 $1.1 \times 10^3\ s^{-1}$

7.8 0.6 J, same at later times.

7.9 2,000 W

7.10 $\nu = \dfrac{1}{2\pi}\sqrt{\dfrac{1}{LC}}$, i.e., $C = \dfrac{1}{4\pi^2\nu^2 L}$

For L = 200 μH, ν = 1200 kHz, C = 87.9 pF.

For L = 200 μH, ν = 800 kHz, C = 197.8 pF.

The variable capacitor should have a range of about 88 pF to 198 pF.

7.11 (a) 50 rad s^{-1}

(b) 40 Ω, 8.1 A

(c) $V_{Lrms} = 1437.5$ V, $V_{Crms} = 1437.5$ V, $V_{Rrms} = 230$ V

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

Chapter 8

8.1 (a) $C = \varepsilon_0 A / d = 8.00$ pF

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

$$\frac{dV}{dt} = \frac{0.15}{80.1\times10^{-12}} = 1.87\times10^{9}\ \text{V s}^{-1}$$

(b) $i_d = \varepsilon_0 \frac{\mathrm{d}}{\mathrm{d}t}\Phi_E$. Now across the capacitor $\Phi_E = EA$, ignoring end corrections.

Therefore, $i_d = \varepsilon_0 A \frac{\mathrm{d}\Phi_E}{\mathrm{d}t}$

Now, $E = \frac{Q}{\varepsilon_0 A}$. Therefore, $\frac{\mathrm{d}E}{\mathrm{d}t} = \frac{i}{\varepsilon_0 A}$, which implies $i_d = i = 0.15$ A.

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

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

(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. $i_0 = \sqrt{2} I_{rms} = 9.76$ μA. For $r = 3$ cm, $R = 6$ cm, $B_0 = 1.63 \times 10^{-11}$ T.

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

8.4 **E** and **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, 3.14×10^8 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 $\lambda = 1$ m)

$$= \frac{6.63\times10^{-34}\times3\times10^{8}}{1.6\times10^{-19}}\text{eV} = 1.24\times10^{-6}\text{ eV}$$

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, $\lambda = 10^{-12}$ m corresponds to photon energy = 1.24×10^6 eV = 1.24 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: $u_E = (1/2)\varepsilon_0 E^2$

Energy density in **B** field: $u_B = (1/2\mu_0)B^2$

Using $E = cB$, and $c = \dfrac{1}{\sqrt{\mu_0 \varepsilon_0}}$, $u_E = u_B$