MAGNETISM AND MATTER

5.3) Magnetic field strength, $B = 0.25\ T$
Torque on the bar magnet, $\tau = 4.5 \times 10^{-2}\ J$

The angle between the bar magnet and the external magnetic field, $\theta = 30°$.

Torque is related to magnetic moment (M) as:
$\tau = MB \sin\theta$
$\therefore M = \frac{\tau}{B \sin\theta}$
$= \frac{4.5 \times 10^{-2}}{0.25 \times \sin 30°} = 0.36\ J\ T^{-1}$

Hence, the magnetic moment of the magnet is $0.36\ J\ T^{-1}$

5.4) Moment of the bar magnet, $M = 0.32\ J\ T^{-1}$
External magnetic field, $B = 0.15\ T$

(a) The bar magnet is aligned along the magnetic field. This system is considered as being in stable equilibrium.

Hence, the angle θ, between the bar magnet and the magnetic field is $0°$

Potential energy of the system $= -MB\cos\theta$

$= -0.32 \times 0.15 \cos 0$
$= -4.8 \times 10^{-2}\ J$

(b) The bar magnet is oriented $180°$ to the magnetic field. Hence, it is in unstable equilibrium
$\theta = 180°$

Potential energy = $-MB\cos\theta$

$= -0.32 \times 0.15 \cos 180^\circ$

$= 4.8 \times 10^{-2}$ J

5.5) Number of turns in the solenoid, $n = 800$

Area of cross-section, $A = 2.5 \times 10^{-4}\ m^2$

Current in the solenoid, $I = 3.0$ A

$M = nIA$

$= 800 \times 3 \times 2.5 \times 10^{-4}$

$= 0.6$ J T^{-1}

5.8) $n = 2000$

$A = 1.6 \times 10^{-4}\ m^2$

$I = 4.0$ A

(a) $M = nAI$

$= 2000 \times 4 \times 1.6 \times 10^{-4}$

$= 1.28\ A m^2$

(b) $B = 7.5 \times 10^{-2}$ T

$\theta = 30^\circ$

$\tau = MB\sin\theta$

$= 1.28 \times 7.5 \times 10^{-2} \sin 30^\circ$

$= 0.048$ J

Since the magnetic field is uniform, the force on the solenoid is zero. The torque on the solenoid is 0.048 J

5.9) $N = 16$

$r = 10$ cm $= 0.1$ m

$A = \pi r^2 = \pi \times (0.1)^2\ m^2$

$I = 0.75$ A

$B = 5.0 \times 10^{-2}$ T

$v = 2\ s^{-1}$

$m = NIA = NI\pi r^2$

$16 \times 0.15 \times \pi \times (0.1)^2$

$= 0.377\ JT^{-1}$

$$v = \frac{1}{2\pi}\sqrt{\frac{mB}{I}}$$

$$\therefore I = \frac{mB}{4\pi^2 v^2}$$

$$= \frac{0.377 \times 5 \times 10^{-2}}{4\pi^2 \times (2)^2}$$

$= 1.2 \times 10^{-4}\ kg\,m^2$

5.11) $\theta = 12^0$

$\delta = 60^0$

$B_H = 0.16\ G$

$B_H = B\cos\delta$

$$\therefore B = \frac{B_H}{\cos\delta}$$

$$= \frac{0.16}{\cos 60} = 0.32\ G$$

5.12) $H = 0.36\ G$

$$B_1 = \frac{\mu_0 2M}{4\pi d^3} = H \quad \text{—— (1)}$$

$$B_2 = \frac{\mu_0 M}{4\pi d^3} = \frac{H}{2}$$

$B = B_1 + B_2$

$$= H + \frac{H}{2}$$

$= 0.36 + 0.18 = 0.54\ G$

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5.18) Current in the wire = 2.5 A

$R = 0.33G = 0.33 \times 10^{4}$ T

$\delta = 0$

$B_H = R\cos\delta = 0.33 \times 10^{-4} \cos 0 = 0.33 \times 10^{-4}$ T

$B_C = (\mu_0 / 2\pi) \times (I/r)$

$B_C = (4\pi \times 10^{-7} / 2\pi) \times (2.5/r) = (5 \times 10^{-7} / r)$

$B_H = B_C$

$0.33 \times 10^{-4} = 5 \times 10^{-7} / r$

$r = 5 \times 10^{-7} / 0.33 \times 10^{-4}$

$= 0.015$ m $= 1.5$ cm