2009 EM MC

MCB $\frac{26}{35} \to \frac{33.4}{45}$

1) (e) 2) $I = \frac{V}{R}$ (a) ✓

3) V/m, N/C (e) ✓

4) (e) ✓ 5) (b) ✓ 6) $C = \frac{k\varepsilon_0 A}{d}$

$\frac{2\varepsilon_0 \pi r^2}{d}$

$\frac{4}{2} \cdot 2 = 8$ (e) ✓

7) (a) ✓ 8) (c) ✓ 9) $B = \mu_0 n I$

$\oint B\,dl = \mu_0 I$ (a) ✓

10) $U = \frac{1}{2} C V^2$ (e) ✓

11) (e) ✓ 12) (c) d 13) (b) ✓

14) $V = \frac{kQ}{R}$ (e) ✓

15) $W = qV = 4\mu C \cdot 20V$

= (d) e

16) ΔB out of page

II, (b) ✓

17) (d) ✓ 18) $\overleftarrow{B_0}$ (b) ✓

19) $I = \frac{V}{R} = \frac{6}{4}$ (d) e

20) $V = \frac{C}{Q}$ $C = QV$ (b) d

~~BACK~~

21) $KE = qV = \frac{1}{2} m v^2$

$V = Er$ $qV = 3\varepsilon_0 (r) q$

$\varepsilon_0 d = 3\varepsilon_0 r q$

$r = \frac{1}{3} d$ (a) ✓

22) $U_L = \frac{1}{2} L I^2$ (e) a

23) I tran, can't do work or change KE

since always ⊥

(a) ✓

24) $R = \frac{\rho L}{A}$ $\frac{4 l}{\frac{1}{4} A}$ (e) ✓

25) I, $\frac{1}{2}$ III (d) ✓

26) L (−) R (+)

(d) e

27) (e) ✓ 28) (c) ✓

29) (a) d

30) $\frac{kQq}{r}$

$3\frac{kQ^2}{L} + 3\frac{kQ^2}{L}$ (e) ✓

31) (c) ✓ 32) $\mathcal{E} = IR = \frac{dB}{dt} A$

$\frac{dB}{dt} = \frac{IR}{A} = \frac{1.0\,mA \cdot 30\,\Omega}{5.0\,m^2}$

= 0.01 (d) ✓

33) $C = QV$ $C = \frac{k\varepsilon_0 A}{d}$

$C_x = 5 C_y$ $V = \frac{C}{Q}$

$V = \frac{C}{Q}$ $V_x = 5V_y$ Q equal

(b) d

−4 −4

34) F_e mg $F_e = mg = \frac{KQq}{h^2}$

$h^2 = \frac{KQq}{mg}$ (e) ✓

35) F = I l B

$\tau = \left(IlB\frac{d}{2}\right)2 = IlBd$

(a) b

9) $\oint B \cdot dl = \mu_0 I$ $\cancel{dB = \frac{\mu_0}{4\pi}} \cdot \frac{Idl \times \hat{r}}{r^2}$

$\cancel{2r} \to \frac{B}{4}$

$B \cdot \cancel{(2\pi r)}(2\pi r) = \mu_0 I$

$B = \cancel{\frac{\mu_0 I}{4\pi^2 r^2}}$ $\frac{\mu_0 I}{2\pi r}$ (a)

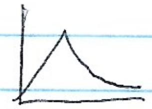
-1

2009 E/M FR

$\frac{36}{45}$ B

9:30–9:44
1:35

1) a) (i) $r < R$ → radially inwards +1



$$E = \frac{dV}{dr}$$

$$= \frac{d}{dr}\left(\frac{Q_0}{4\pi\varepsilon_0 R}\left(-2+3\left(\frac{r^2}{R^2}\right)\right)\right) +1$$

$$= \frac{d}{dr}\left(\frac{Q_0}{4\pi\varepsilon_0 R}\left(-2+\frac{3r^2}{R^2}\right)\right)$$

$$= 6r \cdot \frac{Q_0}{4\pi\varepsilon_0 R} \cdot \frac{1}{R^2}$$

$$= \boxed{\frac{3Q_0 r}{2\pi\varepsilon_0 R^3}} +1$$

(ii) $r > R$ – radially outward +1

$$E = \frac{dV}{dr} = \frac{d}{dr}\left(\frac{Q_0}{4\pi\varepsilon_0 r}\right)$$

r^{-1} or $-r^{-2}$

$$|E| = \frac{Q_0}{4\pi\varepsilon_0 r^2}$$

$$= \boxed{\frac{Q_0}{4\pi\varepsilon_0 r^2}} +1$$

b) (i) $\int E \cdot dA = \frac{Q_{enc}}{\varepsilon_0}$ +1

$$E \cdot 4\pi r^2 = \frac{Q_{enc}}{\varepsilon_0} = \frac{3Q_0 r}{2\pi\varepsilon_0 R^3} \cdot 4\pi r^2$$ +1

$$Q_{enc} = \boxed{6Q_0\frac{r^3}{R^3}}$$ (−1) negative!

(ii) $Q_{enc} = \boxed{Q_0}$ +1

(−1) explicitly state Gauss' law

−2

c) at $r = R$, the electric field is continuous. Thus,

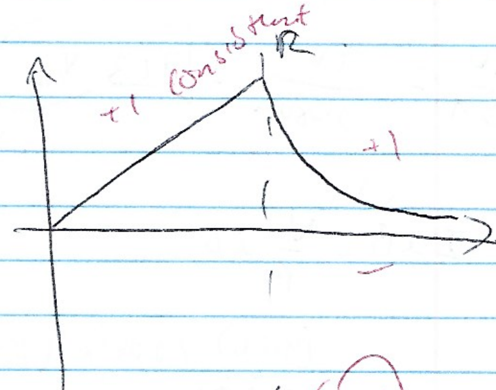
$$\frac{Q_0}{4\pi\varepsilon_0 r^2} = \frac{3Q_0 r}{2\pi\varepsilon_0 R^3}$$

$$\frac{3r}{2R^3} = \frac{1}{2r^2}$$

$$\frac{4r^3}{R^3}$$

at $r = R$, the function for enclosed charge is $6Q_0\frac{r^3}{R^3}$, which should equal Q_0. however, $6Q_0 \neq Q_0$, so there is no charge. (−2)

d)



(−1)

$F = qE$

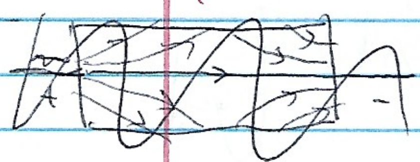
−3

2) a) $R = \rho \frac{l}{A} = \frac{(4.5\times10^{-4}\,\Omega\cdot m)(0.080\,m)}{(5.0\times10^{-6}\,m^2)}$ +1

$= 7.2\,\Omega$

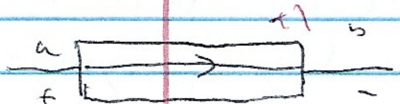
$P = \frac{V^2}{R} = \frac{(9.0V)^2}{7.2\,\Omega} = \boxed{11.3\,W}$ +1

b) +1



~~electric field~~

+1



electric field points from (+) to (−) polarity (−1) potential or current

c) $E = \frac{\Delta V}{\Delta x} = \frac{9V}{0.080m} = \boxed{113\ V/m}$ +1

+1

d) +1 $F_m = IlB = \frac{V}{R} lB$

$= \frac{(9.0V)}{(7.2\Omega)}(0.080m)(0.25T)$

$= \boxed{0.025N}$ +1

e)

+1

f) $\Sigma F = ma = 0$

$F_e - F_m = 0$ +1

$F_e = F_m$ +1

+1 Units

$qE = qvB$

$E = vB$

$= (3.5\times10^{-3}\,m/s)(0.25T)$

$= \boxed{8.75\times10^{-4}\ V/m}$

+1

−2

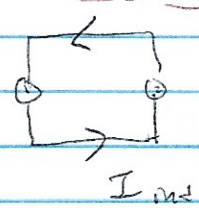
3) a) $\mathcal{E} = \frac{d\Phi}{dt} = L^2\frac{dB}{dt}$ +1

$= L^2 \frac{d}{dt}(at+b)$ +1

$= \boxed{aL^2}$ +1 +1

b) (i) $I = \frac{\mathcal{E}}{R_{eq}} = \boxed{\frac{aL^2}{2R_0}}$ +1 +1

(ii)



+1

c) $P = I^2R = \frac{a^2L^4}{4R_0^2}\cdot R_0$ +1

$= \boxed{\frac{a^2L^4}{4R_0}}$ +1

d) Brighter +1

If the 3rd bulb is added, the overall eq. resistance is lower +1 while the emf remains the same. +1 This means the current thru the 1st bulb increasing, increasing the power output, which makes it brighter. +1

e) dimmer (−2)

the extra wire makes it become two connected loops, where the induced emf is reduced, making the power less and the bulb dimmer.

−2

2009 E/M BR

MC 12, 15, 19, 20, 22, 26, 29, 33, 35

12) (d) ✓ 15) $\frac{W}{t} = \frac{8e^{-5}\,\text{J}}{5\,s} = (e)$ ✓

19) $I = \frac{V}{R} = \frac{6}{9} =$ (d) e

20) (d)? ✓ 22) (d)? a

26) (d) e 29) (a) d

33) $Q =$, V splits

$C = QV$ $V = \frac{C}{Q}$ (b) d

35) $F = IlB$

$\tau = IdB\frac{d}{2}$

$\Sigma\tau = Id^2B$ (b) ✓ +4

19) e 22) a 26) e 29) d 33) d

+5

FR

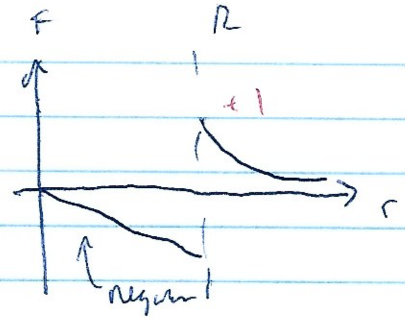
1) b) (i) $Q_{enc} = -6Q_0\frac{r^3}{R^3}$ +1

(ii) $\int E\,dA = \frac{Q_{enc}}{\varepsilon_0}$ +1

$E \cdot 4\pi r^2 = \frac{Q_{enc}}{\varepsilon_0}$

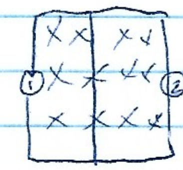
c) There is charge.
Since the E field needs to be continuous, and $-6Q_0\frac{r^3}{R^3} + Q_0$, the charge at the surface needs to cancel this out, so $Q_s = Q_0 + 6Q_0$
+2 $= 7Q_0$

d) +1



2) b) the conventional current is from a to b, so the electric field is in the same direction of conv. current
+2

3) e) Brightness remains the same.



why??

+2

3) e) brightness same.

Area cut in 1/2; 1/2 $\mathcal{E}$, but R is also $\frac{1}{2}R_0$, so P is the same.

+2