1998 EM MC

$\frac{31}{35}$ MC

EM total

$\frac{45}{35}\cdot\frac{31}{35}$ + $\frac{34}{55}$ = $\boxed{\frac{74}{90}}$

36) V_0, C, R

$I = \frac{dQ}{dt}$

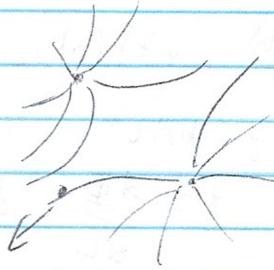
$P = I^2 R$ $V = \frac{Q}{C}$ (b) ✓

37) $P = I\Delta V = \frac{V^2}{R}$

$R = \frac{V^2}{P} = \frac{144V^2}{24W} = 6\,\Omega$

4, 8 → 4, 2 (e) ✓

38) (c) ✓

39) 

(e) ✓

40) $F = k\frac{Qq}{S^2}$

F, F, $F\sqrt{2}$ (d) ✓

41) (c) ✓ 42) $P = I^2 R$ (d) ✓

43) $I = \frac{dQ}{dt}$

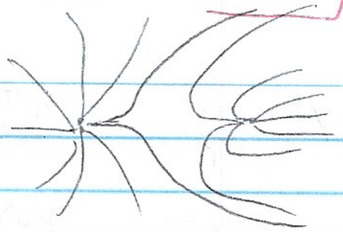
10^9 protons, 1 m

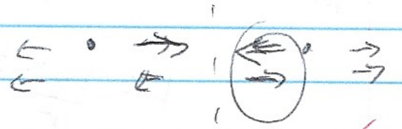
$= \frac{Q}{t}$ $\frac{Q}{d}\cdot d$

$= \frac{Q}{d}\cdot\frac{d}{t} = (10^9 \text{ prot}/m)(1.6\times10^{-19}C)\cdot v$

$= 1.6\times10^{-8}A$

$v = 1e7\ m/s$ (d) ✓

44) (a) ✓ 45) 



(c) ✓ II, III

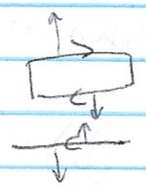
46) $V = \frac{kQ}{r}$ (e) ✓

47) (c) d

48) $W = \Delta U = q\Delta V$

$\Delta V = \frac{U}{q} = \frac{5J}{2mC}$

$= 2.5e3$ (c) ✓

49) 

(a) ✓

50) (d) ✓

51) $\cancel{Q}\ \cancel{\frac{1}{2}CV^2} = \frac{1}{2}QV$

$V = \frac{Q}{C} = \frac{Qd}{\varepsilon_0 A}$

$U = qV = \frac{Qed}{\varepsilon_0 A}$ (a) ✓

52) (d) c 53) (c) ✓ 54) (e) ✓

55) $\frac{mv^2}{R} = \frac{ke^2}{R^2}$

$mv^2 = \frac{1}{4\pi\varepsilon_0}\cdot\frac{e^2}{R}$

$K = \frac{1}{2}mv^2$ (b) ✓

56) CCW $\varepsilon = -\frac{d\Phi}{dt}$

$= -L^2\frac{dB}{dt} = -L^2(-b) = bL^2$ (e) ✓ -2

$I = \frac{\varepsilon}{R} = \frac{bL^2}{R}$

57) $qvB = \frac{mv^2}{r}$ $\qquad \frac{2\pi r}{T} = v$

$v = \frac{qBr}{m}$ $\qquad 2\pi r f = v$

$f = \frac{v}{2\pi r}$

$f = \frac{qB\cancel{r}}{m} \frac{1}{2\pi \cancel{r}}$

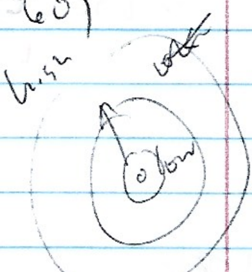
(a) ✓

58) constant field → constant force → const. acceleration

(a) ✓

59) $E = \frac{-dV}{dr} = -2kr_0$ (c) ✓

60) high ~~low~~



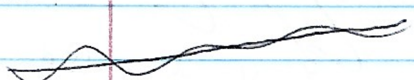
electron - goes bw to high potential

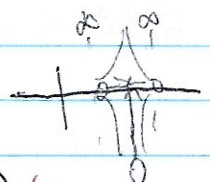
F away

E toward

(b) ✓

61)





(a) ✓

62) (d) ✓ 63) $W = qV$

$V_{center} = \frac{kQ}{r_{At}}$ & $W = \frac{kQq}{r}$

$\oint E_{inside} \cdot dA = \frac{Q_{enc}}{\varepsilon_0}$

$\cancel{E \cdot 4\pi r^2 = \frac{Q}{\varepsilon_0}}$ $\qquad E_{inside} = 0$

$V = \int E\,dr = 0$

(b) c

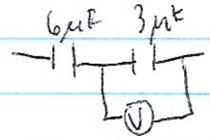
-1

64) $\left((6\mu F^{-1}) + (3\mu F)^{-1}\right)^{-1}$

$= 2\mu F$ (b) ✓

65) $V = \frac{Q}{C}$ $\qquad Q_{total} = C_{eq}V = (2\mu F)(12V)$

$= 24\mu C$



Q equal V splits

$24\mu C$ $\qquad V = \frac{24\mu C}{3\mu F} = 8V$

(d) ✓

66) (b) ✓ 67) (b) c

68) $\varepsilon = bAt^{\frac{1}{2}}$

$\varepsilon = \frac{d\Phi}{dt} = dAt^{\frac{1}{2}}$

$\cancel{A}\,dB = d\cancel{A}t^{\frac{1}{2}}dt$

$B = d\int t^{\frac{1}{2}}dt$

$= \frac{2d}{3}t^{3/2}$ (e) ✓

69) $E = \frac{\Delta V}{\Delta x}$ (b) ✓

70) $\varepsilon = \frac{k\varepsilon_0 A}{d}$ (a) ✓

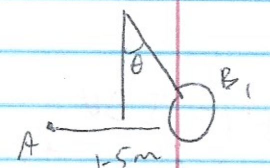
-1

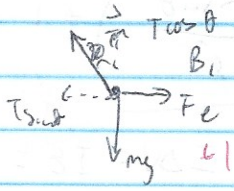
1998 EM FR

34/45

1)

a)





+1

$T\cos\theta = mg$

$T = \frac{mg}{\cos\theta}$ +1 $T\sin\theta = F_e = \frac{kQ_BQ_A}{r^2}$

$mg\tan\theta = \frac{kQ_BQ_A}{r^2}$

$Q_B = \frac{mg\tan\theta\, r^2}{kQ_A}$ +1

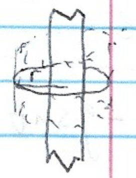
$= \frac{(0.025\,kg)(9.8\,m/s^2)\tan(20)(1.5m)^2}{(9.0\times10^9\,\frac{Nm^2}{C^2})(120\times10^{-6}\,C)}$

$= \boxed{18.6\,\mu C} = \boxed{1.86\times10^{-7}\,C}$ +1

b) the equilibrium angle will remain the same since the mass, radius, or charge didn't change; the conducting sphere will still have the charge distributed evenly throughout the outer surface. The force still acts through the center of the sphere.

-2

c) $\int E\cdot dA = \frac{Q_{enc}}{\varepsilon_0}$ $\lambda = \frac{Q}{l}$ +1



$A = 2\pi r l$

$E\cdot 2\pi r\, dl = \frac{\lambda\, dl}{\varepsilon_0}$ +1

$E\cdot 2\pi r = \frac{\lambda}{\varepsilon_0}$ -2

$E = \frac{\lambda}{2\pi\varepsilon_0 r} = \frac{0.10\,\mu C/m}{2\pi(8.85\times10^{-12}\,\frac{C^2}{Nm^2})\,r}$

$= \frac{1.80\times10^3}{r}\,N/C$ +1

d) $F = qE = (120\,\mu C)\left(\frac{1.8\times10^3}{1.5\,m}\,N/C\right)$ +1

$= \boxed{0.144\,N}$ +1

e) $\Delta V = -\int E\cdot dr$

$= +\int_{0.3}^{1.5}(1.80\times10^3)\frac{dr}{r}$ +1 +1

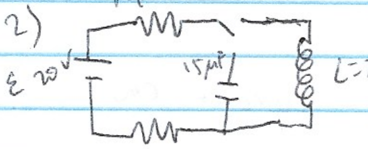
$= +1.80\times10^3\left(\ln|1.5| - \ln|0.3|\right)$

$= +2.90\times10^3\,V$

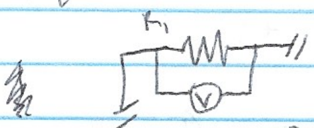
$W = qV = (120\,\mu C)(2.90\times10^3\,V)$ +1

$= \boxed{0.348\,J}$ +1

2)



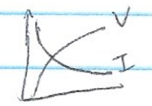
a)



+2

b) $V = IR_1$ $I = \frac{dQ}{dt}$

$V = \frac{Q}{C}$ $Q = CV$



$R_{eq} = 30\,\Omega$

$C = 15\,\mu F$ $\tau = RC = 4.5\times10^{-4}$

$\boxed{V=0}$? -3

0

$I = C\frac{dV}{dt} = \frac{\varepsilon_0}{R_{eq}}$

$\frac{dV}{dt} = \frac{\varepsilon}{RC}$ $V(t) = \int\frac{\varepsilon}{RC}dt$

-3

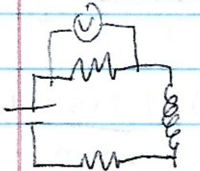
c) (i) $I = 0$ $\boxed{V = 0}$ +2

(ii) $Q = CV = (15\,\mu F)(20V)$

$= \boxed{3\times10^{-4}\,C}$

$300\,\mu C = 3\times10^{-4}\,C$ +1

d) $t = T$



$V = IR = \frac{(20V)}{30\Omega}(10\Omega) = \boxed{6.67\,V}$

−2

$I = \frac{\mathcal{E}}{R_{eq}}$

e) (i) $I_f = \frac{\mathcal{E}}{R_{eq}} = \frac{20V}{30V} = \boxed{0.67\,A}$ +2

(ii) $U_L = \frac{1}{2}LI^2 = \frac{1}{2}(20H)(0.67A)^2$

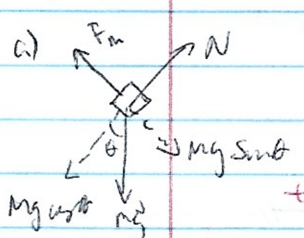
$= \boxed{0.45\,J}$ +1

f) $\mathcal{E}_L = -L\frac{dI}{dt} = \mathcal{E}$

−2

$\frac{dI}{dt} = -\mathcal{E}L$

3) a)



Current CW

+1

+1

$F_m = IlB = mg\sin\theta$ +1

$\boxed{I = \frac{mg\sin\theta}{Bl}}$ +1

$\mathcal{E} = Blv$ +1 $I = \frac{\mathcal{E}}{R}$ +1

Skipped the derivation

$\frac{mg\sin\theta}{Bl} = \frac{Blv}{R}$

−1

$\boxed{v = \frac{mgR\sin\theta}{B^2l^2}}$ +1

$P = I^2R = I\Delta V$ +1

c) $P = I\Delta V = I\mathcal{E} = \frac{mg\sin\theta}{Bl}\cdot Blv$

$= mgv\sin\theta = mg\sin\theta\cdot\frac{mgR\sin\theta}{B^2l^2}$

$= \boxed{\frac{m^2g^2\sin^2\theta R}{B^2l^2}}$ +1

d) $\Sigma F = mg\sin\theta - IlB = m\frac{dv}{dt}$

$I = \frac{d\theta}{dt} = \frac{V}{R} = \frac{Blv}{R}$ +1

$mg\sin\theta - \frac{B^2l^2v}{R} = m\frac{dv}{dt}$

$g\sin\theta - \frac{B^2l^2v}{mR} = \frac{dv}{dt}$

$dt = \frac{dv}{g\sin\theta - \frac{B^2l^2}{mR}v}$ +1

$u = g\sin\theta - \frac{B^2l^2}{mR}v$

$\frac{du}{dv} = -\frac{B^2l^2}{mR}$

$dv = -\frac{mR}{B^2l^2}du$

$t = -\frac{mR}{B^2l^2}\ln\left|g\sin\theta - \frac{B^2l^2}{mR}v(t)\right|$

$-\frac{B^2l^2t}{mR} = \ln|\quad|$

$g\sin\theta - \frac{B^2l^2}{mR}v(t) = e^{-\frac{B^2l^2t}{mR}}$

$\boxed{v(t) = -\frac{mR}{B^2l^2}\left(e^{-\frac{B^2l^2t}{mR}} - g\sin\theta\right)}$

−1

−5

(e) the final speed will be less. +1
Because power is being dissipated through both resistors now, because of Conservation of Energy, the bar must move at a slower speed since more energy is being dissipated through the resistors.

this is reasonable, right? +1