1993

Arm Mech

	B	BB	BBR
ML	28	30	35
ML_s	36	38.4	45
FR	30	35	45
TOT	66	73.6	90

E/M

	B	BB	BBR
ML	25	28	35
ML_s	32.1	36	45
FR	42	45	45
TOT	74.1	81	90

1993 M

Mech 29/35

1) (a) ✓ 2) $\Delta x = v_0 t + \frac{1}{2}at^2$

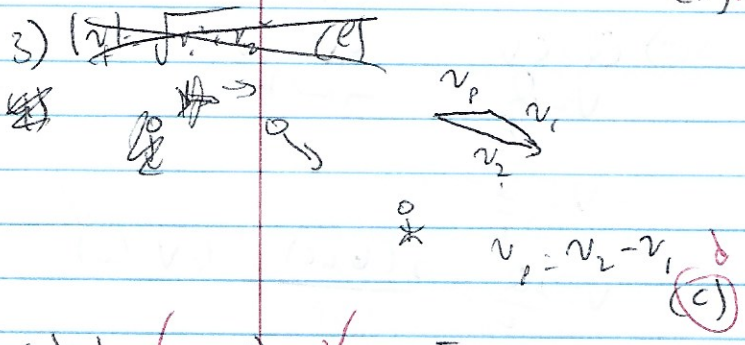
$v_f = v_0 + at$

$a = \frac{v_f}{t}$

$\Delta x = \frac{1}{2}\frac{v_f}{t}t^2 = \frac{1}{2}(30\,m/s)(6s)$

$= 90\,m$ (d) ✓

3) [illegible] (c)



$v_p = v_2 - v_1$ (c)

4) b ✓ 5) c ✓ 6) $E_{total} = 100\,J$

$mgh = 100\,J$

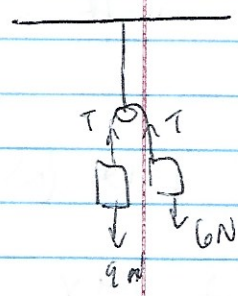
$m(10)(10) = 50$

$m = 0.5$ $h = \frac{100\,J}{0.5kg \cdot 10\,m/s^2}$

$= 20\,m$ (b) ✓

7) C ✓ 8) A ✓

9)



$\Sigma F = ma$

$9N - 6N = (1.5)a$

$3N = 1.5a$

$a = 2\,m/s^2$ (d) ✓

$F = \frac{W}{v} = 2\,N$ (e) ✓

10) $W = F\vec{v}\cos\theta = F\vec{v}$

11) (c) ✓ 12) c ✓

13) $\frac{mv^2}{r} = -mg + F$ $\omega = \frac{v}{r}$

$v = r\omega$

$mg + \frac{mr^2\omega^2}{r} = F$

(e) ✓ -2

14) (e) c 15) (b) e 16) (e) d 17) b ✓

18) a ✓ 19) d ✓ 20) $\omega_f^2 = \omega_0^2 + 2\alpha\theta$

$\omega_f = \sqrt{2\alpha(2\pi)}$

$= \sqrt{4\pi\alpha}$ (c) ✓

21) $\frac{3}{5}m \cdot \frac{v_0}{2} = \frac{3}{5}mv$

$mv_0 = 2mv$ $v = \frac{1}{2}v_0$ (b) e

22) $\frac{GM}{r^2}$ $r = x$ (c) ✓

23) $2kx = mg$

$k = \frac{mg}{2x} = \frac{(1.2kg)(10\,m/s^2)}{2(0.15)}$

$= \frac{12}{0.3} = 40$ (a) ✓

24) (a) ✓ 25) $v_{0y} = \frac{v}{\sqrt{2}}$

$\frac{1}{2}m\left(\frac{v}{\sqrt{2}}\right)^2 = mgh$ (c) ✓

26) $\frac{\frac{1}{12}mL^2}{\frac{1}{12}(2m)(2L)^2} = \frac{mL^2}{8mL^2}$ (e) ✓

27) (c) ✓ 28) (d) ✓

29) (b) ✓ 30) [illegible]

$x_{cm} = \frac{5kg(l)}{15kg} = \frac{1}{3}l$

$AB = \frac{1}{3}l$ $AC = \frac{1}{2}l$

$AD = \frac{2}{3}l$ $AE = l$ -4

a: $I = 5(l^2) = 5$

b: $I = 10\left(\frac{1}{3}l\right)^2 + 5\left(\frac{2}{3}l\right)^2 = 3.33$

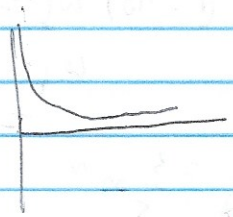
c: $I = 10\left(\frac{1}{2}l\right)^2 + 5\left(\frac{1}{2}l\right)^2 = 3.75$

d: $I = 10\left(\frac{2}{3}l\right)^2 + 5\left(\frac{1}{3}l\right)^2 = 5$

e: $I = 10l^2 = 10$ (e) ✓

E/M MC e/m 25/35

31) $U = -\frac{GMm}{r}$ $\frac{1}{r}$ (c)



32) idle guns (a)

33) $T = 2\pi\sqrt{\frac{g}{L}}$ (a)

34) $F_f = \mu mg\cos\left(\tan^{-1}\left(\frac{3}{4}\right)\right)$

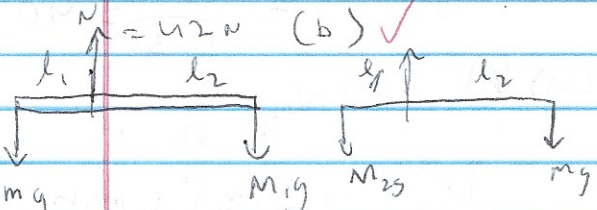
$= 0.3 \cdot 5\text{kg} \cdot 10\left(\frac{m}{s^2}\right) = 12$

$F = F_f + mg\sin\theta$

$= 12N + (5kg)(10)\left(\frac{3}{5}\right)$

$= 42N$ (b)

35)



$mgl_1 = M_1gl_2$ $mgl_2 = M_2gl_1$

$l_2 = \frac{M_2 l_1}{m}$

$ml_1 = \frac{M_1 M_2 l_1}{m}$

$m^2 = M_1 M_2$ (e)

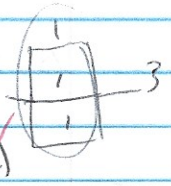
-1

36) I, II (c)

37)

(a)

38) (e) 39) 3μF



(c)

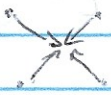
40) $Q = CV$ $V = \frac{Q}{C}$

2V 2V

$\frac{1}{2}V = \frac{Q}{C}$

$V = \frac{2Q}{C} = \frac{2(6\mu C)}{2\mu F} = 6V$ (a)

41) $V = 4V_0$



$E_T = 0$ (d)

42) (?) b 43) ← B; $B = \mu_0 nI$ (e)

44) $R = \frac{\rho l}{A}$

$P = I^2R \rightarrow \rho, l$ (c)

45) $0.5 + 0.2 + 1.5 + R$ $V = IR$

$R + 2 = \frac{6V}{I}$

$R + 2 = \frac{6}{2} = 3$ $R = 1\Omega$ (a)

46) $R = 1.2\Omega$

$V = IR = 2A \cdot 1.2\Omega = 2.4V$

6 - 2.4 3.6 (b)

47) $P = I^2R = 4 \times 1.5 = 6J$

$P = \frac{W}{t}$ $W = Pt = 360J$ (c)

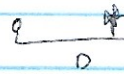
-3

48) $E_1 = \frac{kQ}{r^2}$ $E_2 = \frac{kQ}{4r^2}$ (a) ✓

49) $V = \frac{kQ}{r}$ $\frac{kQ}{r_1} - \frac{2kQ}{r_2} = 0$

$\frac{kQ}{r_1} = \frac{2kQ}{r_2}$

$\frac{r_1}{r_2} = \frac{1}{2}$



$+\frac{2}{3}D$

$= \frac{5}{3}D$ (d) ✓

50) $E = \frac{dV}{dr} = -2cr^{-3}$ (a) ✓

51) $E = \frac{kQ_{enc}}{r^2}$ (a) ✓

52) $\frac{kQ}{r} + \frac{kQ_2}{r_2}$ (e) ✓ $V_{inside} = V_{surface}$

53) $\Delta V = qV$ (d) ✓

54) $F = qV$ (a) ✓ $V = 0$

55) (d) ✓ 56) (c) ✓

57) (a) ✓ 58) (a) ✓

59) $V = 2V$ $I = \frac{V}{R} = \frac{\mathcal{E}}{R}$ (b) ✓

60) $U_L = \frac{1}{2}LI^2 = \frac{1}{2}L\cdot\frac{\mathcal{E}^2}{R^2}$

$= \frac{L\mathcal{E}^2}{2R^2}$ (b) ✓

61) $\mathcal{E} = -L\frac{dI}{dt}$ (e) ✓

62) $(3\Omega^{-1} + 6\Omega^{-1})^{-1} = 2\Omega$

$(2+r)(0.5A) = 20V$

$2 + r = 25\Omega$

$r = 5\Omega$ (d) ✓

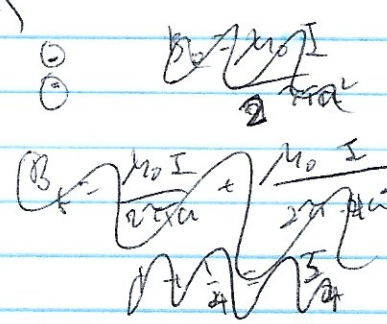
63) $0.3m(IlB)$

$= 0.3 \cdot 2A \cdot 0.3m \cdot 0.05T$

$= 0.009 Nm$ (b) ✓

64) $E \cdot 4\pi r^2 = \frac{Q_{enc}}{\varepsilon_0}$ (d) ✓

65)



$B = \frac{\mu_0 I}{2\pi r} + \frac{\mu_0 I}{2\pi r}$

$\frac{\mu_0 I}{2\pi r} + \frac{\mu_0 I}{2\pi r} = \frac{4}{3}B_0$ (d) ✓

66) (e) ✓ 67) $P = I^2R$ $P = I\Delta V$

$V = IR$

$P = \frac{V^2}{R}$ (a) ✓ $I = \frac{V}{R}$

68) (e) ✓ 69) $C = \frac{\kappa A \varepsilon_0}{d}$ $d \downarrow$ $C \uparrow$

(e) ✓

70) (b) ✓

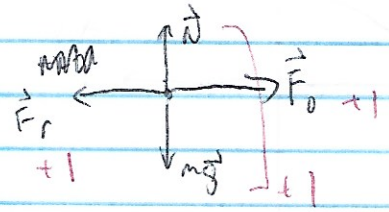
-2

1993 FR/MECH 30 mech 15

Mech 1 a) $PE_s = \frac{1}{2}kA^2 = \frac{1}{2}(400\ N/m)(0.5\ m)^2$ +1 +1

$= 50\ J$ +1

Mech 2 a)



+1

$F_r = kv$ (Resistive) +1

b) $PE_s = \frac{1}{2}mv_f^2 + \mu m_c g = \frac{1}{2}kA^2$ +1 COE

+1

$mv_f^2 + 2\mu m_c g = kA^2$ −1 W_f

$m_c v_f^2 = kA^2 - 2\mu m_c g d$ +1

$v_f = \frac{1}{m_c}\sqrt{kA^2 - 2\mu m_c g d}$

$= \frac{1}{4\ kg}\sqrt{(400\ N/m)(\frac{1}{2}\ m)^2 - 2(0.4)(4\ kg)(10\ m/s^2)(0.5\ m)}$

$= 2.24\ m/s$ −1

c) $m_c v_c + m_d(0) = (m_c + m_d)v_f$ +1 cop +1

$v_f = \frac{m_c}{m_c + m_d}(v_c) = \frac{4\ kg}{6\ kg}(2.24\ m/s)$ −1

$= 1.53\ m/s$

d) $\frac{1}{2}(m_c + m_d)v_f^2 = \mu(m_c + m_d)gd$ +1

+1 COE implied

$d = \frac{(m_c + m_d)v_f^2}{2\mu(m_c + m_d)g} = \frac{(1.53\ m/s)^2}{2(0.4)(10\ m/s^2)}$

$= 0.29\ m$ −1

units +1

−4

b) $\sum F_x = ma$ +1

$F_0 - kv = ma$ +1

$a = \frac{F_0 - kv}{m}$ +1

c) $F_0 - kv = m\frac{dv}{dt}$ $a = \frac{dv}{dt}$ +1

$\int (F_0 - kv)\,dt = \int m\,dv$

$mv = (F_0 - kv)t$

$v(t) = \frac{1}{m}(F_0 - kv)t$

$\frac{F_0 - kv}{m} = \frac{dv}{dt}$

$\frac{F_0 - kv}{dv} = \frac{m}{dt}$

$\int \frac{dv}{F_0 - kv} = \int \frac{dt}{m}$ +1

$u = F_0 - kv$

$\frac{du}{dv} = -k$

$dv = -\frac{du}{k}$

$-\frac{1}{k}\int \frac{1}{u}\,du$

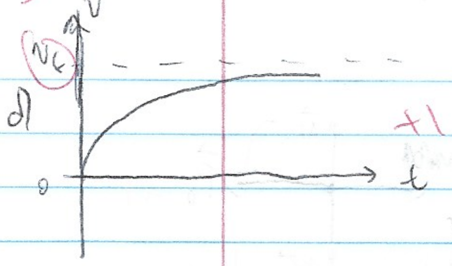
$= -\frac{1}{k}\ln|F_0 - kv| = \frac{t}{m}$

$\ln|F_0 - kv| = -\frac{kt}{m}$

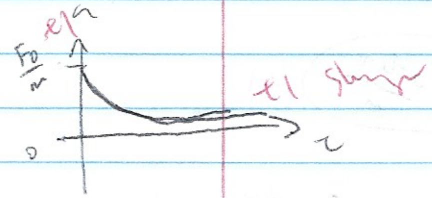
$F_0 - kv = e^{-\frac{kt}{m}}$

$v = \frac{1}{k}(F_0 - e^{-\frac{kt}{m}})$ 3 integration

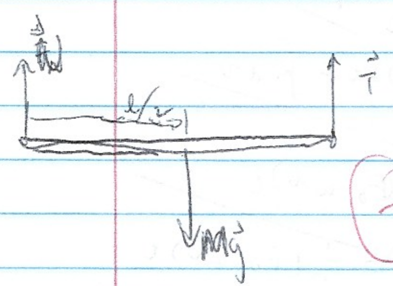
d)



e) $a = \frac{dv}{dt}$



Mech 3) a)



-1 $\tau = r \times F$ say explicitly!

$\Sigma \tau = I\alpha = 0$ +1 $\qquad \Sigma F = ma = 0$

$Mg\frac{l}{2} - Tl = 0 \qquad T + N - Mg = 0$

$T = \frac{1}{2}Mg \qquad Mg - N = T$

$\frac{1}{2}Mg = Mg - N \qquad \boxed{N = \frac{1}{2}Mg}$ +1

straight up +1

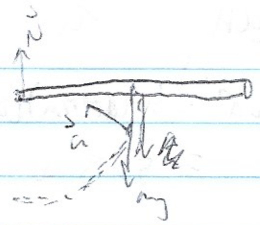
b) $\Sigma \tau = Mg\frac{l}{2} = I\alpha$ +1

$\frac{l}{2}Mg = \frac{1}{3}Ml^2\alpha$

$\boxed{\alpha = \frac{3}{2}\frac{g}{l}}$ +1

-2

c)



~~$\Sigma F = Ma$~~

~~$Mg = Ma \quad a = g$~~

(d) $\boxed{a_T = 0 \ m/s}$ (-2)

(d) $\Sigma F_T = Ma = 0$ +1

$N - Mg = 0$ (-2)

$\boxed{N = Mg}$

(e) ~~$Mg\frac{l}{2}$~~ $PE_{g_0} + KE_{r_0} = PE_{g_f} + KE_{r_f}$ +1 cor

$Mg\frac{l}{2} = mgh + \frac{1}{2}I\omega^2$ +1

$h = \left(\frac{l}{2}\right)\cos\theta$ +1

$\frac{Mgl}{2} = mg\frac{l}{2}\cos\theta + \frac{1}{2} \cdot \frac{Ml^2}{3} \cdot \omega^2$

$Mgl(1 - \cos\theta) = \frac{1}{3}Ml^2\omega^2$

$\omega^2 = \frac{3g(1-\cos\theta)}{l}$ (-2)

$\boxed{\omega = \sqrt{\frac{3g(1-\cos\theta)}{l}}}$

-6

#2 E/M
45

1993 E/M FR

1) a)

b)(i) $\int E \cdot dA = \frac{Q_{en}}{\varepsilon_0}$ +1 $r \to R$

$E \cdot 2\pi r\, dl = \frac{Q}{\varepsilon_0}$ +1 $\quad \rho = \frac{Q}{V}$

$\rho = \frac{Q}{A \cdot dl}$

$Q = \rho A dl$ +1 $\quad A = \pi R^2$

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

$E = \frac{\rho \cdot \pi r^2}{2\pi r \varepsilon_0} = \boxed{\frac{\rho_0}{2\varepsilon_0}}$ r R −1

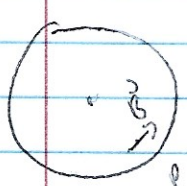
(ii) $E \cdot 2\pi r\, dl = \frac{Q \cdot r^2}{\varepsilon_0 R^2}$ → same ratio

$E \cdot 2\pi r\, dl = \frac{\rho A dl\, r^2}{\varepsilon_0 R^2}$ ×1

$E = \frac{\rho \pi R^2 \cdot r^2}{\varepsilon_0 R^2 \, 2\pi r} = \boxed{\frac{\rho r^3}{2\varepsilon_0 R^2}}$ −1

$\frac{\rho}{2}$ ρ_1 +1

(c)



d) $dB = \frac{\mu_0}{4\pi} \cdot \frac{I\, dl \times \hat{r}}{r^2}$

$\int B \cdot dl = \mu_0 I_{enc}$ +1

$\int B \cdot dl = \mu_0 I \cdot \frac{r^2}{R^2}$ ← same ratio

$B \cdot 2\pi r = \mu_0 I \cdot \frac{r^2}{R^2}$ +1

$\boxed{B = \frac{\mu_0 2\sigma}{2\pi R^2}}$ +1

2) (a) (i) $\Phi = BA = \boxed{B_0 ab}$ +1

(ii) $\boxed{\mathcal{E}_{ind} = 0 V}$ $(v = 0)$ +1

(iii) $\boxed{\Sigma F_n = 0}$ $(v = 0)$ +1

(b) $\cos\frac{\pi}{2} = 0$

$\mathcal{E} = -\frac{d\Phi}{dt} = -\frac{dB}{dt} \cdot ab$

(X) $B=0$ (✓) $B=0$ (X)

0 $\frac{\pi}{2}$ π $\frac{3\pi}{2}$ 2π

↳ $\downarrow B$ when $\omega t = \frac{\pi}{2}$, B is decreasing becoming more negative

$\frac{dB}{dt}$ is (−)

~~If the loop was turning~~

−3

(c) $\mathcal{E} = -\frac{d\Phi}{dt} = IR = -\frac{dB}{dt} \cdot ab$ +1 +1 flux +1

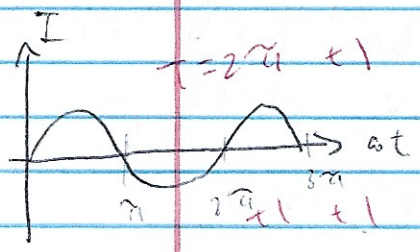
$B = B_0 \cos \omega t$

$\frac{dB}{dt} = -B_0 \omega \sin \omega t$

$IR = B_0 \omega \sin \omega t \, ab$

$I = \frac{B_0 \omega ab \sin(\omega t)}{R}$ +1

(i) $I(t) = \frac{B_0 \omega ab}{R} \sin(\omega t)$

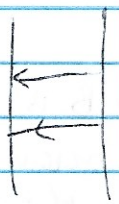


$T = 2\pi$ +1 +1 +1

(ii) I_{max} is when $\sin(\omega t) = 1$ +1

$I_{max} = \frac{B_0 \omega ab}{R}$ +1

3)



a) RHR +1
(-ẑ) direction +1

b) $\vec{F}_\ell$ ends to point to the left

∴, K should be (+) charged plate +1

(c) $V = EF$ +1

$E = \frac{V}{R} = \frac{1500\,V}{0.012m} = \frac{125{,}000\ V/m}{(1.25 \times 10^{-5})}$ +1

(d) $q\vec{E} = q\vec{v}B$ +3 (equal & opp.)

$v = \frac{E}{B} = \frac{125{,}000\,V/m}{0.20\,T} = 6.25 \times 10^5\ m/s$ +1

(e) $q v B = \frac{mv^2}{R}$

$m = \frac{qBR}{v} = \frac{(1.60 \times 10^{-19} C)(0.20\,T)(0.50\,m)}{6.25 \times 10^5\ m/s}$

$= 2.56 \times 10^{-26}\ kg$ +1

(f) $qvB = \frac{mv^2}{R}$ +1

$R = \frac{mv}{qB} = \frac{(2.56 \times 10^{-26}\ kg)(6.25 \times 10^5\ m/s)}{(2)(1.60 \times 10^{-19} kg)(0.20\,T)}$

$= 0.25\ m$ +1

Units +1

1993 BR

MCMB 2 FRMB 5 MCMR 5 FRMR 10

MCGB 9 FREB 3 MCER 7 FRER 0

MC

3) 11, 21, 14, 15, 16, 31, 37, 42, 46, 48, 50, 53, 57, 59, 61, 68, 70

3) v_1 $\to v$ v_2

$\vec{v} + \vec{v}_2 = \vec{v}_1$

$\vec{v} = \vec{v}_1 - \vec{v}_2$ (b) d

11) (e) d

21) $m v_0 = \frac{2}{5} m \cdot \frac{v_0}{2} + \frac{3}{5} m v_f$

$\frac{6}{5} m v_0 = \frac{3}{5} m v_f$

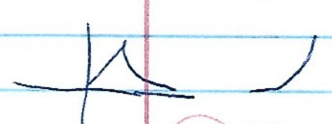
$v_f = \frac{6}{5} \cdot \frac{5}{3}$

$v_f = 2 v_0$ (e) ✓ +1

14) $W = mgh$ (c) +1

15) (b) e 16) (b) d

31) $U_\infty = 0$ (c) d



+2

37) (b) +1

42) 2

46) $V = IR$

$= I(0.2\,\Omega + 1\,\Omega)$

$= 2.4V$

$6V - 2.4V$

$= 3.6V$ (?) (b) c

48) $E = \frac{kQ}{R^2}$ $E = \frac{kQ}{(\frac{R}{2})^2} = \frac{4kQ}{R^2}$ (e) +1

blan

+2

50) $E = \frac{dV}{dr} = -2ar^{-3}$ (a) e

53) $\Delta V = 4V$ (d) +1

57) $I = \frac{V}{R} = \frac{V}{R_1 + R_2}$ (a) b

59) $I = \frac{V}{R} = \frac{\mathcal{E}}{R}$ (b) a

~~61) $\mathcal{E} = -L \frac{dI}{dt}$ (e)~~

68) (d) a 70) $R = 2\,\Omega$ (b) e

+1

FRM

1) b) $PE_{s0} + KE_0 = PE_{sf} + KE_f + W_f$ +1

$\frac{1}{2} k A^2 = \frac{1}{2} m v_c^2 + \mu m_c g A$

$\frac{1}{2} m v_c^2 = \frac{1}{2} k A^2 - \mu m_c g A$

$m v_c^2 = k A^2 - 2\mu m_c g A$

$v_c^2 = \frac{kA^2}{m_c} - 2\mu g A$

$v_c = \sqrt{\frac{kA^2}{m_c} - 2\mu g A}$

$= \sqrt{\frac{(400\,N/m)(0.5m)^2}{4kg} - 2(0.4)(9.8\,m/s^2)(0.5m)}$

$= 4.59\,m/s$ +1

c) $v_f = \frac{m_c}{m_c + m_s}(v_c) = \frac{4kg}{6kg}(4.59\,m/s)$

$= 3.06\,m/s$ +1

+3

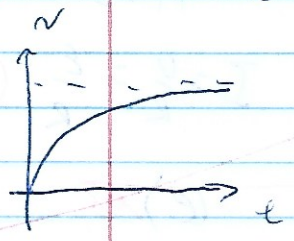
d) $d = \frac{v_f^2}{2\mu g} = \frac{(3.0\ m/s)^2}{2(0.4)(9.8\ m/s^2)}$

$= 1.19\ m$ +1

2) c) ?

3) a) $\tau = \vec{r} \times \vec{F} = rF$ +1

2) d)



3) c) - e) +2

~~EM~~ EM E/M

1) b) (i) $E \cdot 2\pi r l = \frac{\rho \cdot \pi R^2}{\varepsilon_0}$

$E = \frac{\rho R^2}{2\varepsilon_0 r}$ +1

(ii) ~~$E 2\pi r = \rho \pi R^2$~~

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

$E \cdot 2\pi r\, dl = \frac{\rho A\, dl\, r^2}{\varepsilon_0 R^2}$

$E 2\pi r = \frac{\rho \cdot \pi r^2 r^2}{\varepsilon_0 R^2}$

$E = \frac{\rho r^2}{2\varepsilon_0} = \frac{\rho r}{2\varepsilon_0}$ +1

+3/

MCM 3) b 11) b 15) c 16) d 31) d) +5/

MCE

42) B 46) C 50) e 57) b 59) a 68) a 70) e +7/

FRM

2) c) $a = F_0 - kv$ $dv = -k\,dv$

$-\frac{1}{k}\int \frac{dv}{a} = \int \frac{1}{m} dt$

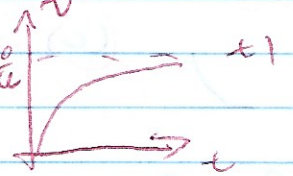
$\ln(F_0 - kv) - \ln C = -\frac{k}{m} t$ +1

$v = \frac{1}{k}\left(F_0 - Ce^{-kt/m}\right)$ +1

$C = F_0$, $t = 0$, $v = 0$

$v = \frac{F_0}{k}\left(1 - e^{-kt/m}\right)$ +1

2) d)



+1

3) c) $a = \alpha r$ $r = \frac{l}{2}$

$a = \frac{3}{2}\frac{2}{l}\cdot\frac{l}{2} = \frac{3}{4}g$ +2

d) $\Sigma F = ma = Mg - Fr$

$Fr = Mg - Ma$

$= Mg - M\cdot\frac{3}{4}g$ +1

$F_r = \frac{1}{4}Mg$ +1

+4/

3) c) $\frac{1}{2} I \omega^2 = Mg \frac{l}{2} \sin\theta$

$\omega = \sqrt{\frac{Mgl}{I} \sin\theta}$ +1

$= \sqrt{\frac{3g}{l} \sin\theta}$ +1

+2