total: $\frac{151.9}{180}$

1984 MCM

Mech: $\frac{29}{35} \to \frac{37.3}{45}$

1) (d) ✓ 2) $\Delta y = \cancel{v_0 t} + \frac{1}{2} g t^2$

$t = \sqrt{\frac{2y}{g}} = \sqrt{\frac{2 \cdot 10}{10}} = \sqrt{2}$ (c) ✓

3) (c) ✓ 4) (a) ✓ 5) (b) ✓ 6) L const. $I\omega^2$ ~~(d)~~ c

7) (e) ✓ 8) $\frac{W}{t} = \frac{PE}{t} = \frac{mgH}{T}$ (b) ✓

9) $\Sigma F = m_t a = F$

$a = \frac{F}{3}$ $\quad \Sigma F_1 = m_1 a$

$= 1 \cdot \frac{F}{3}$ (e) ✓

10) $\omega_f = \cancel{\omega_0} + \alpha t$

$\alpha = \frac{\omega_f}{t} = 0.5 \ \mathrm{rad/s^2}$ (a) ✓

11) $L = I\omega = 4 \cdot 1 = 4$ (d) ✓

12) $K = \frac{1}{2} I \omega^2 = \frac{1}{2} \cdot 4 \cdot (1)^2 = 2$ (b) ✓

13) $(m_1 + m_2) v$ ~~(a)~~ b

14) $\downarrow m_2 g h$, $\uparrow m_1 g h$

$(m_2 - m_1) g h$ (a) ✓

15) $W = \int F \cdot dr$ (e) ✓

16) $\Sigma F_y = 0 \quad \Sigma F_x = 0 \quad \tau = 0$

(a) ✓

17) $P_x: 2m_0 v_0 \cos\theta = 2m_0 v_f$

$m_0 v_0 = 2m_0 v_f$

$v_f = \frac{1}{2} v_0$ (b) ✓

18) (d) ✓ 19) $v = r\omega = r \frac{d\theta}{dt}\Big|_{t=4}$

$= 2 \cdot (6t+2)\big|_{t=4} = 2(24+2) = 2 \cdot 26 = 52$

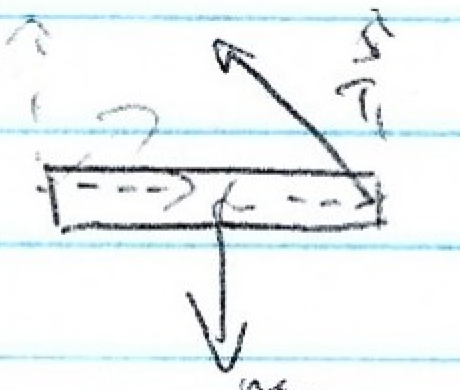
-2 (d) ✓

20) $g = \frac{GM}{r^2} = \frac{G \cdot \frac{1}{10} M_e}{\frac{1}{4}(r_e)^2} = \frac{4}{10} g$

$= 4$ (b) ✓

21) $F v \cos\theta = \mu m g v = (0.25)(40)(10)(\frac{1}{2})$

$= 50$ (c) ✓

22) 

(b) ✓

23) $mgA = \frac{1}{2} k A^2$

$mg = \frac{1}{2} k A$ $\quad A = \frac{2mg}{k} = \frac{2 \cdot 0.1 \cdot 10}{40}$

$= \frac{2}{40}$ ~~(b)~~ a

24) $\leftarrow 1T$

$\frac{1}{2} T$ $\quad t = \frac{1}{2} \cdot 2\pi \sqrt{\frac{m}{k}}$

$= \pi \sqrt{\frac{0.1}{40}}$

$= \frac{\pi}{20}$ ~~(b)~~ c

25) $A \sim 4$ ~~(a)~~ e

26) mr is same everywhere ~~(e)~~ b

27) $I_0 + m(\frac{1}{2} L)^2 = I_0 + \frac{1}{4} m L^2$ (a) ✓

28) $24 + (24)(10) + \frac{1}{2}(6)(10)^2$

$= 24 + 240 - 300$

$= 264 - 300 = -36\,m$ (c) ✓

29) $\frac{(\frac{1}{2} L m + \frac{1}{2} L m)}{3m} = \frac{1}{3} L$ (b) ✓

30) $\to v$ $\quad$ (w

$\downarrow a$ $\quad 3 = \frac{v^2}{300}$ $\quad 900 = v^2$

$v = 30$ (a) ✓

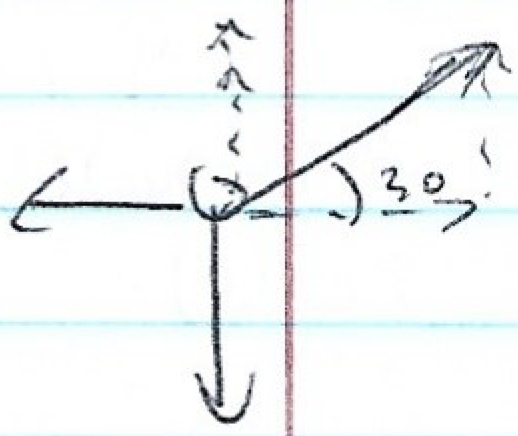
-4

$E: \frac{30}{35} \to \frac{38.6}{45}$

MCE 1984

31) $\left(\frac{M_1}{M_2}\right)v = $ (e) ✓

32)



$T\sin\theta = 100$

$T\sin 30 = 100$

$T = \frac{100}{\frac{1}{2}} = 200$ (d) ✓

33) $K = \frac{1}{2}mv^2 = \frac{q}{4}$

$K \propto \left(\frac{dx}{dt}\right)^2 = \left(\frac{3}{2}t^{\frac{1}{2}}\right)^2 = \frac{9}{4}t$

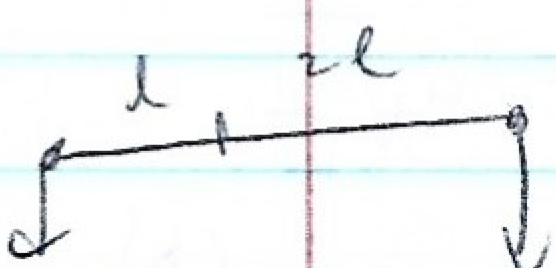
(c) ✓

34) $\frac{1}{2}(10)^2 + (1)(10)(70) = \frac{1}{2}(30)^2 + W_f$

$50 + 700 = 450 + W_f$

$W_f = 750 - 450 = 300$ (c) ✓

35)



$\Sigma\tau = I\alpha$

$I = (3M)(l)^2 + (M)(2l)^2 = 7Ml^2$

$-3Mgl + 2Mgl = 7Ml^2\alpha$

$-Mgl = 7Ml^2\alpha$

$\alpha = \frac{1}{7}\cdot\frac{g}{l}$ (a) ✓

Mech:

6) (c) 13) (b) 23) (a) 24) (c) 25) (e) 26) (b)

36) $C = \frac{k\varepsilon_0 A}{d}$ $\quad \frac{2A}{2d} = \frac{A}{d}$

(c) ✓

37) $P = \frac{V^2}{R}$ $\quad R = \frac{V^2}{P} = \frac{(110)^2}{100}$ (e) ✓

38) $\int I\,dt = \Delta Q$ $\quad I = \frac{dQ}{dt}$

$= Q \to$ coulombs

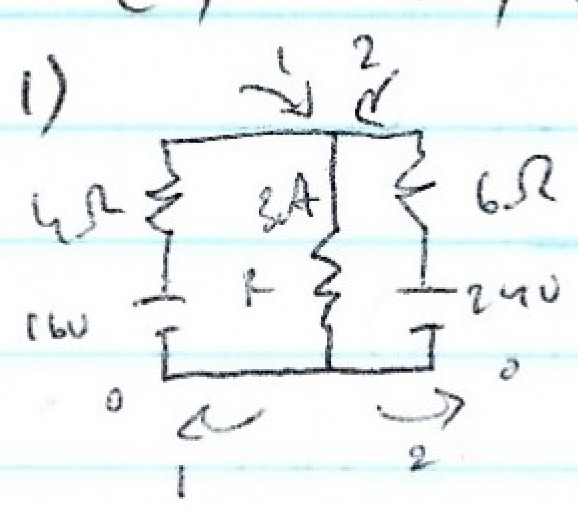
$\int E \cdot dx \to$ Volts $\quad \frac{C}{V}$

$C = \frac{Q}{V}$ (d) ✓

= Farads

39) (a) ✓ 40) ~~(d)~~ b $\to$ 2 forces $\perp$

41)



$V = IR$

$V_4 = 4\,V$

12V $\quad V_6 = 6 \cdot 2 = 12V$

$R = \frac{V}{I} = \frac{12V}{3A} = 4\,\Omega$ (b) ✓

42) $\oint E \cdot dA = \frac{Q_{enc}}{\varepsilon_0}$ (c) ✓

43) μ

$W = 0$ ~~(d)~~ b

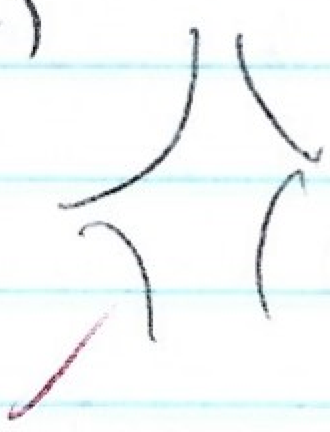
44) ~~(b)~~ a 45) ~~(d)~~ e

46) (d)? ✓

47) $\frac{F}{l} = \frac{\mu_0 I_1 I_2}{2\pi r}$ (d) ✓

48) (e) ✓ 49) (b) ✓ 50) (e) ✓

51) (d) ✓ 52) (a) ✓



53) (a) ✓

-4

54) (a) ✓
I ↑

55) (e) ✓

56) $P = I\Delta V$

$I = \frac{V}{R}$ $P = \frac{V^2}{R_{eq}}$

$R_{eq}\uparrow$ (e) ✓

57) (a) ✓ $V \to 0$

58) (a) ✓ $I \to 0$

59) $V \to$ const (b) ✓

60) $\frac{6}{3} = 2$ (b) ✓

61) $U = \frac{1}{2}CV^2$

$= \frac{1}{2}(6\mu)(2V)^2$

$= 12\mu$ (c) ✓

62) ← →

$\Sigma F \leftarrow$ $\Sigma \tau$ ccw

(b) ✓

63) ~~(e)~~ (a) ✓ form to oppose

64) neg. charge (e) ✓ if it were = no

65) $\frac{1}{2}+Q$ $\frac{1}{2}+Q$

$F_a = \frac{kQ^2 \cdot \frac{1}{4}}{d^2} = \frac{1}{4}\frac{kQ^2}{d^2}$

$F_b = \frac{k(2Q)(Q)}{d^2} = 2$

$F_b = 8F_a$ (e) ✓

66) $k\uparrow$ $C\uparrow$ ~~ΔQ~~ Q unchanged

$V = \frac{Q}{C}$ $V\downarrow$ (b) ✓

67) $\oint B \cdot dl = \mu_0 I_{en}$

$B \cdot 2\pi r = \mu_0 I_{en}$ (a) ✓

68) $B = \mu_0 n I$ (C) ✓

69) $\tau = RC$ ~~(a) b~~

(a) ✓

70) ~~(c)~~ d -1

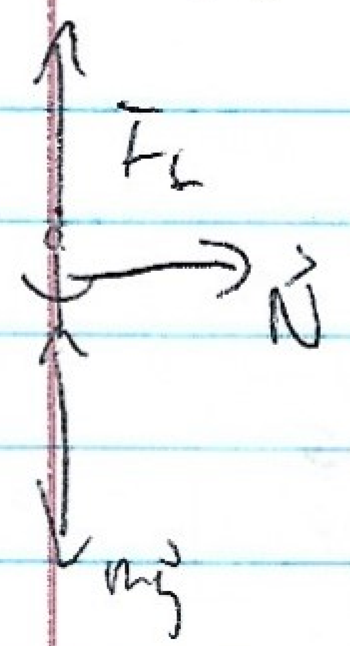
E: 40) b 43) b 44) d 45) e

70) d

1984 FRM

Mech: $\frac{43}{45}$

1) a)



+4

b) $F_c = \frac{mv^2}{R} = \frac{(50\,kg)(5m\cdot(2\frac{rad}{s}))^2}{5m}$

$v = r\omega$

$= \boxed{1000\,N}$ +5

Normal force from the walls.

c) $F_f = mg = (50kg)(9.8\,m/s^2) = \boxed{490\,N}$

friction from the walls.

d) NO. +4

$F_f = \mu N = mg$, but $N = F_c$

$\frac{\mu \cancel{m} v^2}{R} = \cancel{m}g$

Since masses cancel out, then it only depends on the coefficient of friction, speed, radius, and acceleration due to gravity, not mass. +2

2) a) $F_c = \frac{\cancel{m}v_0^2}{2R_e} = \frac{G\cancel{m}M_e}{(2R_e)^2}$

$v_0^2 = \frac{GM_e}{2R_e}$

$\boxed{v_0 = \sqrt{\frac{GM_e}{2R_e}}}$ +5

b) $3mv_0 - mv_0 = (4m)v_f$

$2mv_0 = 4mv_f$

$\boxed{v_f = \frac{1}{2}v_0}$ +4

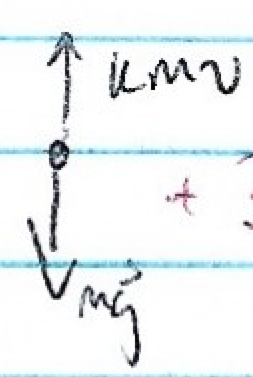
c) $E = KE + U_g = \frac{1}{2}(4m)(\frac{1}{2}v_0)^2 + \frac{GM_e(4m)}{2R_e}$

+1 +2 (-) sign +1

$= \frac{1}{2}mv_0^2 + \frac{4GM_em}{2R_e} = \frac{1}{2}m\cdot\frac{GM_e}{2R_e} + \frac{2GM_em}{R_e}$

$= \boxed{\frac{9}{4}\frac{GM_em}{R_e}}$ -2

3) a)



+3

b) $\Sigma F = ma = m\frac{dv}{dt}$

$\boxed{\cancel{m}\frac{dv}{dt} = \cancel{m}(g - kv)}$ +4

c) $\cancel{m}g = k\cancel{m}v_t$ $\quad \Sigma F = 0 = ma$

$\boxed{v_t = \frac{g}{k}}$ +3

d) $\frac{dv}{dt} = g - kv$ $\qquad \frac{dv}{g-kv} = dt$

$u = g - kv$ $\quad \frac{du}{dv} = -k$ $\quad dv = -\frac{du}{k}$

$-\frac{1}{k}\int_0^v \frac{du}{u} = \int_0^t dt$

$-\frac{\ln|g-kv|}{k} - \frac{-\ln|g|}{k} = t$

$-\ln\left|\frac{g-kv}{g}\right| = kt$

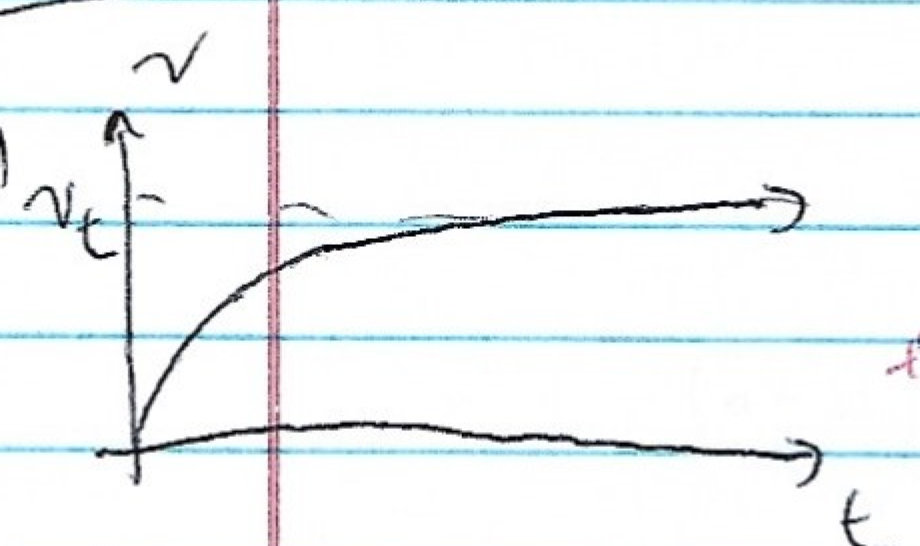
$\frac{g-kv}{g} = e^{-kt}$

$-kv = ge^{-kt} - g$

$\boxed{v = \frac{g}{k}(1 - e^{-kt})}$

+4

3) e)



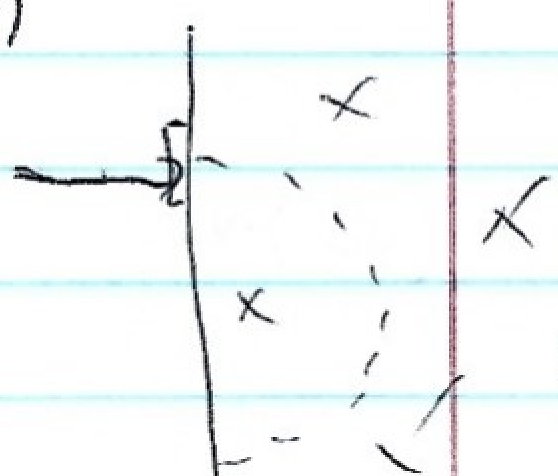
+2

1984 FRE

1) a) $\frac{1}{2}mv^2 = q\mathcal{E} = e\mathcal{E}$

$\boxed{\mathcal{E} = \frac{mv^2}{2e}}$ +3

b)



+3

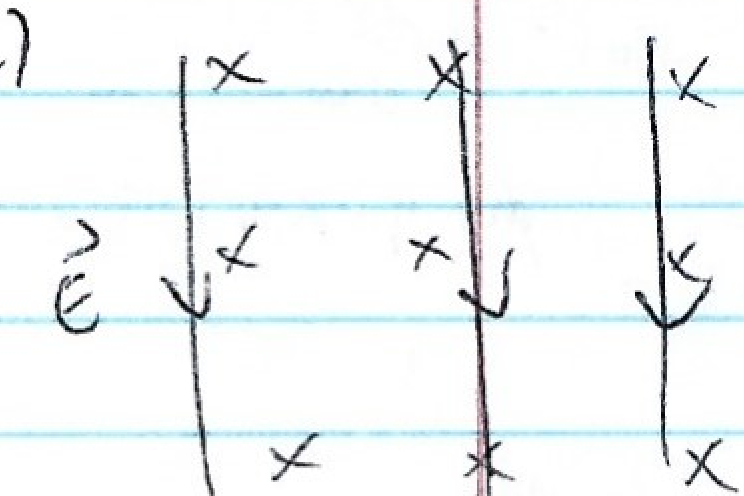
c) $F_B = F_c = qvB = \frac{mv^2}{r}$

$r = \frac{mv}{qB} = \boxed{\frac{mv}{eB}}$ +4

d) (i) $qvB = qE$ $\boxed{E = vB}$ +3

F ↑

(ii)



+2

2) a) $E = \frac{\Delta V}{\Delta r}$ $E_1 = \frac{V}{a}$ $E_2 = \frac{V}{b}$

$\frac{E_1}{E_2} = \frac{V}{a} \cdot \frac{b}{V} = \boxed{\frac{b}{a}}$ +3

b) $\sigma = \frac{Q}{A}$ +1

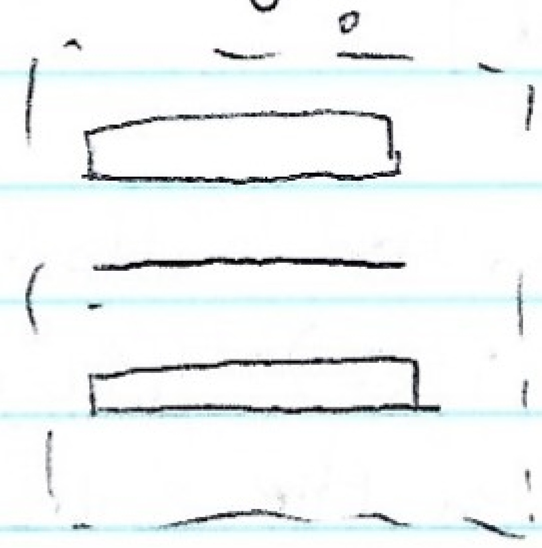
$\int E \cdot dA = \frac{Q_{enc}}{\varepsilon_0}$ +1

33/45

$\int E \cdot dA = \frac{\sigma A}{\varepsilon_0}$

$E(2A) = \frac{\sigma A}{\varepsilon_0}$ $\boxed{E = \frac{\sigma}{2\varepsilon_0}}$ -3

c)



$\int E \cdot dA = \frac{Q_{enc}}{\varepsilon_0}$

$E \cdot 2A = \frac{\sigma A}{\varepsilon_0}$

$E = \frac{\sigma}{2\varepsilon_0}$ $q = \frac{F}{E}$

total enclosed charge density $= \sigma$

thus, induced charge density $= -\sigma$

b/c of conservation of charge.

-4

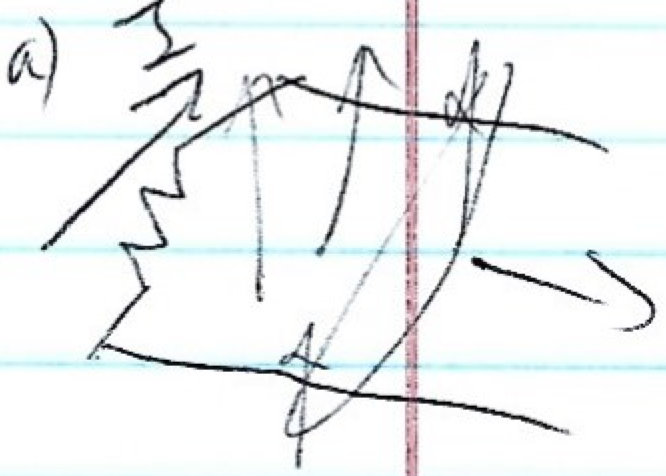
d) $V = \int E \cdot dr$

$= \int_{-b}^{a} \frac{\sigma}{2\varepsilon_0} dr$

$= \boxed{\frac{\sigma}{2\varepsilon_0}(a+b)}$ -3

[illegible] FRQ

3) a) $\Delta B \uparrow$ $\quad B_{ind} \downarrow$ $\quad \boxed{I_{ind} \circlearrowright}$

a) 

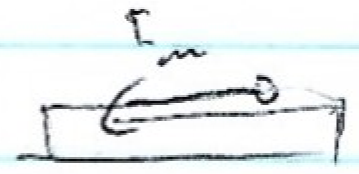
+2

b) $I = \frac{\mathcal{E}}{R} = \frac{1}{R} \cdot \frac{d\Phi}{dt} = \frac{B}{R} \cdot \frac{dA}{dt}$

$= \frac{B}{R} \cdot l \frac{dr}{dt}$ +4

$= \boxed{\frac{Bl v_0}{R}}$ Sign doesn't matter since it's magnitude.

c) 



Side view

+2

d) $F_m = IlB = \boxed{\frac{B^2 l^2 v_0}{R}}$ +2

e) $P = \frac{\mathcal{E}^2}{R}$ ~~$\frac{B}{R} l \ldots$~~

+1

$= \frac{1}{R} \cdot (Blv)^2$ (−2) though, it should be a function of t, right?

$= \boxed{\frac{B^2 l^2 v_0^2}{R} \cdot e^{-\left(\frac{2B^2 l^2 t}{Rm}\right)}}$

f) $E = Pt = \int_0^\infty \frac{B^2 l^2 v_0^2}{R} e^{-\left(\frac{2B^2 l^2 t}{Rm}\right)} dt$

$u = -\frac{2B^2 l^2 t}{Rm} \qquad \frac{du}{dt} = \frac{-2B^2 l^2}{Rm}$

$dt = \frac{du}{\left(\frac{-2B^2 l^2}{Rm}\right)}$

$= \lim_{b \to \infty} \int_0^b \frac{B^2 l^2 v_0^2}{R} \cdot \frac{Rm}{-2B^2 l^2} \cdot e^u \, du$

~~$= \frac{-mv_0^2}{2} \ldots = \lim_{b\to\infty} \left(\frac{-mv_0^2}{2} (e^b - 1) \right)$~~

$= \lim_{b \to \infty} \left(\frac{-mv_0^2}{2} \cdot \left(e^{\left(\frac{-2B^2 l^2}{Rm} b\right)} - e^0 \right) \right)$

$= \frac{1}{2} m v_0^2 = KE_0$ +2

M: 2) c) $E = \frac{1}{4} \frac{GM_E m}{R_E} - \frac{8}{4} \frac{GM_E m}{R_E}$

$= \boxed{-\frac{7}{4} \frac{GM_E m}{R_E}}$

E: 2) b) $\int E \cdot dA = E_1 A + E_2 A$

$Q_{en} = \sigma A$

$E_1 A + E_2 A = \frac{\sigma A}{\varepsilon_0} \qquad E_1 + E_2 = \frac{\sigma}{\varepsilon_0}$

c) $\int E \cdot dA = 0, \; Q_{en} = 0$

$\int E \cdot dA = \sigma_1 A + \sigma_2 A + \sigma A = 0$

$\sigma_1 + \sigma_2 = -\sigma$

d) $E_1 a = E_2 b \qquad E_1 + E_2 = \frac{\sigma}{\varepsilon_0}$

$E_1 = \frac{\sigma b}{(a+b)\varepsilon_0} \qquad E_2 = \frac{\sigma a}{(a+b)\varepsilon_0}$

$V = \frac{ab\sigma}{(a+b)\varepsilon_0}$

3) e) $P = I^2 R = \left(\frac{Blv}{R}\right)^2 R$

$= \boxed{\frac{(Blv)^2}{R}}$