Total: $\frac{124}{180}$

1988 MCM

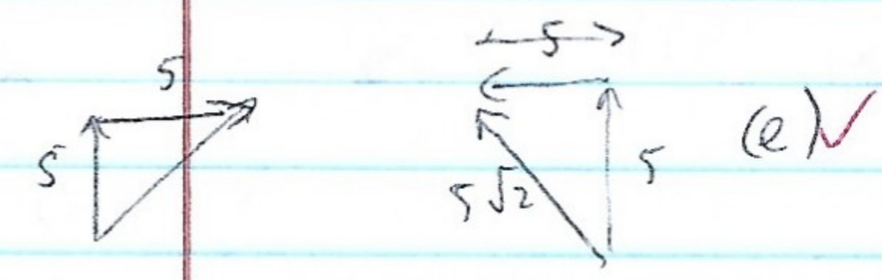
Mech: $\frac{28}{35} \to \frac{36}{45}$

1) (e) ✓ 2) $m_1 v_{1i} + m_2 v_{2i} = m_1 v_{1a} + m_2 v_{2a}$ (a) ✓

3) $4(6) = (8) v_f \quad v_f = 3$ (c) ✓

4) $F = m\frac{dv}{dt} = 2mbt$; (e) ✓

5) (~~b~~) c Const. accel → Should be doubles in the next interval

6) 

(e) ✓

7) 

(e) ✓

8) $0 = M_1 v - (M_2 - M_1) v_f$

$(M_2 - M_1) v_f = M_1 v \quad v_f = \frac{M_1}{M_2 - M_1} v$

$K_1 = \frac{1}{2} M_1 v^2$

$K_2 = \frac{1}{2}(M_2 - M_1) v_f^2$

$= \frac{1}{2}(M_2 - M_1)\frac{M_1^2}{(M_2 - M_1)^2} v^2$

$= \frac{1}{2} M_1 v^2 \left(\frac{M_1}{M_2 - M_1}\right)$ (d) ✓

9) $\frac{M(1) + M(2) + (\frac{1}{2}M)(1.5)}{3.5\,M} \Leftarrow \pi$

$\frac{3 + 0.75}{3.5} = \frac{15}{4} \Big/ \frac{7}{2} = \frac{15}{4} \cdot \frac{2}{7} = \frac{15}{14}$

$y = \frac{(M)(1) + M(1) + (\frac{1}{2}M)(2)}{\frac{7}{2}M} = \frac{3 \cdot 2}{7} = \frac{6}{7}$

(a) ✓

10) ~~$x_f = x_0 +$~~ $y = v_{0y} t + \frac{1}{2} g t^2$

$= v_0 \sin\theta$ ~~$v_f^2 = v_0^2 + 2gy$~~ ✓

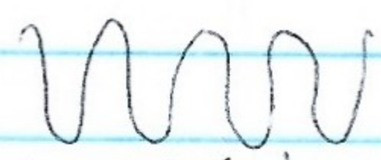
$y = \frac{(v_0 \sin\theta)^2}{2(10)} = \frac{(200 \cdot \frac{1}{2})^2}{20} = 500$ (c)

-1

11) $v(t) = 6t^2$

$x(t) = 2t^3 \big|_{t=2} = 2 \cdot 8 = 16$ (b) ✓

12) (~~a~~) e 13) $J = F\Delta t = \Delta P$



$\Delta y = v_{0y} t + \frac{1}{2} g t^2 \quad t = \sqrt{\frac{2h}{g}} = \sqrt{\frac{20}{10}} = \sqrt{2}$

time to fall T = down + up (~~b~~) d

14) $a(2) = t\big|_{t=2} = 2$ (a) ✓

15) $\int_0^6 4 + \frac{1}{2}t^2\,dt = \left(4t + \frac{1}{6}t^3\right)_0^6$

$= 24 + 36 = 60$ (e) ✓

16) $h_0 = L - L\cos\theta$

$mgL(1 - \cos 60) = \frac{1}{2} m v^2$

$gL(1 - \frac{1}{2}) = \frac{1}{2} v^2 \quad v = \sqrt{gL}$ (a) ✓

17) $\Delta KE = \Delta PE + W_{ext}$ (a) ✓

18) (b) ✓ 19) $K = \frac{1}{2} k x^2$ (c) ✓

20) $v \uparrow \; L =$ (d) ✓

21) $g = \frac{GM}{r^2} \quad \frac{G \cdot 4M}{(2R_e)^2}$ (c) ✓

22) $a_1 = \frac{GM}{R_1^2} \quad a_2 = \frac{GM}{(2R_1)^2}$

$a_2 = \frac{1}{4} a_1$ (e) ✓

23) $mgh = \frac{1}{2} I\omega^2 + \frac{1}{2} M v^2 = Mgh$ ~~$+ U_g$~~

$\frac{1}{2} \cdot \frac{2}{5} M R^2 \cdot \frac{v^2}{R^2} + \frac{1}{2} M v^2 = Mgh$

$\frac{1}{5} v^2 + \frac{1}{2} v^2 = gh \quad h = \frac{7v^2}{10g}$ (d) ✓

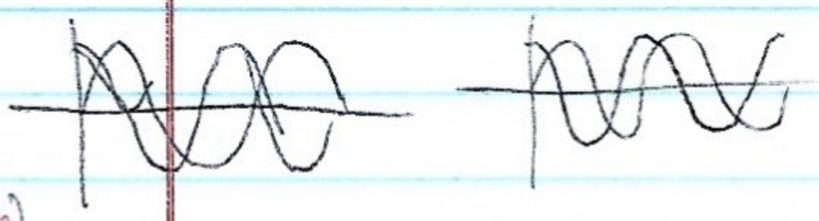
24) (c) ✓ 25) (d) ✓ 26) $3t = 2\pi$

$t = \frac{2\pi}{3}$ (c) ✓

-2

E: $\frac{28}{35} \to \frac{36}{45}$

1988 MC

27) ? 

(A) b

28) $g = \frac{GM}{r^2} = \frac{(6.67\times10^{-11})(M_E)}{r^2}$ (d) ✓

29) $a = \frac{\Sigma F}{m} = \frac{\Sigma F = ma}{}$ $\Sigma F = ma = (2)(\frac{20}{5})$ $= 8$ (a) ✓

30) $T = 2\pi\sqrt{\frac{m}{k}}$ (B) a Same d Same

31) (C) ✓ $\cos 60 = \lambda_2$

32) $W = \int F\,dr$ $F = \frac{dW}{dr} = 12x - 4\Big|_{x=3}$ $= 36 - 4 = 32$ (A) b

33) $x = \bar{v}t$ $y = v_0 t + \frac{1}{2}at^2$ $t = \sqrt{\frac{2y}{g}} = \sqrt{\frac{90}{10}} = 3$

$\bar{v} = \frac{20}{3} = 10$ (b) ✓

34) $T = 2\pi\sqrt{\frac{m}{k}}$ k↑ T↓ (c) ✓

35) $g = \frac{GM}{(2R)^2} = \frac{v^2}{R}$ $\frac{GM}{4R^2} = \frac{v^2}{R}$ $v = \frac{1}{2}v_0$ (A) b

-4

mech: 5)(c) 2)(e) 3)(d)

27) b 30) a) 32) b) 35) b

36) $F = \frac{kqq}{R^2}$ $\frac{kq_1q_2}{(2d)^2}$ (A) e

37) (e) ✓

38) (d) ✓ 39) (e) ✓

$F = qE$

40) $W = \int F\cdot dr = qEd = (3e-8)(4e4)(\frac{1}{2})$ $= 6e-4$ (a) ✓

41) (A) d 42) ✗ ✗ (e) ✓

43) (d) ✓ 44) (d) ✓ 45) $qvB = qE$ $B = \frac{E}{v}$ (a) ✓

46) (b) ✓ 47) (h) ✓ 48) (c) ✓

49) $C_1 = \frac{k\varepsilon_0 S^2}{d}$ $C_2 = \frac{k\varepsilon_0 \cdot 4S^2}{2d}$

$C_2 = 2C_1$ (b) ✓

50) (e) ✓ 51) (B) e 52) (e) ✓

53) (b) ✓ 54) 2V $R = \frac{V}{I} = \frac{2}{\frac{1}{2}} = 4$ (c) ✓

55) DB (X) B_{ind} (·) I_{ind} CCW

$I = \frac{1}{R}\frac{d\Phi}{dt} = \frac{(0.5)^2}{4(10+2\Omega)}\left(\frac{0.4}{2}\right)$

$= 5A$ (b) ✓

56) $E_{system} = 0$ (a) ✓ 57) (d) ✓

58) $V = \frac{[H]\cdot[A]}{[s]}$ $V = [A][\Omega]$

$[A][\Omega] = \frac{[H][A]}{[s]}$ $\frac{[H]}{[\Omega]} = [s]$ ✓

-3

$M: \frac{30}{45}$

1988 FR M

59) $qvB = \frac{mv^2}{r}$ $r = \frac{m}{qB}$ (b) ✓
24

60) ? (d) a 61) (c) ✓
25 26

62) ↓ B ↑ B ind ↑ I ind
27

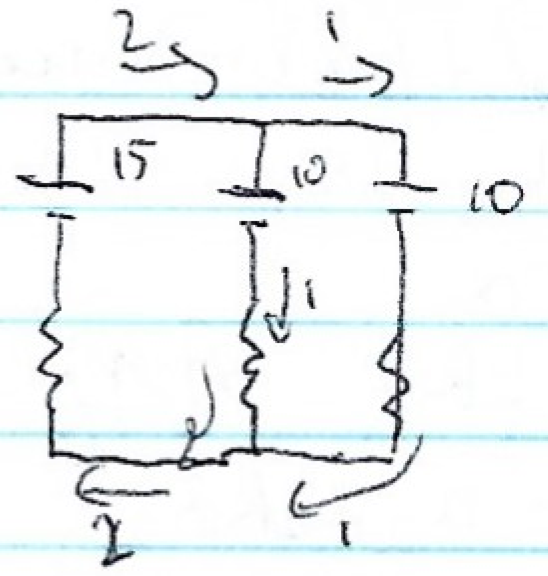
x → y (a) ✓

63) (c) ✓ 64) attraction ← (b) ✓
27 28

65) $F = \frac{\mu_0 I_1 I_2}{2\pi r}$ $\frac{4}{2}$ (d) ✓
30

66) $\frac{kQ}{r}$ (b) ✓
31

67) (a) b 68)
32 33



$10 - V_2 = 8$ (b) d

69) ⇄ ⟵⟶ ⟶ (c) ✓
34

70) (a) b
35

−4

G: 36) e 51) e 41) d
60) a 68) d 70) b 67) b

a) $\frac{mv^2}{r} = N\sin\theta$

$N\cos\theta = mg$

$N = \frac{mg}{\cos\theta}$

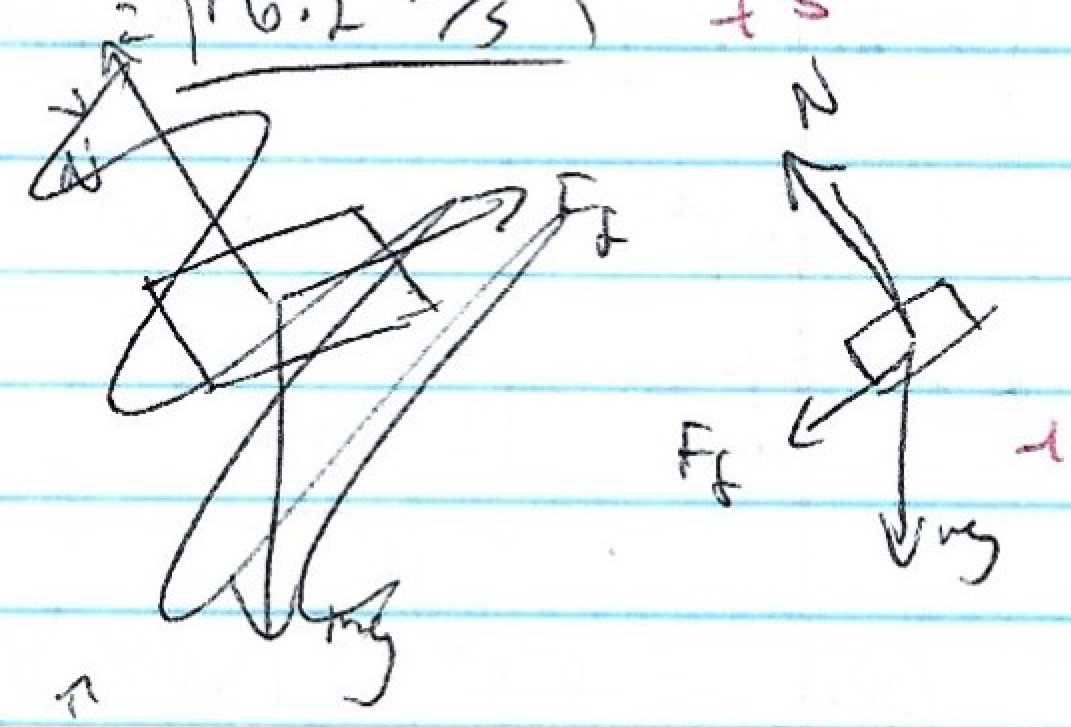
$\frac{mv^2}{r} = mg\tan\theta$

$v = \sqrt{rg\tan\theta}$

$= \sqrt{(100m)(9.8 m/s^2)\tan(15^\circ)}$

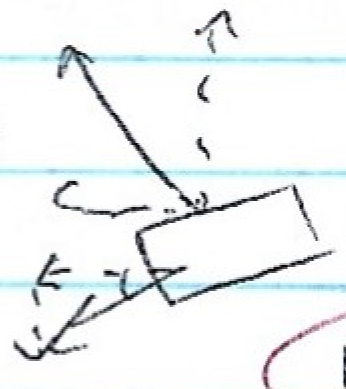
$= 16.2\ m/s$ +5

b)



+4

c)



$F_c = N\sin\theta + F_f\cos\theta = \frac{mv^2}{r}$ +1

$mg - N\cos\theta - F_f\sin\theta = 0$! ~

$N\cos\theta + F_f\sin\theta = mg$

$N\cos\theta + \mu N\sin\theta = mg$

$N = \frac{mg}{(\cos\theta + \mu\sin\theta)}$ $\frac{mv^2}{r} = N(\sin\theta + \mu\cos\theta)$

$\frac{mv^2}{r} = mg\left(\frac{\sin\theta + \mu\cos\theta}{\cos\theta + \mu\sin\theta}\right)$

$\frac{v^2}{r}\cos\theta + \frac{v^2}{r}\mu\sin\theta = g\sin\theta + \mu g\cos\theta$

$\mu\left(g\cos\theta - \frac{v^2}{r}\sin\theta\right) = \frac{v^2}{r}\cos\theta - g\sin\theta$

$\mu = \left(\frac{\frac{v^2}{r}\cos\theta - g\sin\theta}{g\cos\theta - \frac{v^2}{r}\sin\theta}\right)$ (−4)

−4

1) c) cont'd

$$\mu = \frac{\left(\frac{(25\ m/s)^2}{100\ m}\cos 15 - (9.8\ m/s^2)\sin 15\right)}{\left((9.8\ m/s^2)\cos 15 - \frac{(25\ m/s)^2}{100\ m}\sin 15\right)}$$

$$= \boxed{0.45} \quad -1$$

2) a) $\frac{1}{2}mv^2 = \frac{1}{2}kx^2 + \frac{1}{2}mv_f^2$

$$W_s = \int_0^{0.10\,m} F\cdot dr = \frac{1}{2}kx^2 = (0.10\ m)(20\ N)\left(\tfrac{1}{2}\right)$$

$$k(0.10\ m)^2 = (0.10\ m)(20\ N)$$

$$k = \frac{20\ N}{0.10\ m} = \boxed{200\ N/m} \quad +3$$

b) $\Delta KE = \Delta PE_s = \frac{1}{2}kx^2 = \frac{1}{2}(200\ N/m)(0.10\ m)^2$

$$= \boxed{1.0\ J} \quad +2$$

c) $\Delta KE = W_s = \int_{0.10}^{0.15} F\cdot dr$

$$= (0.05\ m)(10\ N) + \frac{1}{2}(0.05\ m)(40\ N)$$

$$= \boxed{2.0\ J} \quad +3$$

d) $\frac{1}{2}mv_0^2 = \Delta PE_{s1} + \Delta PE_{s2} = 3.0\ J$

$$v_0 = \sqrt{\frac{2E}{m}} = \sqrt{\frac{2(3.0\ J)}{5\ kg}}$$

$$= \boxed{1.10\ m/s} \quad +3$$

-1

e) Springs in parallel → k is addition.

$$W_s = \int_{0.10}^{0.15} F\cdot dr = 2.0\ J = \frac{1}{2}(k_1+k_2)x^2$$

$$k_1 + k_2 = \frac{2(2.0\ J)}{(0.05\ m)^2} = 1600\ N/m$$

$$k_2 = 1600\ N/m - 200\ N/m = \boxed{1400\ N/m} \quad -3$$

3) a) $I_1 = \frac{1}{2}MR^2 \quad I_2 = \frac{1}{2}M(2R)^2$

$$= \boxed{4I} \quad +3$$

b) Since they are coupled, the tangential speeds are the same.

$a = r\alpha$

$a_2 = R\alpha \quad \omega = v/R$

$R\alpha_1 = a_2 = 2R\alpha_2$

$$\boxed{\alpha_2 = \frac{1}{2}\alpha} \quad +2$$

c) $\Sigma\tau = I\alpha = RT \quad \boxed{T = \frac{I\alpha}{R}}$

$\Sigma\tau = I\alpha = RT \quad \boxed{T = I\alpha}$

$\Sigma\tau = 5I\alpha = RT$

$= (I_{total})\alpha = RT$

c) $\boxed{T = \frac{5I\alpha}{R}}$ -4

d) $\Sigma\tau = I_{total}\alpha = \boxed{5I\alpha}$ -3

e) $KE_r = \frac{1}{2}I\omega^2 \quad \omega = \omega_0 + \alpha t$

$$= \boxed{\frac{1}{2}I\alpha^2 t^2} \quad +3$$

-10

E: 22/45

1988 FRE

1) a) $V = \frac{kQ}{a}$ $\quad Q = \frac{Va}{k} = 4\pi\varepsilon_0 Va$ +3

b) $\int E\,dA = \frac{Q_{in}}{\varepsilon_0}$ $\quad Q_{in} = Q = 4\pi\varepsilon_0 Va$

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

$\boxed{E = \frac{Va}{r^2}}$ +4

c) $V_b = V_{ground} = 0$

~~$V_a = \Delta V = V$~~

~~d) $V = \frac{Q}{C}$ $\quad C = \frac{Q}{V} = \frac{4\pi\varepsilon_0 Va}{V}$~~

$= \boxed{4\pi\varepsilon_0 a}$

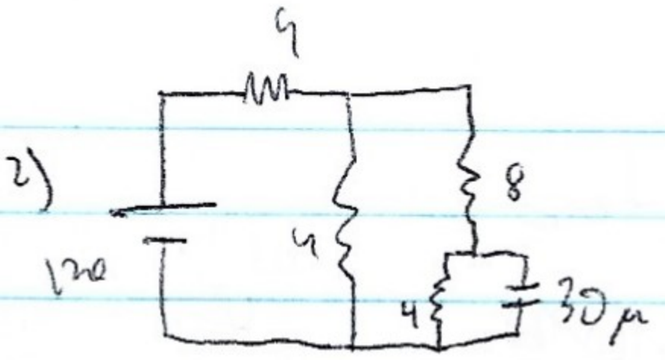
$V = -\int_0^b E \cdot dr$

$= -\int_0^b \frac{Va}{r^2} dr = \frac{Va}{b} = \boxed{V \cdot \frac{a}{b}}$ -5

d) $C = \frac{Q}{V} = \frac{4\pi\varepsilon_0 Va}{V \cdot \frac{a}{b}} = \boxed{4\pi\varepsilon_0 b}$ -3

-8

2)



a) $I = \frac{V}{R_{eq}} = \frac{120V}{(9V + (\frac{1}{4} + \frac{1}{12})^{-1})} = \boxed{10A}$ +4

b) $\Delta V_4 = IR = 10A \cdot 4\Omega = 40V$

$\Delta V_{(8,4)} = 120 - 40V = 80V$

8Ω resistor dissipates twice the voltage as the

4Ω resistor → 20V

$I = \frac{V}{R} = \frac{20V}{8\Omega} = \boxed{2.5A}$ -3

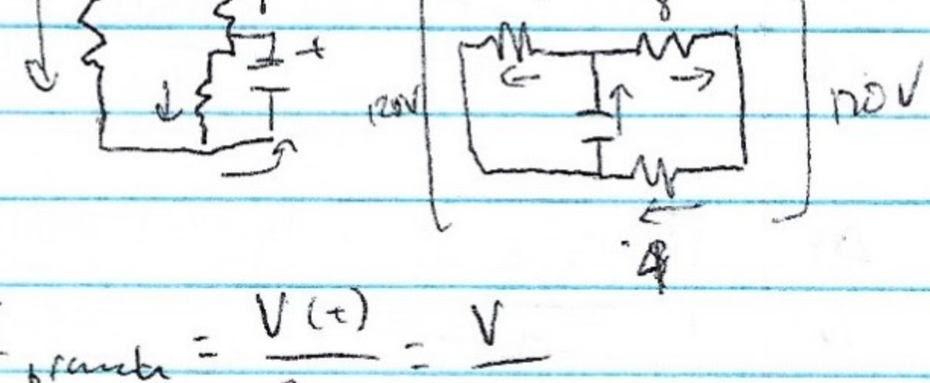
c) $V_c = \mathcal{E} = \boxed{120V}$ -2

d) $U = \frac{1}{2} CV^2 = \frac{1}{2}(70\mu F)(120V)^2$

+1

$= \boxed{0.2163}$ -1

e)



$I_{branch} = \frac{V(t)}{R_{eq}} = \frac{V}{12\Omega}$

$P = I^2 R = \frac{V^2}{(12\Omega)^2} \cdot 8\Omega$

$E = \int_0^\infty P \cdot dt = \frac{8}{144} \int V^2 dt$

$V(t) = ?$ -4

-7

3) a) $\int B \cdot d\ell = \mu_0 I_{enc}$ +1

$= B \cdot 2h = \mu_0 n i h$

$n \rightarrow \frac{\text{turns}}{\text{length}}$

$nh = \text{turns}$

$\boxed{B = \frac{1}{2}\mu_0 n i}$ $\quad B = \mu_0 n I$? (-3)

b) $\frac{B}{S}$ $\quad \Delta B \leftarrow$ $\quad B_{ind} \rightarrow$

I_{ind} ↺

$\mathcal{E} = -N\frac{d\Phi}{dt} = -\pi r_2^2 \frac{dB}{dt} = -\pi r_2^2 \left(\frac{0-i}{t}\right)\cdot \mu_0 n$

$= \boxed{\frac{\pi r_2^2 i \mu_0 n}{t}}$ +4

c) $E_{ind} = -\frac{dV}{dr}$ $\quad \mathcal{E} = \frac{\Delta V}{\Delta r} = \boxed{\frac{\pi r_2 i \mu_0 n}{2t}}$ (-3)

d) $B \rightarrow \Delta B \leftarrow B_{ind} \rightarrow$ ↺ I_{ind}

$\mathcal{E} = -\frac{d\Phi}{dt} = -\pi r_3^2 \frac{dB}{dt} = \boxed{\frac{\pi r_3^2 \mu_0 n i}{t}}$ +2

e) $E = \frac{\Delta V}{\Delta r} = \boxed{\frac{\pi r_3 \mu_0 n i}{t}}$ (-2)

-8

Mech:

1) c) $N\cos\theta - F_f \sin\theta - mg = 0$

$\mu = \frac{v^2\cos\theta - g r \sin\theta}{v^2 \sin\theta - g r \cos\theta} = 0.32$

2) e) $k_2 = 6000\ N/m$

3) c) $T = \frac{I\alpha}{R}$

d) $\tau = 2I\alpha$

E: 1) c) $\Delta U = V\frac{b-a}{b}$

d) $C = \frac{1}{k}\cdot\frac{ab}{a-b}$

2) c) $V = 10V$

d) $U = 150\ \mu J$

e) $U = 250\ \mu J$

3) a) $B = \mu_0 n i$

d) $\mathcal{E} = \frac{\pi r_2 i \mu_0 n}{2t}$ $\quad E = \frac{\mu_0 n i r_2}{2t}$

e) $E = \frac{\mu_0 n i r_1^2}{2t r_3}$