Q 1 (1)

Q 2-4

$$1\ \frac{\text{miles}}{\text{hour}^2} = \frac{1\ \text{miles}}{\text{hours}^2}\left(\frac{1609\,m}{1\ \text{mile}}\right)\left(\frac{1\ \text{hour}}{3600\,s}\right)^2$$

$$= 1.24\times10^{-4}\ m/s^2$$

(2) $a = 1000 \times 1.24\times10^{-4} = 0.124\ m/s^2$

(3) $a = 500 \times 1.24\times10^{-4} = 0.0621\ m/s^2$

(4) $a = 2000 \times 1.24\times10^{-4} = 0.248\ m/s^2$

Q 5-7

$$a_{average} = \frac{V_f - V_i}{\Delta t}$$

(5) $|a_{average}| = \left|\frac{(-10)-(10)}{10}\right| = 2.00\ m/s^2$

(6) $|a_{averge}| = \left|\frac{(-20)-(20)}{20}\right| = 2.00\ m/s^2$

(7) $|a_{average}| = \left|\frac{(-20)-(20)}{10}\right| = 4.00\ m/s^2$

Q 8 (1)

Q 9 (1)

Q 10 (1)

Q 11-13

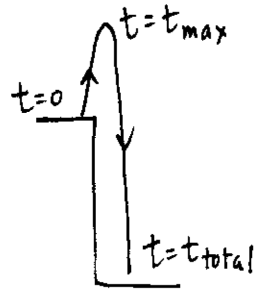
$$V_{average} = \frac{\Delta x}{\Delta t}$$

(11) $V_{average} = \frac{(20)-(-10)}{3} = 10\ m/s$

(12) $V_{average} = \frac{(20)-(-10)}{15} = 2\ m/s$

(13) $V_{average} = \frac{(20)-(-10)}{30} = 1\ m/s$

Q 14-16



At max height, $\underset{0}{V_f} = V_i + at$

$0 = V_i - g t_{max} \Rightarrow t_{max} = \frac{V_i}{g}$

Time from highest point to bottom $= t_{total} - t_{max}$

Distance from highest point to bottom

$= \underbrace{V}_{\to 0 \text{ at highest point}}(t_{total} - t_{max})^2 + \frac{1}{2} a (t_{total} - t_{max})^2 = \frac{1}{2} g (t_{total} - t_{max})^2$

$= \frac{1}{2} g (t_{total} - \frac{V_i}{g})^2$

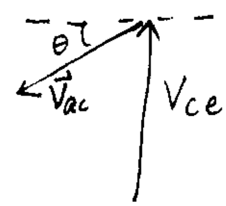
(14) $d = \frac{1}{2}(9.8)(10 - \frac{20}{9.8})^2 = 310\,m$

(15) $d = \frac{1}{2}(9.8)(12 - \frac{25}{9.8})^2 = 437\,m$

(16) $d = \frac{1}{2}(9.8)(8 - \frac{30}{9.8})^2 = 120\,m$

Q 17-19

a = air, c = cyclist, e = earth



$\vec{V}_{ac} = \vec{V}_{ae} - \vec{V}_{ce}$

$\vec{V}_{ae} = \vec{V}_{ac} + \vec{V}_{ce}$

$V_{ae,x} = V_{ac,x} + \overset{0}{V_{ce,x}} = -|V_{ac}|\cos\theta$

$V_{ae,y} = V_{ac,y} + V_{ce,y} = -|V_{ac}|\sin\theta + |V_{ce}|$

speed $= \sqrt{(|V_{ac}|\cos\theta)^2 + (-|V_{ac}|\sin\theta + |V_{ce}|)^2}$

angle $= \tan^{-1} \frac{-|V_{ac}|\sin\theta + |V_{ce}|}{+|V_{ac}|\cos\theta}$

(17) $|V_{ac}| = 1$, $\theta = 30°$, $|V_{ce}| = 2$, ans = 60° N of W, 1.73 m/s

(18) $|V_{ac}| = 2$, $\theta = 30°$, $|V_{ce}| = 3$, ans = 49° N of W, 2.65 m/s

(19) $|V_{ac}| = 3$, $\theta = 30°$, $|V_{ce}| = 2$, ans = 11° N of W, 2.65 m/s

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Q 20-22

$S = \underset{\to 0}{V_0} t + \frac{1}{2} a t^2$, At t_1, $S_1 = \frac{1}{2} a t_1^2$

At t_2, $S_2 = \frac{1}{2} a t_2^2$

$\Delta S = S_2 - S_1 = \frac{1}{2} a (t_2^2 - t_1^2)$

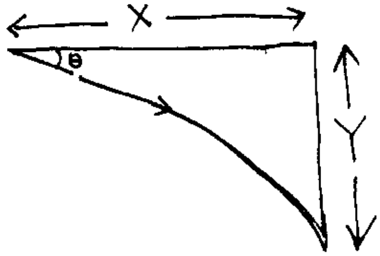
$a = \frac{2(\Delta S)}{t_2^2 - t_1^2}$

(20) $a = \frac{2(26)}{7^2 - 6^2} = 4\,m/s^2$

(21) $a = \frac{2(22.5)}{8^2 - 7^2} = 3\,m/s^2$

(22) $a = \frac{2(18)}{5^2 - 4^2} = 4\,m/s^2$

Q 23-25



$$X = V_x t \Rightarrow t = \frac{X}{V_x} = \frac{X}{V\cos\theta}$$

$$y = v_y t + \frac{1}{2} a t^2$$

$$\Rightarrow -Y = (-V\sin\theta)\left(\frac{X}{V\cos\theta}\right) - \frac{1}{2} g \left(\frac{X}{V\cos\theta}\right)^2$$

$$= -X\tan\theta - \frac{1}{2} g \left(\frac{X}{V\cos\theta}\right)^2$$

$$\frac{1}{2} g \left(\frac{X}{V\cos\theta}\right)^2 = Y - X\tan\theta$$

$$V = \sqrt{\frac{\frac{1}{2} g X^2/\cos^2\theta}{Y - X\tan\theta}} = \frac{X}{\cos\theta}\sqrt{\frac{g}{2(Y - X\tan\theta)}}$$

(23) $X = 2$, $Y = 0.75$, $\theta = 5°$, $V = 5.86$ m/s

(24) $X = 1.25$, $Y = 0.75$, $\theta = 5°$, $V = 3.47$ m/s

(25) $X = 2.5$, $Y = 0.9$, $\theta = 5°$, $V = 6.73$ m/s

Q 26-28

$$V_f^2 - \underset{\uparrow 0}{V_0^2} = 2as$$

$$V_1^2 = 2as_1 \Rightarrow a = \frac{V_1^2}{2s_1}$$

$$V_2^2 = 2as_2$$

$$s_2 = \frac{V_2^2}{2a} = \frac{V_2^2}{2\left(\frac{V_1^2}{2s_1}\right)} = s_1\left(\frac{V_2}{V_1}\right)^2$$

(26) $s_2 = 8\left(\frac{10}{5}\right)^2 = 32$ m

(27) $s_2 = 10\left(\frac{8}{4}\right)^2 = 40$ m

(28) $s_2 = 12\left(\frac{3}{6}\right)^2 = 3$ m

PROBLEMS 29 - 31

① FIND ACCELERATION: $2ax = v^2 - v_0^2 \Rightarrow a = \dfrac{v^2 - v_0^2}{2x}$

BUT $v = 0$, SO $a = \dfrac{-v_0^2}{2x}$

② FIND FORCE: $F = ma \Rightarrow F = -\dfrac{m v_0^2}{2x}$

BUT WE WANT MAGNITUDE, SO $\boxed{|F| = \dfrac{m v_0^2}{2x}}$

③ CONVERT v_0 FROM km/hr TO m/s

$$v\left(\frac{m}{s}\right) = v\left(\frac{km}{hr}\right) \cdot \frac{1000\ m}{km} \cdot \frac{1\ hr}{3600\ s} = \frac{v(km/hr)}{3.6}$$

29. $v_0 = \dfrac{90\ km}{hr} = 25\ m/s$

$$F = \frac{(1500\ kg)(25\ m/s)^2}{150\ m} = \boxed{3130\ N}$$

SIMILAR FOR 30, 31

PROBLEMS 32 - 34

① USE ENERGY TO FIND VELOCITY OF CHILD WHEN SHE HITS THE WATER (WATER LEVEL AS REFERENC

$$PE_i + KE_i = PE_f + KE_f \Rightarrow mgh + 0 = 0 + \tfrac{1}{2}mv^2$$

$$\Rightarrow v = \sqrt{2gh}$$

② FIND ACCELERATION: $\cancel{v_f}^{\,0} = v - at \Rightarrow a = -\dfrac{v}{t}$

③ FIND FORCE: $F = ma = +\dfrac{mv}{t} = \dfrac{m\sqrt{2gy}}{t}$

FORCE EXERTED BY WATER

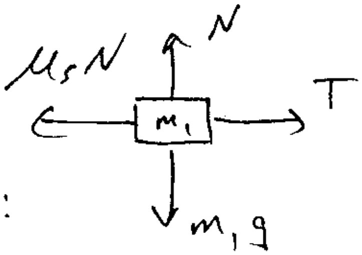
32. $$F = \frac{(30\ kg)\sqrt{2(9.8\ m/s^2)(2m)}}{0.3\ s} = \boxed{626\ N}$$

SIMILAR FOR 33, 34

PROBLEM 35 – 37

FREE-BODY DIAGRAMS:

m_1:



m_2:

FROM m_2 DIAGRAM

$$T = m_2 g$$

FROM m_1 DIAGRAM

$$N = m_1 g$$

$$\Rightarrow \quad T - \mu_s N \le 0 \Rightarrow m_2 g - \mu_s m_1 g \le 0 \Rightarrow \boxed{m_2 \le \mu_s m_1}$$

35. $m_2 \le (0.3)(5\text{ kg})$

$$\boxed{m_2 \le 1.5\text{ kg}}$$

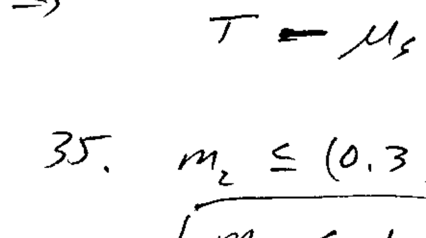
SIMILAR FOR 36, 37

PROBLEMS 38 – 40

① USE ENERGY TO FIND SPEED OF BOY LEAVING SLIDE

$$PE_i + KE_i = PE_f + KE_f \Rightarrow mgH + 0 = mgh + \tfrac{1}{2}mv^2$$

$$\Rightarrow v = \sqrt{2g(H-h)}$$



② FIND d FROM KINEMATIC EQNS

$$d = vt$$

③ FIND t FROM KINEMATIC EQUATIONS

$$h = \tfrac{1}{2} g t^2 \Rightarrow t = \sqrt{\frac{2h}{g}}$$

④ SUBSTITUTE EXPRESSIONS FOR v & t

$$d = vt = \sqrt{2g(H-h)}\sqrt{\frac{2h}{g}} = \sqrt{4h(H-h)}$$

38. $d = \sqrt{4(0.4\text{m})(3.0\text{m} - 0.4\text{m})}$

$$= \boxed{1.74\text{ m}}$$

SIMILAR FOR 39, 40

PROBLEMS 41-43

'WEIGH' MEANS FORCE DUE TO GRAVITY, F_{GRAV}

$$\Rightarrow \quad F_{GRAV} = G \frac{m_{OBJECT}\, m_{EARTH}}{r^2}$$

SOLVE FOR m_{OBJECT}: $\quad m_{OBJECT} = \dfrac{F_{GRAV}\, r^2}{G\, m_{EARTH}}$

NOTE: CONVERT r FROM km TO m

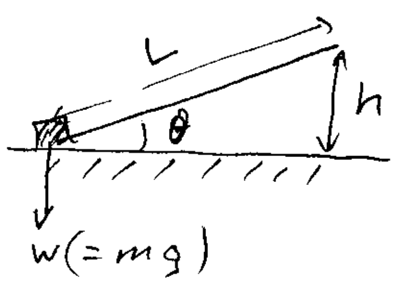
41. $$m_{OBJECT} = \frac{(300\text{ N})(30000\text{ km})(1000\ \frac{\text{m}}{\text{km}})}{(6.67\times10^{-11}\ \frac{\text{Nm}^2}{\text{kg}^2})(5.98\times10^{24}\text{ kg})}$$

$$= \boxed{667\text{ kg}}$$

SIMILAR FOR 42, 43

44. NEWTON'S 3RD LAW TELLS US THAT THE FORCES MUST BE EQUAL

PROBLEMS 45-47



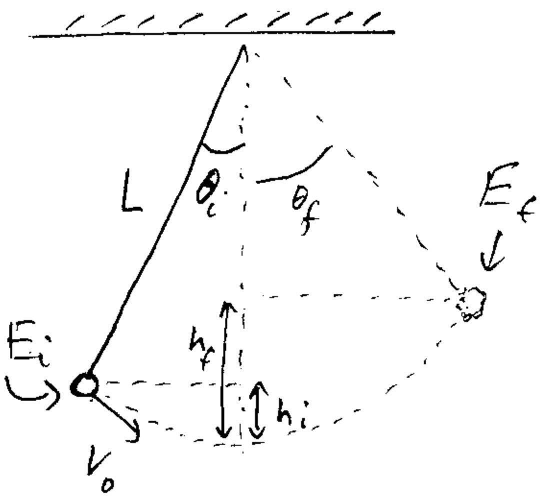
THE CHANGE IN POTENTIAL ENERGY IS SIMPLY $\Delta PE = mgh = wh$

$h = L\sin\theta \Rightarrow \boxed{\Delta PE = wL\sin\theta}$

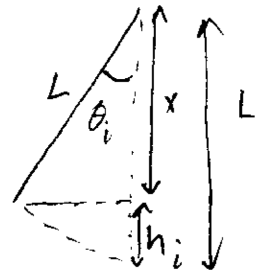
45. $\Delta PE = (40\text{ N})(5\text{ m})(\sin 37^\circ) = \boxed{120\text{ J}}$

SIMILAR FOR 46 - 47

PROBLEM 48-50



① FIND h_i, h_f



$x = L\cos\theta_i$

$h_i + x = L$

$\Rightarrow h_i = L - x = L - L\cos\theta_i$

$h_i = L(1-\cos\theta_i)$

SIMILARLY, $h_f = L(1-\cos\theta_f)$

② NOW USE CONSERVATION OF ENERGY

$$E_i = E_f \Rightarrow PE_i + KE_i = PE_f + KE_f$$

$$\cancel{m}gh_i + \tfrac{1}{2}\cancel{m}v_0^2 = \cancel{m}gh_f + 0$$

$$\Rightarrow \quad h_f = h_i + \frac{v_0^2}{2g}$$

③ SUBSTITUTE IN h_f ; h_i

$$L(1-\cos\theta_f) = L(1-\cos\theta_i) + \frac{v_0^2}{2g}$$

SOLVE FOR $\cos\theta_f$: $(1-\cos\theta_f) = (1-\cos\theta_i) + \frac{v_0^2}{2gL}$

$$\Rightarrow -\cos\theta_f = -\cos\theta_i + \frac{v_0^2}{2gL}$$

$$\Rightarrow \boxed{\cos\theta_f = \cos\theta_i - \frac{v_0^2}{2gL}}$$

48. $\cos\theta_f = \cos 25^\circ - \frac{(1.2\ m/s)^2}{2(9.8\ m/s^2)(2\ m)} = 0.91 - 0.04$

$= 0.87$

$\theta_f = \cos^{-1}(0.87) = \boxed{30^\circ}$ SIMILAR FOR 49, 50

51. SINCE THE PLAYER IS ACCELERATING, HIS FEET MUST EXERT A FORCE GREATER THAN HIS WEIGHT