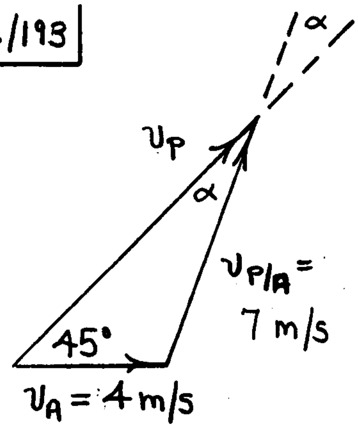
2/193



With P being the puck:

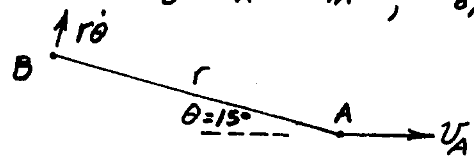
$\underline{v}_P = \underline{v}_A + \underline{v}_{P/A}$

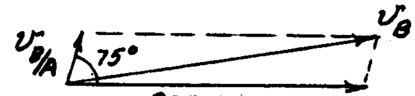
Law of sines :

$$\frac{\sin 45^\circ}{7} = \frac{\sin \alpha}{4}$$

$$\underline{\alpha = 23.8^\circ}$$

2/199 $\underline{v}_B = \underline{v}_A + \underline{v}_{B/A}$, $v_{B/A} = r\dot{\theta} = 60(\frac{5}{180}\pi) = 5.24$ m/s





$v_A = \frac{200}{3.6} = 55.6$ m/s

$v_B^2 = (5.24)^2 + (55.6)^2 + 2(5.24)(55.6)\cos 75° = 3264\ (m/s)^2$

$v_B = 57.1$ m/s or $v_B = 57.1(3.6) = \underline{206\ km/h}$

$\underline{a}_B = \underline{a}_A + \underline{a}_{B/A}$, $a_A = 0$, $a_{B/A} = r\dot{\theta}^2 = 60\left(\frac{5\pi}{180}\right)^2 = 0.457\ m/s^2$

Thus $a_B = a_{B/A} = \underline{0.457\ m/s^2}$ from B to A

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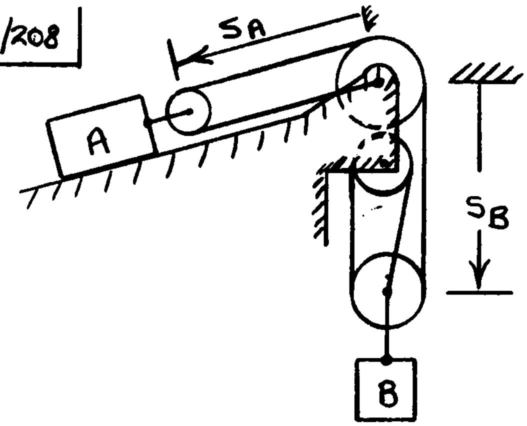


Cable length $L = 2s_A + 3s_B$ + constants

$0 = 2v_A + 3v_B$, $0 = 2a_A + 3a_B$

$v_A = -\frac{3}{2} v_B = -\frac{3}{2}(2) = \underline{-3 \text{ ft/sec}}$

$a_A = -\frac{3}{2} a_B = -\frac{3}{2}(-0.5) = \underline{+0.75 \text{ ft/sec}^2}$

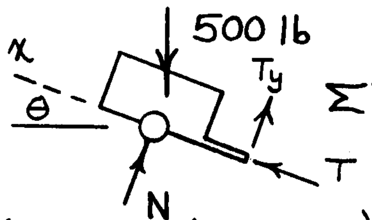
or $\begin{cases} v_A = 3 \text{ ft/sec up the incline} \\ \underline{a_A = 0.75 \text{ ft/sec}^2 \text{ down the incline}} \end{cases}$

3/10 $\overset{\nwarrow}{+}$ $v^2 - v_0^2 = 2a(s-s_0)$

$$0^2 - \left(5\,\frac{5280}{3600}\right)^2 = 2a(-4)$$

$$a = 6.72 \text{ ft/sec}^2$$

FBD of cart (treat as a particle):



(Static)

$\Sigma F_x = 0:\quad T_s - 500 \sin 18.43° = 0$

$T_s = 158.1$ lb

$\left(\theta = \tan^{-1}\frac{4}{12} = 18.43°\right)$

$$\Sigma F_x = ma_x:\quad T - 500 \sin 18.43° = \frac{500}{32.2}(6.72)$$

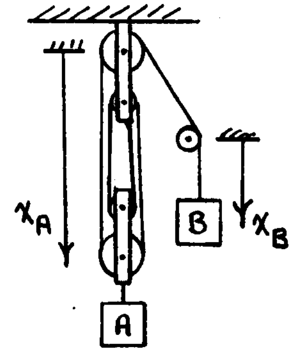
$$T = 262 \text{ lb}$$

Percent increase $\quad n = \dfrac{262-158.1}{158.1}(100\%)$

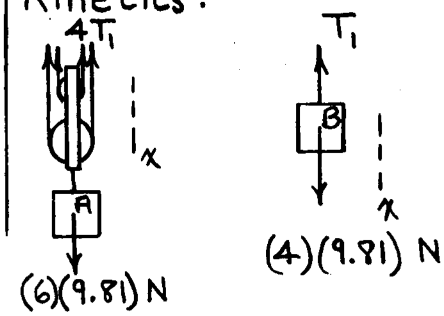
$$= \underline{66.0\%}$$

3/11 Kinematics: $4x_A + x_B = L_{rope} + \text{constant}$

$$\therefore \quad 4a_A + a_B = 0 \qquad (1)$$



Kinetics:



$$A: \ \Sigma F_x = ma_x: \ 6(9.81) - 4T_1 = 6a_A \qquad (2)$$

$$B: \ \Sigma F_x = ma_x: \ 4(9.81) - T_1 = 4a_B \qquad (3)$$

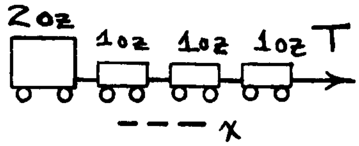
Solution of Eqs. (1) – (3):
$$\begin{cases} a_A = -1.401 \ \text{m/s}^2 \\ a_B = 5.61 \ \text{m/s}^2 \\ \underline{T_1 = 16.82 \ \text{N}} \end{cases}$$

Tension in cable above A

$T_2 = 4T_1 = \underline{67.3 \text{ N}}$

3/13 | Coupler 1 will fail first, because it must accelerate more mass than any other coupler.

Rear part of train:

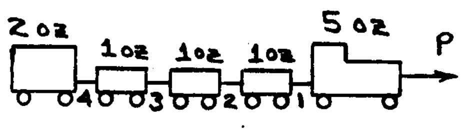


$$\Sigma F_x = ma_x$$

$$T = 0.2 = \left(\frac{5/16}{32.2}\right) a$$

$$a = 20.6 \text{ ft/sec}^2$$

Whole train:

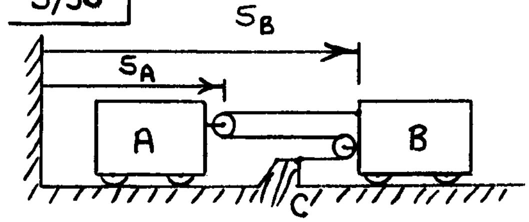


$$\Sigma F_x = ma_x$$

$$P = \left(\frac{10/16}{32.2}\right)(20.6)$$

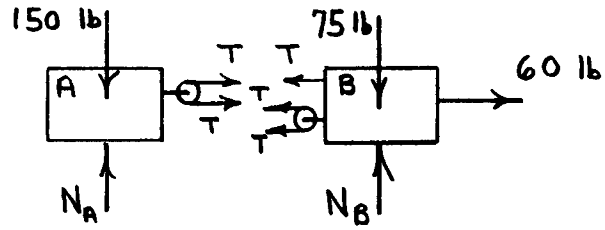
$$\underline{P = 0.4 \text{ lb}}$$

3/36



$$L = 2(s_B - s_A) + (s_B - s_C) + \text{constants}$$

$$\Rightarrow \quad 0 = 3a_B - 2a_A \qquad (1)$$



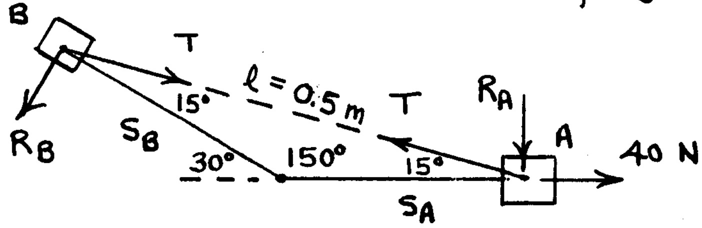
$\xrightarrow{+}$ $\Sigma F = ma$: (A) $2T = \dfrac{150}{32.2} a_A$ (2)

(B) $60 - 3T = \dfrac{75}{32.2} a_B$ (3)

Solve Eqs. (1)–(3):
$$\begin{cases} a_A = 7.03 \text{ ft/sec}^2 \\ a_B = 4.68 \text{ ft/sec}^2 \\ T = 16.36 \text{ lb} \end{cases}$$

3/44

$\sin 150° / l = \sin 15° / s_B$, $s_B = s_A = 0.259$ m



Law of cosines: $l^2 = s_A^2 + s_B^2 - 2 s_A s_B \cos 150°$

$$2l\dot{l} = 0 = 2 s_A v_A + 2 s_B v_B - 2\left(-\frac{\sqrt{3}}{2}\right)(s_A v_B + s_B v_A)$$

$$s_A v_A + s_B v_B + \frac{\sqrt{3}}{2}(s_A v_B + v_A s_B) = 0^*$$

With $s_A = s_B = 0.259$ m, $v_A = 0.4$ m/s : $v_B = -0.4$ m/s

Differentiate $*$: $v_A^2 + s_A a_A + v_B^2 + s_B a_B + \frac{\sqrt{3}}{2}(s_A a_B + v_A v_B + a_A s_B + v_A v_B) = 0$

Numbers: $0.483 a_A + 0.483 a_B + 0.0429 = 0$ (1)

Kinetics:

$\overset{+}{\nwarrow}$ $\Sigma F = m a_B$: $-T\cos 15° = 3 a_B$ (2)

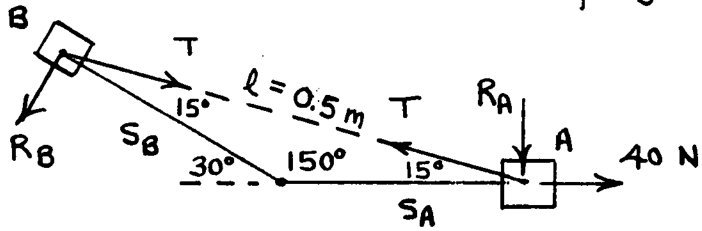
$\overset{+}{\rightarrow}$ $\Sigma F = m a_A$: $40 - T\cos 15° = 2 a_A$ (3)

Solution of Eqs. (1)-(3): $T = 25.0$ N

$a_A = 7.95$ m/s^2

$a_B = -8.04$ m/s^2

$\boxed{3/44}$ $\quad \sin 150° / l = \sin 15° / s_B$, $\quad s_B = s_A = 0.259$ m



Law of cosines: $l^2 = s_A^2 + s_B^2 - 2 s_A s_B \cos 150°$

$$2l\dot{l} = 0 = 2 s_A v_A + 2 s_B v_B - 2\left(-\frac{\sqrt{3}}{2}\right)(s_A v_B + s_B v_A)$$

$$s_A v_A + s_B v_B + \frac{\sqrt{3}}{2}(s_A v_B + v_A s_B) = 0 \; *$$

With $s_A = s_B = 0.259$ m, $v_A = 0.4$ m/s : $v_B = -0.4$ m/s

Differentiate $*$: $v_A^2 + s_A a_A + v_B^2 + s_B a_B + \frac{\sqrt{3}}{2}(s_A a_B + v_A v_B + a_A s_B + v_A v_B) = 0$

Numbers : $\quad 0.483 a_A + 0.483 a_B + 0.0429 = 0 \qquad (1)$

Kinetics :

$\overset{+}{\nwarrow} \Sigma F = m a_B$: $-T\cos 15° = 3 a_B \qquad (2)$

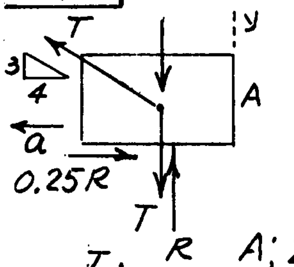
$\overset{+}{\rightarrow} \Sigma F = m a_A$: $40 - T\cos 15° = 2 a_A \qquad (3)$

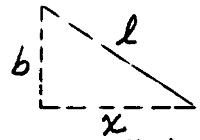
Solution of Eqs. (1)-(3) : $T = 25.0$ N

$a_A = 7.95$ m/s^2

$a_B = -8.04$ m/s^2

▶3/48





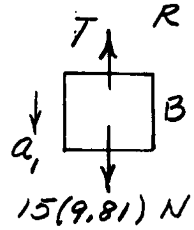
$a = -\ddot{x} \qquad a_1 = -\ddot{\ell}$

$\ell^2 = b^2 + x^2$

$\ell\dot{\ell} = 0 + x\dot{x}$

$\cancelto{0}{\dot{\ell}^2} + \ell\ddot{\ell} = \cancelto{0}{\dot{x}^2} + x\ddot{x}, \quad \ddot{\ell} = \frac{x}{\ell}\ddot{x}$

or $a_1 = \frac{4}{5}a$



$A;\ \Sigma F_y = 0;\ R + \frac{3}{5}T - 30(9.81) - T = 0$

$R = 0.4T + 294.3$

$\Sigma F_x = ma_x;\ 0.8T - 0.25(0.4T + 294.3) = 30a$

$B;\ \Sigma F_y = ma_y;\ 15(9.81) - T = 15(\frac{4}{5}a)$

solve simultaneously to get $\underline{T = 138.0\text{ N}}$

$\underline{a = 0.766\text{ m/s}^2}$