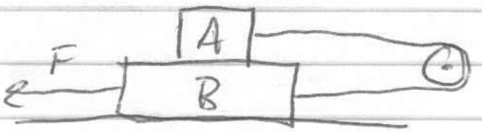
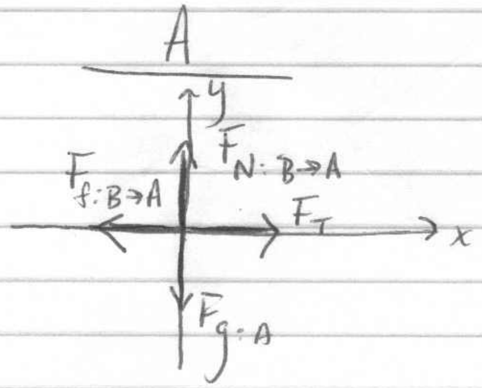
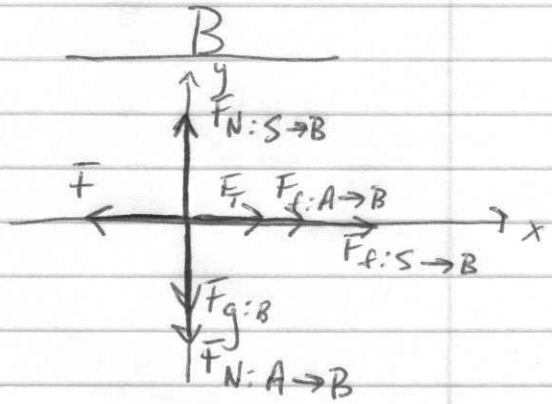
Solutions

1)



A: Block A B: Block B
S: Surface - The table





a)
$$\sum F_{x_A}^{A} = F_T - F_{f:B\to A} = \emptyset$$
$$\sum F_{y_B}^{A} = F_{N:B\to A} - F_{g:A} = \emptyset$$
$$\sum F_x^{B} = F_T + F_{f:A\to B} + F_{f:S\to B} - F = \emptyset$$
$$\sum F_y^{B} = F_{N:S\to B} - F_{g:B} - F_{N:A\to B} = \emptyset$$

$$\Rightarrow \quad F_T = F_{f:B\to A}, \quad F_{N:B\to A} = F_{g:A}$$

and using Newton's 3rd Law, where $|F_{f:B\to A}| = |F_{f:A\to B}|$
and $|F_{N:B\to A}| = |F_{N:A\to B}|$

$$\Rightarrow \quad F_{N:S\to B} = F_{g:B} + F_{g:A}$$

which finally brings us to
$$F = F_T + F_{f:A\to B} + F_{f:S\to B}$$
$$F = F_{f:B\to A} + F_{f:A\to B} + F_{f:S\to B}$$
$$F = 2F_{f:A\to B} + F_{f:S\to B}$$
$$F = 2\mu_s F_{N:A\to B} + \mu_s F_{N:S\to B}$$
$$F = 2\mu_s m_A g + \mu_s (m_A g + m_B g)$$

$$\boxed{F = 100\ \text{N}}$$

Solutions

b) Increasing F to 103 N, and using kinetic friction instead of static (same free body diagrams)

$$\sum F_x^A = F_T - F_{f:B\to A} = m_A a \leftarrow \text{Opposite directions!}$$
$$\sum F_y^A = F_{N:B\to A} - F_{g:A} = \emptyset$$
$$\sum F_x^B = F_T + F_{f:A\to B} + F_{f:S\to B} - F = -m_B a$$
$$\sum F_y^B = F_{N:S\to B} - F_{g:B} - F_{N:A\to B} = \emptyset$$

$$\Rightarrow F_T = m_A a + F_{f:B\to A}, \quad F_{N:B\to A} = F_{g:A}$$
$$F_{N:S\to B} = F_{g:A} + F_{g:B}$$

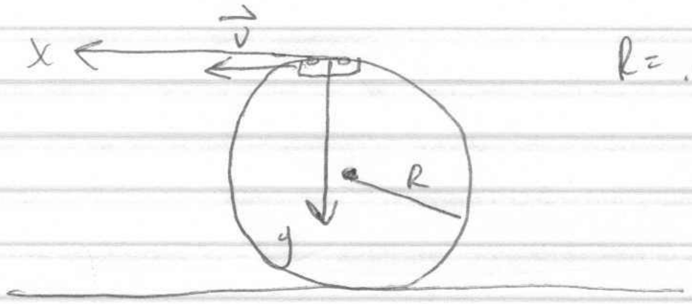
Again, notice Newton's 3rd Law pairs

$$F_T + F_{f:A\to B} + F_{f:S\to B} - F = -m_B a$$
$$m_A a + F_{f:B\to A} + F_{f:A\to B} + F_{f:S\to B} - F = -m_B a$$
$$2F_{f:A\to B} + F_{f:S\to B} - F = -m_B a - m_A a$$
$$2\mu_k F_{N:A\to B} + \mu_k(m_A g + m_B g) - F = -m_B a - m_A a$$
$$2\mu_k m_A g + \mu_k(m_A g + m_B g) - F = -(m_B + m_A) a$$
$$-a = \frac{2\mu_k m_A g + \mu_k(m_A g + m_B g) - F}{(m_A + m_B)}$$
$$a = \frac{F - 2\mu_k m_A g - \mu_k(m_A g + m_B g)}{(m_A + m_B)}$$

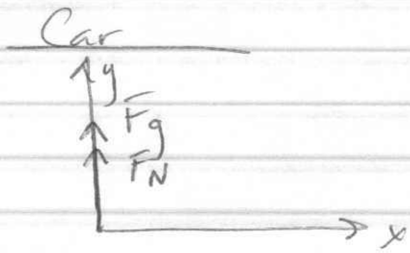
$$\boxed{a = 3.3 \text{ m/s}^2}$$

Solutions

2)



$R = .08\,m \qquad m_c = .15\ kg$



$$\sum F_y = F_N + F_g = m_c a_{rad}$$

If the car just barely stays on the track (minimum speed) then the normal force is 0.

$$F_g = m_c a_{rad}$$
$$m_c g = m_c a_{rad}$$
$$g = v^2/R$$
$$\sqrt{Rg} = v$$

$$\boxed{v = .89\ m/s}$$