MCG 2108 - Fall 2015

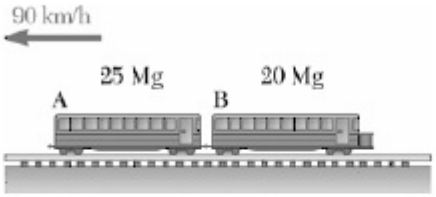
DGD Week 3 (28th Sept and 1st October 2015)

Chapter 12 (Part 1)

Question **12.32** will be solved by the TA

Question **12.12, 12.17** will be assigned to the students

PROBLEM 12.12

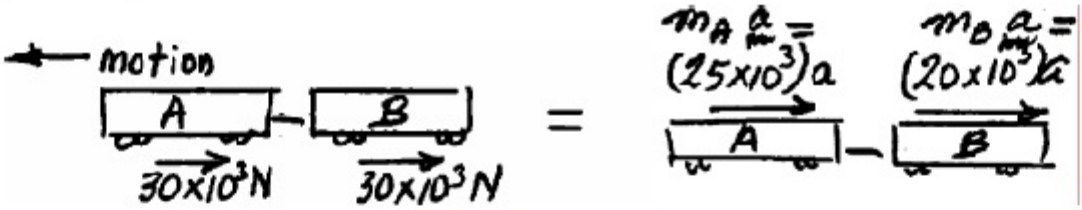


A light train made up of two cars is traveling at 90 km/h when the brakes are applied to both cars. Knowing that car A has a mass of 25 Mg and car B a mass of 20 Mg, and that the braking force is 30 kN on each car, determine (a) the distance traveled by the train before it comes to a stop, (b) the force in the coupling between the cars while the train is showing down.

SOLUTION

$v_0 = 90 \text{ km/h} = 90/3.6 = 25 \text{ m/s}$

(a) Both cars:

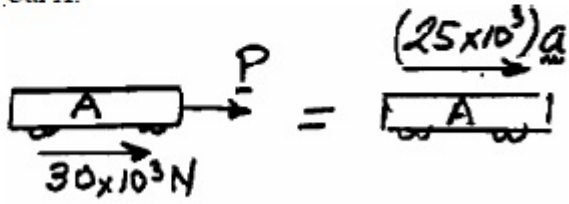


$\pm\rightarrow \Sigma F_x = \Sigma ma$: $60\times10^3 \text{ N} = (45\times10^3 \text{ kg})a$ $\qquad a = 1.333 \text{ m/s}^2 \rightarrow$

$v^2 = v_0^2 + 2ax$: $0 = (25)^2 + 2(-1.333)x$

Stopping distance: $\qquad x = 234 \text{ m}$ ◀

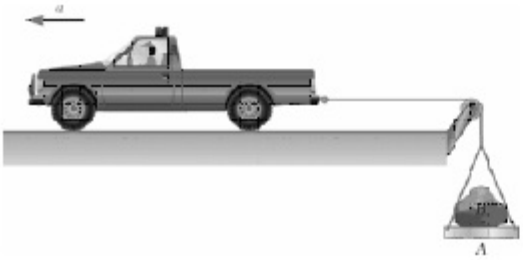
(b) Car A:



$\pm\rightarrow \Sigma F_x = ma$: $30\times10^3 + P = (25\times10^3)a$

$P = (25\times10^3)(1.333) - 30\times10^3$

Coupling force: $\qquad P = +3332 \text{ N}$ $\qquad P = 3.33 \text{ kN (tension)}$ ◀



PROBLEM 12.17

A 2500-kg truck is being used to lift a 500 kg boulder B that is on a 100 kg pallet A. Knowing the acceleration of the truck is 0.3 m/s^2, determine (a) the horizontal force between the tires and the ground, (b) the force between the boulder and the pallet.

SOLUTION

Kinematics:

$$a_T = 0.3 \text{ m/s}^2 \leftarrow$$

$$a_A = a_B = 0.3 \text{ m/s}^2 \uparrow$$

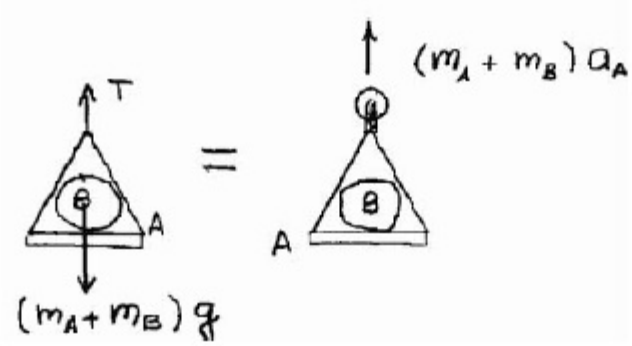
Masses:

$$m_T = 2500 \text{ kg}$$

$$m_A = 100 \text{ kg}$$

$$m_B = 500 \text{ kg}$$

Let T be the tension in the cable. Apply Newton's second law to the lower pulley, pallet and boulder.



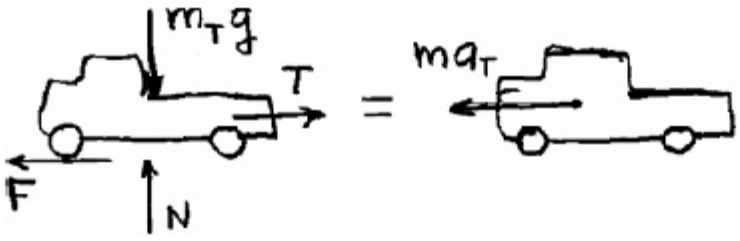
Vertical components $+\uparrow$:

$$T - (m_A + m_B)g = (m_A + m_B)a_A$$

$$T - (600)(9.81) = 600(0.3)$$

$$T = 6066 \text{ N}$$

Apply Newton's second law to the truck.



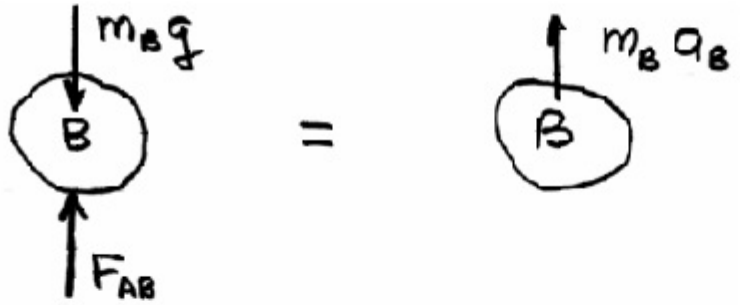
PROBLEM 12.17 (Continued)

Horizontal components $\stackrel{+}{\rightarrow}$: $F - T = m_T a_T$

(*a*) Horizontal force between lines and ground.

$F = T + m_T a_T = 6066 + (2500)(0.3)$ $\qquad F = 6816 \text{ N}$ ◀

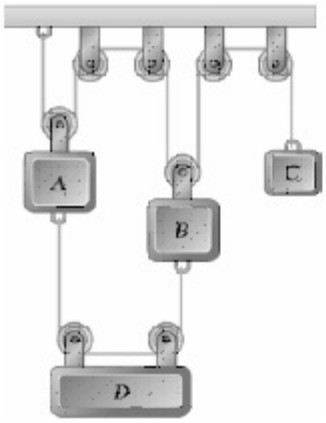
Apply Newton's second law to the boulder.



Vertical components $\uparrow$: $F_{AB} - m_B g = m_B a_B$

$F_{AB} = m_B(g + a) = 500(9.81 + 0.3) = 5055 \text{ N}$

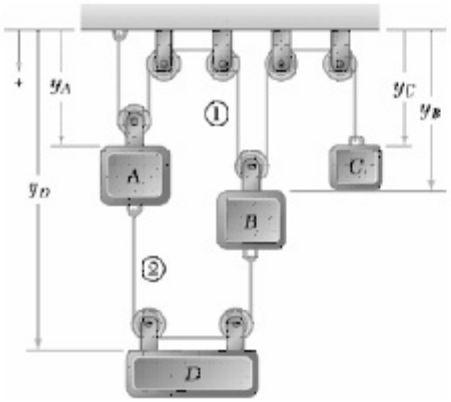
(*b*) Contact force: $\qquad F_{AB} = 5060 \text{ N}$ ◀



PROBLEM 12.32

The masses of blocks A, B, C and D are 9 kg, 9 kg, 6 kg and 7 kg, respectively. Knowing that a downward force of magnitude 120 N is applied to block D, determine (a) the acceleration of each block, (b) the tension in cord ABC. Neglect the weights of the pulleys and the effect of friction.

SOLUTION



Note: As shown, the system is in equilibrium.

From the diagram:

Cord 1: $2y_A + 2y_B + y_C = \text{constant}$

Then $2v_A + 2v_B + v_C = 0$

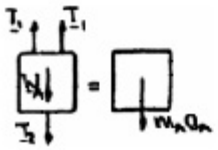
and $2a_A + 2a_B + a_C = 0$ (1)

Cord 2: $(y_D - y_A) + (y_D - y_B) = \text{constant}$

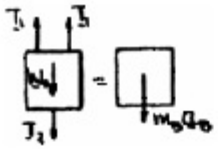
Then $2v_D - v_A - v_B = 0$

and $2a_D - a_A - a_B = 0$ (2)

A:



B:



(a) $+\downarrow \Sigma F_y = m_A a_A$: $m_A g - 2T_1 + T_2 = m_A a_A$

or $9(9.81) - 2T_1 + T_2 = 9a_A$ (3)

$+\downarrow \Sigma F_y = m_B a_B$: $m_B g - 2T_1 + T_2 = m_B a_B$

or $9(9.81) - 2T_1 + T_2 = 9a_B$ (4)

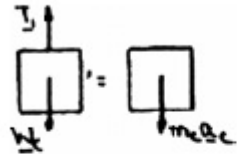
Note: Eqs. (3) and (4) $\Rightarrow \mathbf{a}_A = \mathbf{a}_B$

Then Eq. (1) $\Rightarrow a_C = -4a_A$

Eq. (2) $\Rightarrow a_D = a_A$

PROBLEM 12.32 (Continued)

C:



$$+\downarrow \Sigma F_y = m_C a_C: \quad m_C g - T_1 = m_C a_C$$

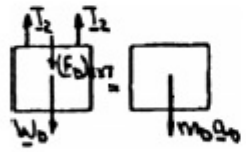
or
$$T_1 = m_C(g - a_C) = 6(g + 4a_A) \qquad (5)$$

$$+\downarrow \Sigma F_y = m_D a_D: \quad m_D g - 2T_2 + (F_D)_{\text{ext}} = m_D a_D$$

or
$$T_2 = \frac{1}{2}[m_D(g - a_D) + 120] = 94.335 - \frac{1}{2}(7a_A) \qquad (6)$$

Substituting for T_1 [Eq. (5)] and T_2 [Eq. (6)] in Eq. (3)

D:



$$9(9.81) - 2 \times 6(g + 4a_A) + 94.335 - \frac{1}{2}(7a_A) = 9a_A$$

or
$$a_A = \frac{9(9.81) - 2 \times 6(9.81) + 94.335}{48 + 3.5 + 9} = 1.0728 \text{ m/s}^2$$

$$\mathbf{a}_A = \mathbf{a}_B = \mathbf{a}_D = 1.073 \text{ m/s}^2 \downarrow \blacktriangleleft$$

and
$$a_C = -4(1.0728 \text{ m/s}^2) \quad \text{or} \quad \mathbf{a}_C = 4.29 \text{ m/s}^2 \uparrow \blacktriangleleft$$

(*b*) Substituting into Eq. (5)

$$T_1 = 6\big(9.81 + 4(1.0728)\big) \quad \text{or} \quad T_1 = 84.6 \text{ N} \blacktriangleleft$$