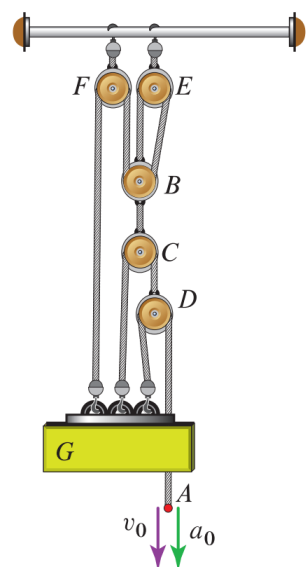


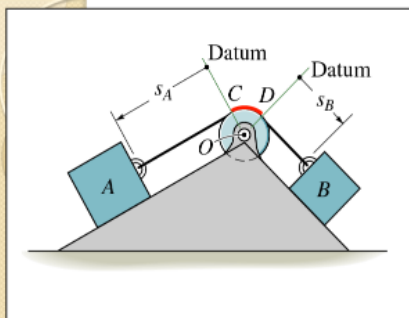
Problem 1

Example 2-21

Assuming that all ropes are vertically aligned, determine the velocity and acceleration of the load G if $v_0 = 3 \text{ ft/s}$ and $a_0 = 1 \text{ ft/s}^2$.



Recall & Analysis



In this example, think the cable length l_{AB} as subdivided in three:

- the length in contact with the pulley, CD
- the length CA
- the length DB

In this geometry, no matter how A and B move, the *quantity* in contact with the pulley is constant. We could write:

$$s_A + l_{CD} + s_B = l_{AB} = \text{constant}$$

Differentiating with respect to time,

$$\frac{ds_A}{dt} + \frac{ds_B}{dt} = 0 \quad \dots \text{or} \dots \quad v_B = -v_A$$

The length of all ropes are constant, so we can set up the equations with them.

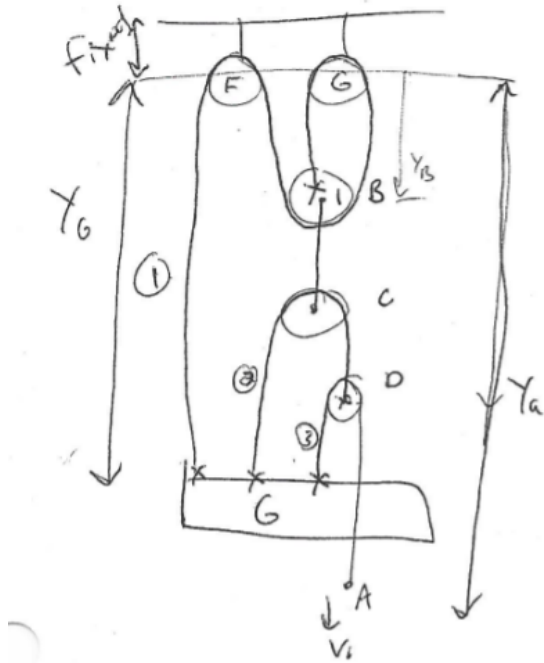
Here, we have three ropes: L_1, L_2, L_3 , L_1 is $G - F - B - E - B$, L_2 is $G - C - D$, L_3 is $G - D - A$. And their lengths are constant, so we can set up the equations with them.

Solution

In case to find v_G and a_G , we should first determine the expression of y_G . But we don't need the the explicit form of it, since our final goal is velocity and acceleartion.

First we need to set up our coordinates system, where y axis points downwards.

As the lengths of all ropes(L_1, L_2, L_3) don't change over time, we can set up the equations with them and coordinates of all pulleys.



$$\begin{cases} L_1 = y_G + 3y_B \\ L_2 = (y_G - y_C) + (y_D - y_C) \\ L_3 = (y_G - y_D) + (y_A - y_D) \\ L_4 = y_C - y_B \end{cases}$$

$$\begin{cases} L_1 = y_G + 3y_B \\ L_2 = y_G + y_D - 2y_C \\ L_3 = y_A + y_G - 2y_D \\ L_4 = y_C - y_B \end{cases}$$

Do derivative w.r.t. time, we have:

$$\begin{cases} 0 = \dot{y}_G + 3\dot{y}_B \\ 0 = \dot{y}_G + \dot{y}_D - 2\dot{y}_C \\ 0 = \dot{y}_G + \dot{y}_A - 2\dot{y}_D \\ 0 = \dot{y}_C - \dot{y}_B \end{cases}$$

So, $\dot{y}_B = \dot{y}_C$, and plug it into the first and second equation, we have: $\dot{y}_D = -\frac{5}{3}\dot{y}_G$, then plug it into the third equation, we have:

$$\dot{y}_G = -\frac{3}{13}\dot{y}_A$$

Placing $\dot{y}_A = v_0 = 3 \text{ ft/s}$ inside, we have $\dot{y}_G = -0.692 \text{ ft/s}$

As for acceleration, do time derivative, We have

$$\ddot{y}_G = -\frac{3}{13}\ddot{y}_A$$

Where $\ddot{y}_A = a_0 = a \text{ ft/s}$, and $\ddot{y}_G = 0.231 \text{ ft/s}^2$

Problem2

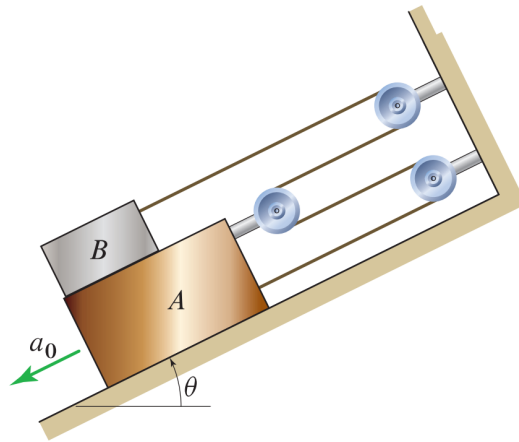
326

Solutions Manual

Example 2-22



Block A is released from rest and starts sliding down the incline with an acceleration $a_0 = 3.7 \text{ m/s}^2$. Determine the acceleration of block B relative to the incline. Also, determine the time needed for B to move a distance $d = 0.2 \text{ m}$ relative to A .



Recall & Analysis

$$\vec{r}_B = \vec{r}_A + \vec{r}_{B/A}$$

Same as the previous problem, we can set up the equations with the lengths of all ropes.

Solution

make \vec{x} pointing downwards the slope.

$$\begin{aligned} L &= 3x_A + x_B \\ 0 &= 3\dot{x}_A + \dot{x}_B \\ 0 &= 3\ddot{x}_A + \ddot{x}_B \end{aligned}$$

using the fact $\ddot{x}_A = a_0$, we have

$$\vec{a}_B = -3\vec{a}_A = -3a_0 = -11.10 \text{ m/s}^2$$

where the positive direction is pointing downwards the incline.

$$\vec{x}_{B/A}(t) = \vec{x}_{B/A}(0) + \dot{\vec{x}}_{B/A}(0)t + \frac{1}{2}\vec{a}_{B/A}t^2$$

$$\begin{aligned}\vec{x}_{B/A}(t) &= \vec{x}_{B/A}(0) + \dot{\vec{x}}_{B/A}(0)t + \frac{1}{2}(\vec{a}_B - \vec{a}_A)t^2 \\ \vec{x}_{B/A}(t) &= \vec{x}_{B/A}(0) + \dot{\vec{x}}_{B/A}(0)t + \frac{1}{2}(-3a_0 - a_0)t^2\end{aligned}$$

Since the block is released from rest, we have $\dot{\vec{x}}_{B/A}(0) = 0$, and $\vec{x}_{B/A}(0) = 0$, so we have:

$$\begin{aligned}\vec{x}_{B/A}(t) &= \frac{1}{2}(-4a_0)t^2 \\ \vec{x}_{B/A}(t) &= -2a_0t^2\end{aligned}$$

When the distance $d = 0.2m$, we have:

$$\begin{aligned}-0.2 &= -2a_0t^2 \\ t &= 0.1644s\end{aligned}$$