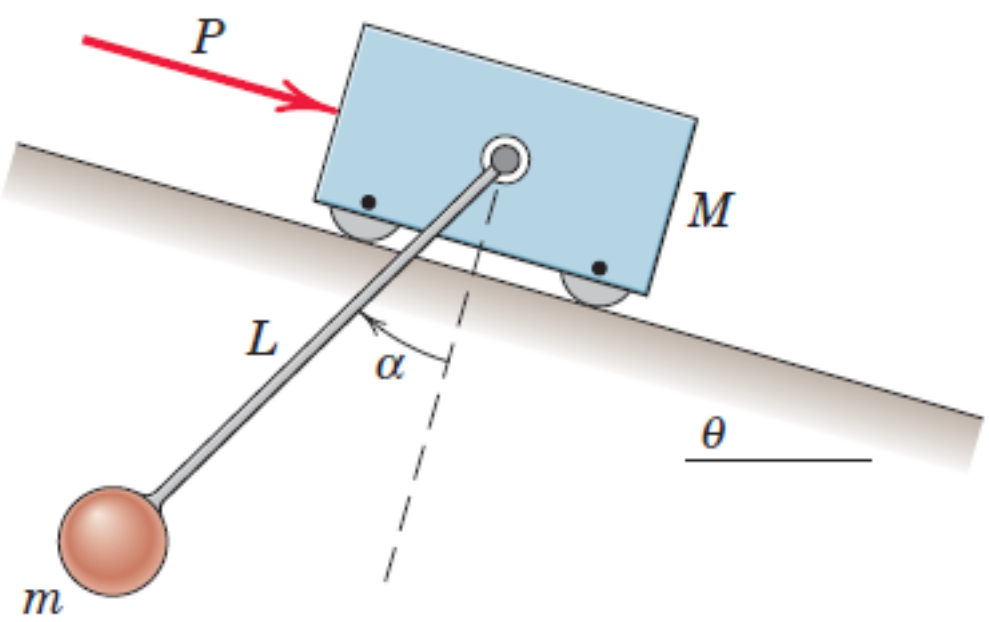


Engineering Mechanics | (8th Edition)

Problem

Determine the steady-state angle α if the constant force P is applied to the cart of mass M . The pendulum bob has mass m and the rigid bar of length L has negligible mass. Ignore all friction. Evaluate your expression for $P = 0$.



Problem 3/10

Walkthrough for problem

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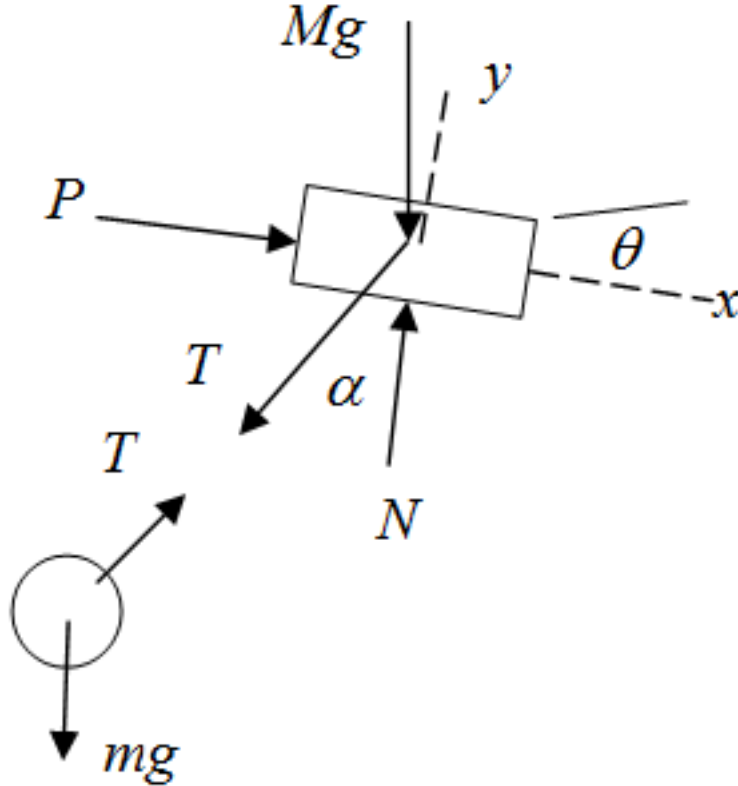
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Step-by-step solution

Step 1 of 5

Draw the free body diagram of the system.



mg Mg P y x θ α T N

Comment

Step 2 of 5

Consider the equilibrium of forces acting on the bob in x-direction using free body diagram.

$$\sum F_x = 0 \quad \dots\dots (1)$$
$$T \sin \alpha + mg \sin \theta = ma_x$$

Here, T is the tension in the rod, m is the mass of the bob, g is the acceleration due to gravity, a_x is the acceleration of the bob, θ is the angle made with the horizontal axis, α is the angle made with the vertical axis.

Consider the equilibrium of forces acting on the bob in y-direction using free body diagram.

$$\sum F_y = 0$$
$$T \cos \alpha - mg \cos \theta = 0 \quad \dots\dots (2)$$

Comment

Step 3 of 5

Consider the equilibrium of forces acting on the entire system in x-direction using free body diagram.

$$\sum F_x = ma_x$$
$$P + (M + m)g \sin \theta = (m + M)a_x$$
$$a_x = \frac{P + (M + m)g \sin \theta}{(m + M)}$$

Here, M is the mass of the cart, p is the force acting on the cart.

Substitute $\left[\frac{P + (M + m)g \sin \theta}{(m + M)} \right]$ for a_x in equation (1).

$$T \sin \alpha + mg \sin \theta = ma_x$$
$$T \sin \alpha + mg \sin \theta = m \left[\frac{P + (M + m)g \sin \theta}{(m + M)} \right]$$
$$T = m \left[\frac{P + (M + m)g \sin \theta}{(m + M) \sin \alpha} \right] - \frac{mg \sin \theta}{\sin \alpha}$$

Comment

Step 4 of 5

Calculate the angle α made by the bar with the vertical using the equation (2).

$$T \cos \alpha - mg \cos \theta = 0$$

Substitute $\left(m \left[\frac{P + (M + m)g \sin \theta}{(m + M) \sin \alpha} \right] - \frac{mg \sin \theta}{\sin \alpha} \right)$ for T .

$$\left(\left[\frac{P + (M + m)g \sin \theta}{(m + M) \sin \alpha} \right] - \frac{g \sin \theta}{\sin \alpha} \right) \cos \alpha - g \cos \theta = 0$$
$$\left(\frac{P \sin \alpha + (M + m)g \sin \alpha \sin \theta - (M + m)g \sin \alpha \sin \theta}{(m + M) \sin^2 \alpha} \right) \cos \alpha - g \cos \theta = 0$$
$$\left(\frac{P \sin \alpha}{(m + M) \sin^2 \alpha} \right) \cos \alpha - g \cos \theta = 0$$
$$\left[\frac{P \sin \alpha \cos \alpha}{(m + M) \sin^2 \alpha} \right] - g \cos \theta = 0$$
$$P \cos \alpha = g \cos \theta (m + M) \sin \alpha$$
$$\tan \alpha = \frac{P}{g \cos \theta (m + M)}$$

Therefore, the angle made by the bar with the vertical is $\tan^{-1} \left(\frac{P}{g \cos \theta (m + M)} \right)$.

Comment

Step 5 of 5

Calculate the angle α when $P = 0$.

$$\tan \alpha = \frac{P}{g \cos \theta (m + M)}$$

Substitute 0 for P .

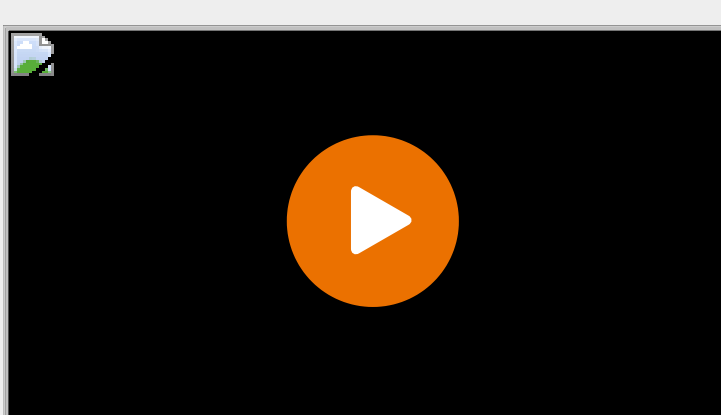
$$\alpha = \tan^{-1} \left(\frac{0}{g \cos \theta (m + M)} \right)$$

$$\alpha = 0^\circ$$

Therefore, the angle made by the bar with the vertical when $P = 0$ is 0° .

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Was this solution helpful? 10 0



WALKTHROUGH VIDEO

For this problem:
Chapter 3, Problem 10P

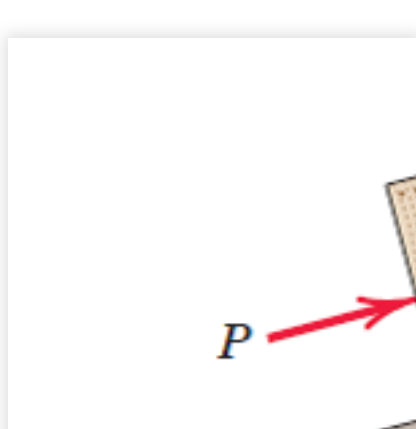
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Recommended solutions for you in Chapter 3

Chapter 3, Problem 2P

The 50-kg crate is stationary when the force P is applied. Determine the resulting acceleration of the crate if (a) $P = 0$, (b)...

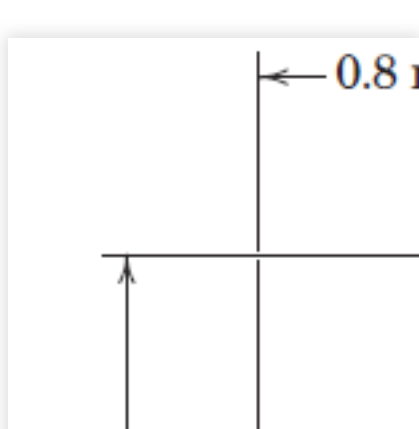
[See solution](#)



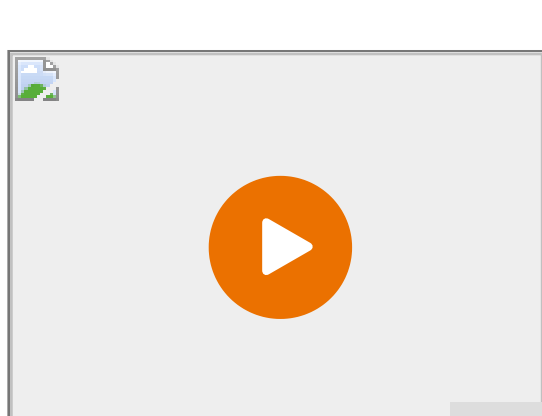
Chapter 3, Problem 100P

The 2-kg collar is at rest in position A when the constant force P is applied as shown. Determine the speed of the collar as it...

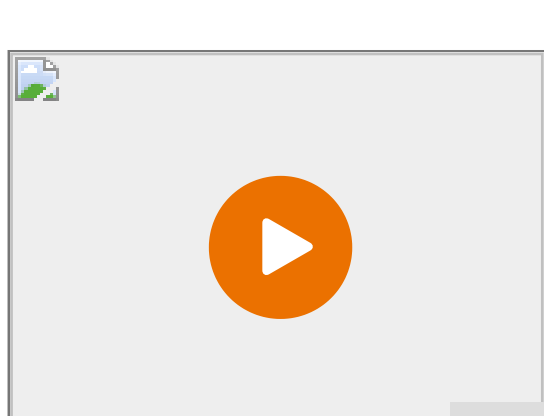
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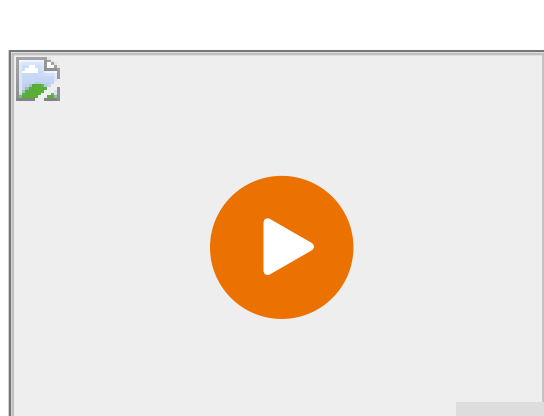
Videos related to Chapter 3



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TEXTBOOK SOLUTION
Linear Algebra Checklist
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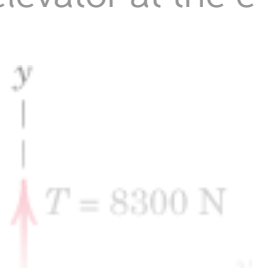
TEXTBOOK SOLUTION
Dry Friction (static and kinetic)
 0 0

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Examples related to Chapter 3

Example 1

A 75-kg man stands on a spring scale in an elevator. During the first 3 seconds of motion from rest, the tension T in the hoisting cable is 8300 N. Find the reading R of the scale in newtons during this interval and the upward velocity v of the elevator at the end of the 3 seconds. The total mass of the elevator, man, and scale is 750 kg.



[Show more](#)

Example 2

Example 3

Example 4

Example 5

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