PHYS141 OUTLINE QUESTIONS SOLUTIONS

BY AHMAD HAMDAN

BZU-HUB.COM

Exercise 1

Chapter 10, Page 250

Principles of Physics, International Edition
ISBN: 9781118230749
Table of contents

Solution Verified Answered 2 years ago

Step 1

a)

For the tractor front wheel not to slide while rotating its linear speed must be the same as the linear speed of the rear wheel. Setting the two speeds equal to each other we get:

$$\begin{aligned} v_f &= v_r \\ r_f\omega_f &= r_r\omega_r \\ \omega_f &= \frac{r_r}{r_f}\omega_r \\ &= \frac{1\,\mathrm{m}}{0.25\,\mathrm{m}}100\,\frac{\mathrm{rev}}{\mathrm{min}} \\ &= \boxed{400\,\frac{\mathrm{rev}}{\mathrm{min}}} \end{aligned}$$

b)

The distance that the tractor passes in 10 minutes is the distance passed in one rotation, $2\pi r$, multiplied by the total number of rotations:

$$\begin{aligned} d &= 2\pi r_r\omega_r t \\ &= 2\pi(1\,\mathrm{m})(100\,\frac{\mathrm{rev}}{\mathrm{min}})(10\,\mathrm{min}) \\ &= \boxed{6283\,\mathrm{m}} \end{aligned}$$

Result

a)

$$\omega_f = 400\,\frac{\mathrm{rev}}{\mathrm{min}}$$

b)

$$d = 6283\,\mathrm{m}$$

Exercise 2

Chapter 10, Page 250

Principles of Physics, International Edition
ISBN: 9781118230749
Table of contents

Solution Verified

Step 1 1 of 2

$$1) \quad \theta - \theta_0 = \frac{1}{2}(\omega_0 + \omega)t \qquad \begin{bmatrix} \text{Because of the constant rate} \\ \text{we use this kinematic equation} \end{bmatrix}$$

$$2) \quad \theta - \theta_0 = \frac{1}{2}(30 + 0) \times 2 \times 60$$

$$3) \quad \theta - \theta_0 = 1800$$

The number of revolution they make all 1800

Result 2 of 2

1800 rev

Rate this solution

Exercise 1 Exercise 3a

Exercise 4

Chapter 10, Page 250

Principles of Physics, International Edition
ISBN: 9781118230749
Table of contents

Solution Verified Answered 2 years ago

Step 1 1 of 3

a)

To get the angular position at $t = 0$ all we have do is to put in the t into the given function $\theta(t)$:

$$\begin{aligned}\theta(0) &= 2 + 4(0)^2 + 2(0)^3 \\ &= \boxed{2\,\text{rad}}\end{aligned}$$

b)

The angular speed at $t = 0$ is:

$$\begin{aligned}\omega(0) &= \frac{d\theta}{dt}\bigg|_{t=0} \\ &= 8t + 6t^2|_{t=0} \\ &= 8(0) + 6(0^2) \\ &= \boxed{0}\end{aligned}$$

c)

The angular speed at $t = 3s$ is:

$$\begin{aligned}\omega(3) &= 8t + 6t^2|_{t=3\,\text{s}} \\ &= 8(3) + 6(3^2) \\ &= \boxed{78\,\frac{\text{rev}}{\text{s}}}\end{aligned}$$

Step 2 2 of 3

d)

The angular acceleration at $t = 4$ s is:

$$\begin{aligned}\alpha(4) &= \frac{d\omega}{dt}\bigg|_{t=4\,\text{s}} \\ &= 8 + 12t|_{t=4\,\text{s}} \\ &= 8 + 12(4) \\ &= \boxed{56\,\frac{\text{rad}}{\text{s}^2}}\end{aligned}$$

e)

Angular acceleration still depends on time t so it is not constant.

Result 3 of 3

a)

$$\theta(0) = 2\,\text{rad}$$

b)

$$\omega(0) = 0$$

c)

$$\omega(0) = 78\,\frac{\text{rev}}{\text{s}}$$

c)

$$\alpha(4) = 78\,\frac{\text{rev}}{\text{s}^2}$$

d)

It is not constant.

Exercise 8

Chapter 10, Page 250

Principles of Physics, International Edition

ISBN: 9781118230749

Table of contents

Solution Verified Answered 2 years ago

Step 1 1 of 2

a)

To get the angular velocity we have to integrate the angular acceleration with respect to time:

$$\begin{aligned}\omega &= \int \alpha dt\\ &= \int 6t^4 - 4t^2 dt\\ &= \frac{6}{5}t^5 - \frac{4}{3}t^3 + \omega_0\\ &= \boxed{\frac{6}{5}t^5 - \frac{4}{3}t^3 + 2.5}\end{aligned}$$

b)

To get the angular position we have to integrate the angular velocity with respect to time:

$$\begin{aligned}\theta &= \int \omega dt\\ &= \int \frac{6}{5}t^5 - \frac{4}{3}t^3 + 2.5dt\\ &= \frac{1}{5}t^6 - \frac{1}{3}t^4 + 2.5t + \theta_0\\ &= \boxed{\frac{1}{5}t^6 - \frac{1}{3}t^4 + 2.5t + +1.5}\end{aligned}$$

Result 2 of 2

$$a)$$

$$\omega = \frac{6}{5}t^5 - \frac{4}{3}t^3 + 2.5$$

$$b)$$

$$\theta = \frac{1}{5}t^6 - \frac{1}{3}t^4 + 2.5t + +1.5$$

Exercise 12

Chapter 10, Page 250

Principles of Physics, International Edition
ISBN: 9781118230749
Table of contents

Solution Verified Answered 1 year ago

Step 1 1 of 3

a)

The average angular acceleration is given by:

$$\alpha = \frac{\Delta\omega}{\Delta t} = \frac{\omega - \omega_0}{t} \qquad (1)$$

where angular speeds ω and ω_0 are given in $\mathrm{rev/min}$ and t is given in s. Therefore, we will first convert s into min:

$$t = 12\,\mathrm{s} = \frac{12}{60} = 0.2\,\mathrm{min}$$

Now we will simply substitute the values into eq. (1):

$$= \frac{3200\,\frac{\mathrm{rev}}{\mathrm{min}} - 1200\,\frac{\mathrm{rev}}{\mathrm{min}}}{0.2\,\mathrm{min} - 0}$$
$$= \boxed{10^4\,\frac{\mathrm{rev}}{\mathrm{min}^2}}$$

Step 2 2 of 3

b)

The number of revolutions in that $0.2\,\mathrm{min}$ is:

$$N = \frac{1}{2}(\omega_0 + \omega)\cdot t$$
$$= \frac{1}{2}(1200 + 3200)\cdot 0.2$$
$$= \boxed{440\,\mathrm{rev}}$$

Result 3 of 3

$$a)$$
$$\alpha = 10^4\,\frac{\mathrm{rev}}{\mathrm{min}^2}$$
$$b)$$
$$N = 440\,\mathrm{rev}$$

Rate this solution

Exercise 16

Chapter 10, Page 251

Principles of Physics, International Edition
ISBN: 9781118230749
Table of contents

Solution Verified Answered 2 years ago

Step 1 1 of 2

a)

The time needed for the merry-go-round to travel 2 full revolutions is:

$$\begin{aligned} t &= \sqrt{\frac{2\theta}{\alpha}} \\ &= \sqrt{\frac{2(2\,\mathrm{rev}\frac{2\pi\,\mathrm{rad}}{\mathrm{rev}})}{1.2\,\frac{\mathrm{rad}}{\mathrm{s}}^2}} \\ &= \boxed{4.58\,\mathrm{s}} \end{aligned}$$

b)

The time needed for the merry-go-round to travel 4 full revolutions is:

$$\begin{aligned} t_4 &= \sqrt{\frac{2\theta}{\alpha}} \\ &= \sqrt{\frac{2(4\,\mathrm{rev}\frac{2\pi\,\mathrm{rad}}{\mathrm{rev}})}{1.2\,\frac{\mathrm{rad}}{\mathrm{s}}^2}} \\ &= 6.47\,\mathrm{s} \end{aligned}$$

Subtracting the time from the part a), the time needed for the first 2 revolutions we can get the time needed for the second 2 revolutions:

$$\begin{aligned} t' &= t_4 - t \\ &= 6.47\,\mathrm{s} - 4.58\,\mathrm{s} \\ &= \boxed{1.89\,\mathrm{s}} \end{aligned}$$

Result 2 of 2

a)

$$t = 4.58\,\mathrm{s}$$

b)

$$t' = 1.89\,\mathrm{s}$$

Exercise 25a

Chapter 10, Page 251

Principles of Physics, International Edition

ISBN: 9781118230749

Table of contents

Solution Verified Answered 1 year ago

Step 1

1 of 2

The angular speed of a point on Earth's surface about the polar axis is

$$\omega_1 = \frac{\theta}{t} = \frac{2\pi}{24 \times 60 \times 60} = 7.3 \times 10^{-5}\ \mathrm{rad/s}$$

The earth rotates about the polar axis once per day. Then $\theta = 1$ rev, and $t = 1$ day.

$$\boxed{\omega_1 = 7.3 \times 10^{-5}\ \mathrm{rad/s}}$$

Result

2 of 2

$$\omega_1 = 7.3 \times 10^{-5}\ \mathrm{rad/s}$$

Rate this solution

Exercise 24 Exercise 25b

Exercise 25b

Chapter 10, Page 251

Principles of Physics, International Edition
ISBN: 9781118230749
Table of contents

Solution Verified Answered 1 year ago

Step 1 1 of 3

The distance between the center of Earth and a point at latitude 40° N on Earth's surface is

$$r = R\cos 40^{\circ} = 6371 \times 10^{3} \times \cos 40^{\circ} = 4880469.147\ \mathrm{m}$$

Where R is the radius of Earth.

Step 2 2 of 3

In a previous part of this exercise, we derived $\omega_1 = 7.3 \times 10^{-5}\ \mathrm{rad/s}$.

The linear speed of a point at latitude 40° N on Earth's surface is

$$v_1 = \omega_1 r = 7.3 \times 10^{-5} \times 4880469.147 = 356.3\ \mathrm{m/s}$$

$$\boxed{v_1 = 356.3\ \mathrm{m/s}}$$

Result 3 of 3

$$v_1 = 356.3\ \mathrm{m/s}$$

Rate this solution

< Exercise 25a Exercise 25c >

Exercise 25c

Chapter 10, Page 251

Principles of Physics, International Edition
ISBN: 9781118230749

Solution Verified Answered 1 year ago

Step 1 1 of 2

In a previous part of this exercise, we derived $\omega_1 = 7.3 \times 10^{-5}\ \mathrm{rad/s}$.

The angular speed of a point on Earth's surface about the polar axis is independent of the point's position on the surface.

$$\omega_2 = 7.3 \times 10^{-5}\ \mathrm{rad/s}$$

$$\boxed{\omega_2 = 7.3 \times 10^{-5}\ \mathrm{rad/s}}$$

Result 2 of 2

$$\omega_2 = 7.3 \times 10^{-5}\ \mathrm{rad/s}$$

Exercise 25b

Rate this solution

Exercise 25d

Exercise 25d

Chapter 10, Page 251

Principles of Physics, International Edition
ISBN: 9781118230749
Table of contents

Solution Verified Answered 1 year ago

Step 1

1 of 2

In a previous part of this exercise, we derived $\omega_2 = 7.3 \times 10^{-5}\ \mathrm{rad/s}$.

The distance between the center of Earth and a point at the equator is the radius of Earth R.

Then the linear speed of a point at the equator is

$$v_2 = \omega_2 R = 7.3 \times 10^{-5} \times 6371 \times 10^3 = 465.083\ \mathrm{m/s}$$

$$\boxed{v_2 = 465.083\ \mathrm{m/s}}$$

Result

2 of 2

$$v_2 = 465.083\ \mathrm{m/s}$$

Exercise 32

Chapter 10, Page 252

Principles of Physics, International Edition
ISBN: 9781118230749
Table of contents

Solution Verified Answered 2 years ago

Step 1

a)

We are given the tangential acceleration and we can use it to get the angular acceleration:

$$\begin{aligned}\alpha &= \frac{a}{r}\\ &= \frac{0.6\,\frac{\mathrm{m}}{\mathrm{s}^2}}{32\,\mathrm{m}}\\ &= 18.75\cdot 10^{-3}\,\frac{\mathrm{rad}}{\mathrm{s}^2}\end{aligned}$$

After 15 s the angular speed is:

$$\begin{aligned}\omega &= \alpha t\\ &= 18.75\cdot 10^{-3}\,\frac{\mathrm{rad}}{\mathrm{s}^2}\cdot 15\,\mathrm{s}\\ &= 0.281\,\frac{\mathrm{rad}}{\mathrm{s}}\end{aligned}$$

The net linear acceleration is:

$$\begin{aligned}a &= \sqrt{a_t^2 + a_r^2}\\ &= \sqrt{(0.6\,\frac{\mathrm{m}}{\mathrm{s}^2})^2 + ((0.281\,\frac{\mathrm{rad}}{\mathrm{s}})^2\cdot 32\,\mathrm{m})^2}\\ &= \boxed{2.6\,\frac{\mathrm{m}}{\mathrm{s}^2}}\end{aligned}$$

Step 2

b)

The velocity is in the tangential direction so we are looking for the angle between the net acceleration ant the tangential acceleration:

$$\begin{aligned}\cos\theta &= \frac{a_t}{a}\\ \cos\theta &= \frac{0.6}{2.6}\\ &\downarrow\\ \theta &= \boxed{76.66^\circ}\end{aligned}$$

Result

a)

$$a = 2.6\,\frac{\mathrm{m}}{\mathrm{s}^2}$$

b)

$$\theta = 76.66^\circ$$

Exercise 34a

Chapter 10, Page 252

Principles of Physics, International Edition
ISBN: 9781118230749
Table of contents

Solution Verified Answered 1 year ago

Step 1 1 of 3

Givens:

The scale is set by, $\omega_s = 6$ rad/s.

Step 2 2 of 3

The rate of change of the angular velocity of the rod is constant, then the angular acceleration of the rod is constant and it is equal to the slope of the straight line in Figure 10-33

$$\alpha = \frac{\Delta\omega}{\Delta t} = \frac{4-1}{4-2} = 1.5 \text{ rad/s}^2$$

Where

- $\dfrac{\Delta\omega}{\Delta t}$ is the rate of change in the angular velocity of the rod.
- α is the angular acceleration of the rod.

$$\boxed{\alpha = 1.5 \text{ rad/s}^2}$$

Result 3 of 3

$$\alpha = 1.5 \text{ rad/s}^2$$

Exercise 33 Rate this solution Exercise 34b

Exercise 34b

Chapter 10, Page 252

Principles of Physics, International Edition

ISBN: 9781118230749

Table of contents

Solution Verified Answered 1 year ago

Step 1 1 of 5

Givens:

The scale is set by, $\omega_s = 6$ rad/s.

Step 2 2 of 5

$$K = \frac{1}{2} I \omega^2 \tag{1}$$

Where K is the kinetic energy of the rod, I is the inertia of the wheel, and ω is the angular velocity of the wheel.

Step 3 3 of 5

At $t = 4$ s, $\omega(4) = 4$ rad/s, and $K = 1.6$ J. Substitute in Eq.1 to find the rotational inertia of the wheel

$$1.6 = \frac{1}{2} \times I \times (4)^2$$
$$\therefore\ I = \frac{2 \times 1.6}{4^2} = 0.2\ \mathrm{kg \cdot\ m^2}$$

Step 4 4 of 5

At $t = 0$ s, $\omega(0) = -2$ rad/s. Substitute in Eq.1 to find the kinetic energy of the rod at this time

$$K(0) = \frac{1}{2} \times 0.2 \times (-2)^2 = 0.4\ \mathrm{J}$$

$$\boxed{K(0) = 0.4\ \mathrm{J}}$$

Result 5 of 5

$$K(0) = 0.4\ \mathrm{J}$$

Exercise 34a

Rate this solution

Exercise 35

Exercise 41a

Chapter 10, Page 252

Principles of Physics, International Edition
ISBN: 9781118230749
Table of contents

Solution Verified Answered 1 year ago

Step 1 1 of 4

Givens:

Mass of each particle, $m = 0.85$ kg.

Length of each rod, $d = 5.6$ cm= 0.056 m.

Mass of each rod, $M = 1.2$ kg.

The combination rotates around the rotation axis with the angular speed $\omega = 0.3$ rad/s.

Step 2 2 of 4

The rotational inertia of the combination about O is given by the following

$$I_{\text{tot}} = I_{r1} + I_{p1} + I_{r2} + I_{p2}$$
$$I_{\text{tot}} = I_{r1\text{CM}} + Md_{r1}^2 + md^2 + I_{r2\text{CM}} + Md_{r2}^2 + m(2d)^2$$
$$I_{\text{tot}} = \frac{1}{12}Md^2 + M(\frac{1}{2}d)^2 + md^2 + \frac{1}{12}Md^2 + M(\frac{3}{2}d)^2 + m(2d)^2 \qquad (1)$$

Where

- (I_{r1}) is the rotational inertia of the first rod measured around O.
- (I_{p1}) is the rotational inertia of the first particle measured around O.
- (I_{r2}) is the rotational inertia of the second rod measured around O.
- (I_{p2}) is the rotational inertia of the second particle measured around O.
- $(I_{r1\text{CM}})$ is the rotational inertia of the first rod measured around its center of mass.
- (M) is the mass of the rod.
- (d_{r1}) is the distance between point O and the center of the first rod.
- (m) is the mass of each particle.
- (d) is the length of the rod (the distance between the first particle and point O.
- $(I_{r2\text{CM}})$ is the rotational inertia of the second rod measured around its center of mass.
- (d_{r2}) is the distance between point O and the center of the second rod.
- $(2d)$ is the distance between the second particle and point O.

Step 3 3 of 4

Substitute in Eq. 1 to calculate the rotational inertia of the combination about O

$$\begin{aligned} I_{\text{tot}} &= \frac{1}{12} \times 1.2 \times (0.056)^2 + 1.2 \times (\frac{1}{2} \times 0.056)^2 + 0.85 \times (0.056)^2 \\ &+ \frac{1}{12} \times 1.2 \times (0.056)^2 + 1.2 \times (\frac{3}{2} \times 0.056)^2 + 0.85 \times (2 \times 0.056)^2 \\ &= 0.0233632 \text{ kg} \cdot \text{m}^2 \end{aligned}$$

$$\boxed{I_{\text{tot}} = 0.0233632 \text{ kg} \cdot \text{m}^2}$$

Result 4 of 4

$$I_{\text{tot}} = 0.0233632 \text{ kg} \cdot \text{m}^2$$

Exercise 41b

Chapter 10, Page 252

Principles of Physics, International Edition

ISBN: 9781118230749

Table of contents

Solution Verified Answered 1 year ago

Step 1 1 of 3

Givens:

Mass of each particle, $m = 0.85$ kg.

Length of each rod, $d = 5.6$ cm= 0.056 m.

Mass of each rod, $M = 1.2$ kg.

The combination rotates around the rotation axis with the angular speed $\omega = 0.3$ rad/s.

Step 2 2 of 3

In a previous part of this exercise, we derived $I_{\text{tot}} = 0.0233632\ \mathrm{kg \cdot m^2}$.

The rotational kinetic energy of the combination is given by the following

$$K = \frac{1}{2} I\omega^2 = \frac{1}{2} \times 0.0233632 \times 0.3^2 = 1.051344 \times 10^{-3}\ \mathrm{J}$$

Where ω is the angular velocity of the combination around the rotation axis.

$$\boxed{K = 1.051344 \times 10^{-3}\ \mathrm{J}}$$

Result 3 of 3

$$K = 1.051344 \times 10^{-3}\ \mathrm{J}$$

Rate this solution

Exercise 41a Exercise 42

Exercise 45

Chapter 10, Page 253

Principles of Physics, International Edition

ISBN: 9781118230749

Table of contents

Solution Verified

Step 1 1 of 3

Givens:

$r_1 = 1.3$ m.

$r_2 = 2.15$ m.

$|\vec{F}_1| = 4.2$ N.

$|\vec{F}_2| = 4.9$ N.

$\theta_1 = 75°$

$\theta_2 = 60°$

Step 2 2 of 3

The net torque of the body about the pivot counterclockwise is given by

$$\tau = r_1 F_1 \sin\theta_1 - r_2 F_2 \sin\theta_2$$
$$\tau = 1.3 \times 4.2 \sin 75^\circ - 2.15 \times 4.9 \sin 60^\circ = -3.85\ \mathrm{N \cdot m}$$

Therefore the body rotates clockwise about the pivot.

$$\boxed{\tau = -3.85\ \mathrm{N \cdot m}}$$

Result 3 of 3

$$\tau = -3.85\ \mathrm{N \cdot m}$$

Exercise 44 Rate this solution Exercise 46

Exercise 51a

Chapter 10, Page 253

Principles of Physics, International Edition
ISBN: 9781118230749
Table of contents

Solution Verified Answered 1 year ago

Step 1

1 of 4

Given Quantities

- $m_1 = 460\text{ g} = 0.460\text{ kg}$: mass of the left block
- $m_2 = 500\text{ g} = 0.500\text{ kg}$: mass of the right block
- $R = 5.00\text{ cm}$: radius of the pulley
- after $t_1 = 5.00\text{ s}$, block 2 falls by $y_1 = 75.0\text{ cm}$ without slipping

Useful Quantities

- $g = 9.80\text{ m/s}^2$: acceleration due to gravity

Required Quantities

- acceleration a of the blocks

Step 2

2 of 4

We use the kinematic equations to calculate acceleration. The tensions can be calculated using Newton's second law of motion. The angular acceleration and tangential acceleration of the pulley have a direct relationship. Finally, the rotational inertia of the pulley must be related to the net torque on the pulley and the angular acceleration.

Step 3

3 of 4

The acceleration of the two blocks must be equal since the length of the rope is constant. Using the kinematic equations, we calculate the acceleration to be

$$\begin{aligned} a &= \frac{2y_1}{t_1^2} \\ &= \frac{2 \cdot (75.0)}{(5.00)^2} \\ &= \boxed{0.0600\text{ m/s}^2} \end{aligned}$$

Result

4 of 4

$$a = 0.0600\text{ m/s}^2$$

Rate this solution

< Exercise 50 Exercise 51b >

Exercise 51b

Chapter 10, Page 253

Principles of Physics, International Edition
ISBN: 9781118230749
Table of contents

Solution Verified Answered 1 year ago

Step 1 1 of 6

Given Quantities

- $m_1 = 460 \text{ g} = 0.460 \text{ kg}$: mass of the left block
- $m_2 = 500 \text{ g} = 0.500 \text{ kg}$: mass of the right block
- $R = 5.00 \text{ cm}$: radius of the pulley
- after $t_1 = 5.00 \text{ s}$, block 2 falls by $y_1 = 75.0 \text{ cm}$ without slipping

Useful Quantities

- $g = 9.80 \text{ m/s}^2$: acceleration due to gravity

Required Quantities

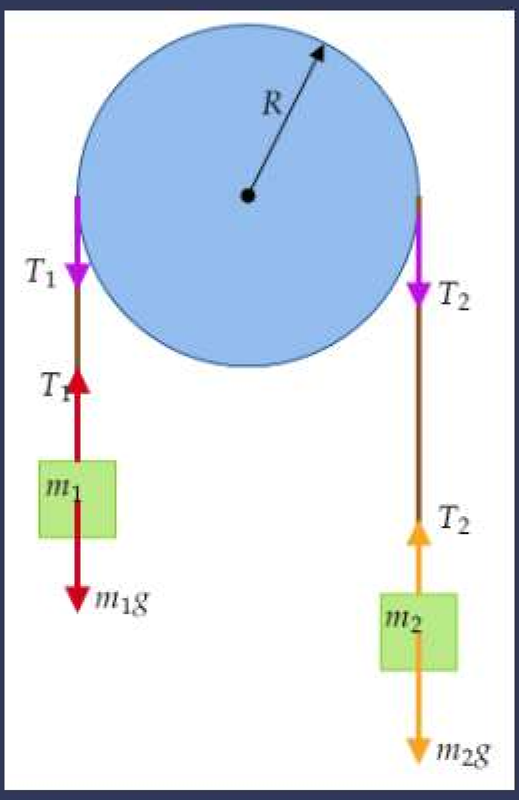
- the tension T_2 supporting block 2

Step 2 2 of 6

We use the kinematic equations to calculate acceleration. The tensions can be calculated using Newton's second law of motion. The angular acceleration and tangential acceleration of the pulley have a direct relationship. Finally, the rotational inertia of the pulley must be related to the net torque on the pulley and the angular acceleration.

Step 3 3 of 6

The force diagram is shown below.



On the free body diagram, red color marks forces which act on block 1. Orange color marks forces which act on block 2 and forces that act on the pulley are marked with a violet color.

Step 4 4 of 6

Let upwards be the positive direction on the vertical forces, and clockwise be the positive direction for the torque. Using Newton's second law on the block 2, which would move downward, we have

$$\sum F_y = m_2 a_2$$
$$m_2 a_2 = T_2 - m_2 g$$
$$\implies T_2 = m_2(a_2 + g) \qquad (1)$$

Step 5 5 of 6

Substituting $m_2 = 0.500 \text{ kg}$, $a_2 = -0.0600 \text{ m/s}^2$, and $g = 9.80 \text{ m/s}^2$ into equation (1), we calculate the tension T_2 to be

$$\begin{aligned} T_2 &= m_2(a_2 + g) \\ &= (0.500)(-0.0600 + 9.80) \\ T_2 &= \boxed{4.87 \text{ N}} \end{aligned}$$

Result 6 of 6

$$T_2 = 4.87 \text{ N}$$

Exercise 51c

Chapter 10, Page 253

Principles of Physics, International Edition
ISBN: 9781118230749
Table of contents

Solution Verified Answered 1 year ago

Step 1 1 of 5

Given Quantities

- $m_1 = 460\text{ g} = 0.460\text{ kg}$: mass of the left block
- $m_2 = 500\text{ g} = 0.500\text{ kg}$: mass of the right block
- $R = 5.00\text{ cm}$: radius of the pulley
- after $t_1 = 5.00$ s, block 2 falls by $y_1 = 75.0\text{ cm}$ without slipping

Useful Quantities

- $g = 9.80\text{ m/s}^2$: acceleration due to gravity

Required Quantities

- the tension T_1 supporting block 1

Step 2 2 of 5

We use the kinematic equations to calculate acceleration. The tensions can be calculated using Newton's second law of motion. The angular acceleration and tangential acceleration of the pulley have a direct relationship. Finally, the rotational inertia of the pulley must be related to the net torque on the pulley and the angular acceleration.

Step 3 3 of 5

Using Newton's 2nd law on the block 1, which would move upward, we have

$$\begin{aligned} \sum F_y &= m_1 a_1 \\ m_1 a_1 &= T_1 - m_1 g \\ \implies T_1 &= m_1(a_1 + g) \end{aligned} \tag{1}$$

Step 4 4 of 5

Substituting $m_2 = 0.460\text{ kg}$, $a_1 = +0.0600\text{ m/s}^2$, and $g = 9.80\text{ m/s}^2$ into equation (1), we calculate the tension T_1 to be

$$\begin{aligned} T_1 &= m_1(a_1 + g) \\ &= (0.460)(0.0600 + 9.80) \\ &= 4.53560\text{ N} \\ T_1 &= \boxed{4.54\text{ N}} \end{aligned}$$

Result 5 of 5

$$T_1 = 4.54\text{ N}$$

Exercise 51d

Chapter 10, Page 253

Principles of Physics, International Edition
ISBN: 9781118230749
Table of contents

Solution Verified Answered 1 year ago

Step 1

1 of 4

Given Quantities

- $m_1 = 460\ \mathrm{g} = 0.460\ \mathrm{kg}$: mass of the left block
- $m_2 = 500\ \mathrm{g} = 0.500\ \mathrm{kg}$: mass of the right block
- $R = 5.00\ \mathrm{cm}$: radius of the pulley
- after $t_1 = 5.00\ \mathrm{s}$, block 2 falls by $y_1 = 75.0\ \mathrm{cm}$ without slipping

Useful Quantities

- $g = 9.80\ \mathrm{m/s^2}$: acceleration due to gravity

Required Quantities

- the angular acceleration α of the pulley

Step 2

2 of 4

We use the kinematic equations to calculate acceleration. The tensions can be calculated using Newton's second law of motion. The angular acceleration and tangential acceleration of the pulley have a direct relationship. Finally, the rotational inertia of the pulley must be related to the net torque on the pulley and the angular acceleration.

Step 3

3 of 4

In a previous part of this exercise, we derived $a = 0.0600\ \mathrm{m/s^2}$.

The angular acceleration is related to the tangential acceleration and radius of the pulley

$$\begin{aligned}\alpha &= \frac{a}{R}\\ &= \frac{0.0600}{5.00}\\ \alpha &= \boxed{1.20\ \mathrm{rad/s^2}}\end{aligned}$$

Result

4 of 4

$$\alpha = 1.20\ \mathrm{rad/s^2}$$

Exercise 52

Chapter 10, Page 253

Principles of Physics, International Edition
ISBN: 9781118230749
Table of contents

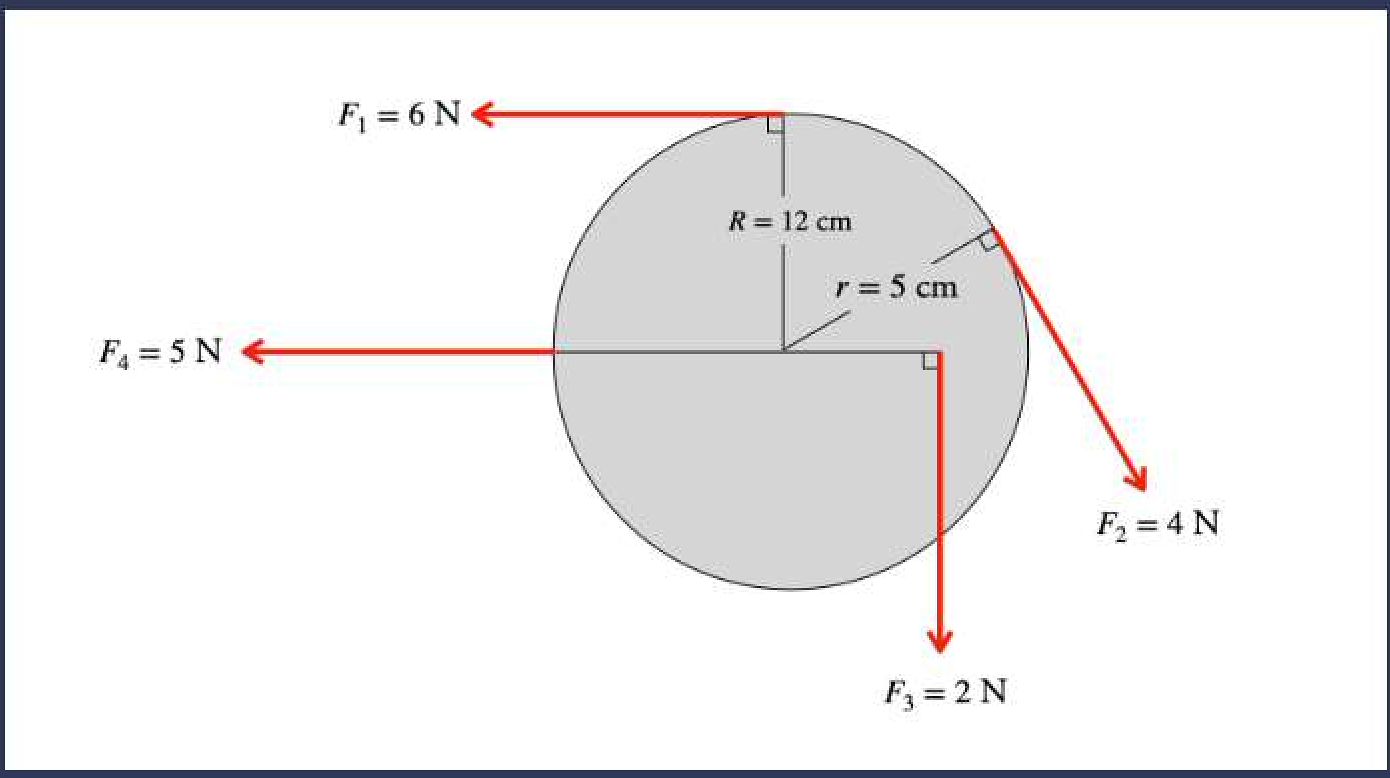
Solutions Verified

Solution A Solution B

Answered 1 year ago

Step 1 1 of 7

In this problem, we are given a cylinder loaded as shown below that rotates about its own axis. The mass of the cylinder is $3\ \mathrm{kg}$. Our goal is to solve for the following quantities: a) magnitude and b) direction of angular acceleration.



Step 2 2 of 7

We can solve this problem by using the relationship of net torque τ_{net} to the angular acceleration α and moment of inertia I of the cylinder, given in Equation (1).

$$\tau_{net} = I\alpha$$
$$\alpha = \frac{\tau_{net}}{I} \qquad \ldots(1)$$

Step 3 3 of 7

Let's now compute for the net torque on the cylinder. Recall that only forces perpendicular to the lever arm generate torque. In this case, force F_4 generates zero torque. We will set counterclockwise as the positive direction.

$$\begin{aligned}\tau_{net} &= F_1 \cdot R - F_2 \cdot R - F_3 \cdot r \\ &= 6 \cdot 0.12 - 4 \cdot 0.12 - 2 \cdot 0.05 \\ &= +0.14\ \mathrm{N \cdot m}\end{aligned}$$

Step 4 4 of 7

Solving for the moment of inertia of the cylinder about its own axis:

$$\begin{aligned}I &= \frac{mR^2}{2} = \frac{3 \cdot 0.12^2}{2} \\ &= 0.0216\ \mathrm{kg \cdot m^2}\end{aligned}$$

Step 5 5 of 7

a) Solving for the angular acceleration α:

$$\begin{aligned}\alpha &= \frac{\tau_{net}}{\alpha} = \frac{0.14}{0.0216} \\ &= \boxed{6.48\,\frac{\mathrm{rad}}{\mathrm{s}^2}}\end{aligned}$$

Step 6 6 of 7

b) The angular acceleration has the same direction as the net torque on the cylinder. Since the net torque has a positive value, the angular acceleration is **counterclockwise**, as per our convention.

Result 7 of 7

a) $\alpha = 6.48\frac{\mathrm{rad}}{\mathrm{s}^2}$
b) counterclockwise

Exercise 57a

Chapter 10, Page 254

Principles of Physics, International Edition
ISBN: 9781118230749
Table of contents

Solution Verified Answered 1 year ago

Step 1

Given

- Rotational inertia of the pulley, $I = 1 \times 10^{-3}$ kg·m^2
- The pulley is rotating around its axle
- Radius of the pulley is $r = 10 \text{ cm} = 0.1 \text{ m}$
- The force magnitude varies in time as $F = 0.5t + 0.3t^2$
- Initial angular speed of the pulley, $\omega_i = 0 \dfrac{\text{rad}}{\text{s}}$

Step 2

a)

Because the force is a function of time (not constant), the angular acceleration is not constant. Then the equations of angular motion for a constant acceleration can not be applied in this case. The magnitude of the torque on the pulley by the force is given by the following:

$$\tau = Fr = 0.1(0.5t + 0.3t^2)$$

where F is the magnitude of the applied force on the pulley, and r is the radius of the pulley. In rotational kinematics, torque takes the place of force in linear kinematics. There is a direct equivalent to Newton's second law of motion $(\vec{F} = m\vec{a})$

$$\begin{aligned} \tau &= I\alpha \\ 0.1(0.5t + 0.3t^2) &= \alpha \times 10^{-3} \\ \alpha &= \frac{0.1(0.5t + 0.3t^2)}{10^{-3}} \\ &= 100(0.5t + 0.3t^2)\text{ , rad/s}^2 \end{aligned}$$

where:

- τ is the torque on the pulley by the force F,
- I is the rotational inertia of the pulley,
- α is the angular acceleration of the pulley. The torque on the pulley in rotational kinematics is equivalent to the force applied on it in linear kinematics. The angular acceleration of the pulley in rotational kinematics is equivalent to linear acceleration in linear kinematics. The rotational inertia of the pulley in rotational kinematics is equivalent to its mass in linear kinematics.

After 3 seconds the angular acceleration of the pulley becomes

$$\begin{aligned} \alpha &= 100(0.5 \cdot 3 + 0.3 \cdot 3^2) \\ &= \boxed{420 \frac{\text{rad}}{\text{s}^2}} \end{aligned}$$

Result

(a) $\alpha = 420 \text{ rad/s}^2$

Exercise 57b

Chapter 10, Page 254

Principles of Physics, International Edition

ISBN: 9781118230749

Table of contents

Solution Verified Answered 1 year ago

Step 1 1 of 3

Given

- Rotational inertia of the pulley, $I = 1 \times 10^{-3}$ kg·m^2
- The pulley is rotating around its axle
- Radius of the pulley is $r = 10 \text{ cm} = 0.1 \text{ m}$
- The force magnitude varies in time as $F = 0.5t + 0.3t^2$
- Initial angular speed of the pulley, $\omega_i = 0 \, \dfrac{\text{rad}}{\text{s}}$

Step 2 2 of 3

b)

The angular speed of the pulley is calculated through integrating the angular acceleration knowing that the initial angular speed is zero

$$\begin{aligned}\omega(t) &= \int (100(0.5t + 0.3t^2)) \, dt \\ &= \frac{50}{2}t^2 + \frac{30}{3}t^3 + C\end{aligned}$$

Substitute $\omega = 0$ and $t = 0$ to calculate the constant C.

$$\begin{aligned}0 &= 0 + 0 + C \\ C &= 0\end{aligned}$$

Therefore,

$$\omega(t) = 25t^2 + 10t^3$$

After 3 seconds the angular velocity of the pulley becomes

$$\begin{aligned}\omega(t) &= 25 \cdot 3^2 + 10 \cdot 3^3 \\ &= \boxed{495 \, \frac{\text{rad}}{\text{s}}}\end{aligned}$$

Result 3 of 3

(b) $\omega = 495 \text{ rad/s}$

Exercise 66

Chapter 10, Page 254

Principles of Physics, International Edition
ISBN: 9781118230749
Table of contents

Solution Verified

Step 1

1 of 4

Let the velocity of the mass m be v

The kinetic energy of the mass is $\frac{1}{2}mv^2$

Kinetic energy of the pulley is $\frac{1}{2}I\omega^2 = \frac{Iv^2}{2r^2}$

Kinetic energy of the spherical shell is $\frac{1}{2}I\omega^2 = \frac{1}{2} \cdot \frac{2MR^2}{3} \cdot \frac{v^2}{R^2} = \frac{Mv^2}{3}$

Step 2

2 of 4

Therefore

$$\text{Total Kinetic Energy} = \frac{mv^2}{2} + \frac{Iv^2}{2r^2} + \frac{Mv^2}{3}$$

$$\text{Total Kinetic Energy} = \left[\frac{m}{2} + \frac{I}{2r^2} + \frac{M}{3}\right] v^2$$

Substitute the values given with the problem

$$\text{Total Kinetic Energy} = \left[\frac{0.6}{2} + \frac{3 \times 10^{-3}}{2\,(0.05)^2} + \frac{4.5}{3}\right] v^2$$

$$\text{Total Kinetic Energy} = 2.4 \times v^2$$

Step 3

3 of 4

Total Kinetic Energy = Decrease in potential energy of mass

$$2.4 \times v^2 = mgh$$

$$2.4 \times v^2 = (0.6)\,(9.8)\,(0.82)$$

$$v^2 = \frac{(0.6)\,(9.8)\,(0.82)}{2.4}$$

$$v = \sqrt{\frac{(0.6)\,(9.8)\,(0.82)}{2.4}} \approx 1.42\ \mathrm{m/s}$$

Result

4 of 4

$$1.42\ \mathrm{m/s}$$