

Find solutions for your homework

Search

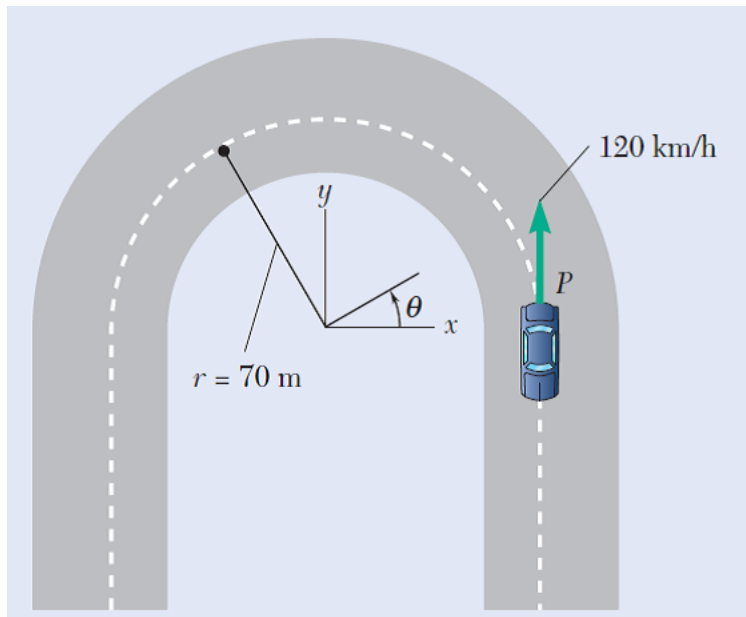
home / study / engineering / mechanical engineering / classical mechanics / classical mechanics solutions manuals / vector mechanics for engineers: statics and dynamics / 12th edition / chapter 11 / 143p

Vector Mechanics for Engineers: Statics and Dynamics | (12th Edition)

[See this solution in the app](#)

Problem

A race car enters the circular portion of a track that has a radius of 70 m. When the car enters the curve at point P , it is travelling with a speed of 120 km/h that is increasing at 5 m/s^2 . Three seconds later, determine the x and y components of velocity and acceleration of the car.



Step-by-step solution

Step 1 of 7

Write the position of P using the polar coordinates.

$$\vec{x} = r \cos \theta \mathbf{i} + r \sin \theta \mathbf{j}$$

Here, \mathbf{i} is a unit vector along the x -axis and \mathbf{j} is a unit vector along the y -axis.

Differentiate the equation with respect to time t .

$$\frac{d\vec{x}}{dt} = \frac{d}{dt}(r \cos \theta \mathbf{i} + r \sin \theta \mathbf{j})$$

$$\vec{v} = -r\dot{\theta} \sin \theta \mathbf{i} + r\dot{\theta} \cos \theta \mathbf{j} \dots (2)$$

Here, v is the velocity.

Differentiate equation (2) with respect to time t .

$$\begin{aligned} \frac{d\vec{v}}{dt} &= \frac{d}{dt}(-r\dot{\theta} \sin \theta \mathbf{i} + r\dot{\theta} \cos \theta \mathbf{j}) \\ &= -r(\dot{\theta}^2 \cos \theta + \ddot{\theta} \sin \theta) \mathbf{i} + r(-\dot{\theta}^2 \sin \theta + \ddot{\theta} \cos \theta) \mathbf{j} \end{aligned}$$

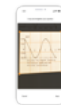
Post a question

Answers from our experts for your tough homework questions

Enter question

Continue to post

16 questions remaining



Snap a photo from your phone to post a question
We'll send you a one-time download link

888-888-8888

Text me

By providing your phone number, you agree to receive a one-time automated text message with a link to the app. Standard messaging rates may apply.

My Textbook Solutions



Vector Mechanics...
12th Edition



University Physics
14th Edition



Marketing Channels
8th Edition

[View all solutions](#)



Chapter 11, Problem 143P	3 Bookmarks	Show all steps: ON
--------------------------	-------------	--------------------

Step 2 of 7

At initial state, the particle is at position 1 at which the angle is 0° and a velocity of 120 km/h . at final position, let the angle the car makes be θ with the horizontal.

Substitute 0° for θ and 70 m for r in equation (1).

$$\begin{aligned}\vec{x}_1 &= 70 \times \cos 0^\circ i + 70 \times \sin 0^\circ j \\ &= 70i\end{aligned}$$

Substitute 0° for θ and 70 m for r , and $\dot{\theta}_1$ for $\dot{\theta}$ in equation (2).

$$\begin{aligned}\vec{v}_1 &= -70 \times \dot{\theta}_1 \sin 0^\circ i + 70 \times \dot{\theta}_1 \cos 0^\circ j \\ &= 70\dot{\theta}_1 j\end{aligned}$$

[Comment](#)

Step 3 of 7

Calculate the magnitude of velocity at starting point.

$$\begin{aligned}v_1 &= |\vec{v}_1| \\ &= \sqrt{(70\dot{\theta}_1)^2 + 0^2} \\ &= 70\dot{\theta}_1\end{aligned}$$

Substitute 120 km/h for v_1 .

$$\begin{aligned}120 \text{ km/h} \times \frac{1000 \text{ m}}{1 \text{ km}} \times \frac{1 \text{ hr}}{3600 \text{ s}} &= 70\dot{\theta}_1 \\ \dot{\theta}_1 &= 0.4762 \text{ rad/s}\end{aligned}$$

Substitute $\dot{\theta}_2$ for $\dot{\theta}$ and 70 m for r in equation (2).

$$\begin{aligned}\vec{v}_2 &= -70 \times \dot{\theta}_2 \sin \theta i + 70 \times \dot{\theta}_2 \cos \theta j \\ &= -70\dot{\theta}_2 \sin \theta i + 70\dot{\theta}_2 \cos \theta j\end{aligned}$$

[Comment](#)

Step 4 of 7

Calculate the magnitude of velocity at final point.

$$\begin{aligned}v_2 &= |\vec{v}_2| \\ &= \sqrt{(-70\dot{\theta}_2 \sin \theta)^2 + (70\dot{\theta}_2 \cos \theta)^2} \\ &= 70\dot{\theta}_2\end{aligned}$$

Calculate the acceleration of the car from the equation.

$$a = \frac{v_2 - v_1}{t}$$

Substitute $70\dot{\theta}_2$ for v_2 .

$$a = \frac{70\dot{\theta}_2 - v_1}{t}$$

Substitute 120 km/h for v_1 , 3 s for t , 5 m/s^2 for a .



Chapter 11, Problem 143P	3 Bookmarks	Show all steps: ON
--------------------------	-------------	--------------------

[Comments \(3\)](#)

Step 5 of 7

Calculate the angular acceleration of the car from the equation.

$$\alpha = \frac{\dot{\theta}_2 - \dot{\theta}_1}{t}$$

Substitute 0.6905 rad/s for $\dot{\theta}_2$, 0.4762 rad/s for $\dot{\theta}_1$ and 3 s for t .

$$\begin{aligned}\alpha &= \frac{0.6905 - 0.4762}{3} \\ &= 0.071433 \text{ rad/s}^2\end{aligned}$$

Calculate the final angular coordinate of the car from the equation,

$$\theta_2 = \dot{\theta}_1 t + \frac{1}{2} \alpha t^2$$

Substitute 0.071433 rad/s^2 for α , 0.4762 rad/s for $\dot{\theta}_1$, and 3 s for t .

$$\begin{aligned}\theta_2 &= 0.4762 \times 3 + \frac{1}{2} \times 0.071433 \times 3^2 \\ &= 1.75 \text{ radians} \times \frac{180^\circ}{\pi \text{ radians}} \\ &= 100.27^\circ\end{aligned}$$

[Comment](#)

Step 6 of 7

Substitute 70 m for r , 100.27° for θ , and 0.6905 rad/s for $\dot{\theta}$ in equation (2).

$$\begin{aligned}\vec{v} &= -r\dot{\theta} \sin \theta \mathbf{i} + r\dot{\theta} \cos \theta \mathbf{j} \\ &= -70 \times 0.6905 \times \sin 100.27^\circ \mathbf{i} + 70 \times 0.6905 \times \cos 100.27^\circ \mathbf{j} \\ &= -47.56 \mathbf{i} - 8.62 \mathbf{j}\end{aligned}$$

Therefore, the velocity of the particle is $\boxed{-47.56 \mathbf{i} - 8.62 \mathbf{j}}$.

[Comment](#)

Step 7 of 7

Substitute 70 m for r , 100.27° for θ , 0.071433 rad/s^2 for $\ddot{\theta}$, and 0.6905 rad/s for $\dot{\theta}$ in equation (3).

$$\begin{aligned}\vec{a} &= -r(\dot{\theta}^2 \cos \theta + \ddot{\theta} \sin \theta) \mathbf{i} + r(-\dot{\theta}^2 \sin \theta + \ddot{\theta} \cos \theta) \mathbf{j} \\ &= \begin{pmatrix} -70(0.6905^2 \cos 100.27 + 0.071433 \sin 100.27) \mathbf{i} \\ +70(-0.6905^2 \sin 100.27 + 0.071433 \cos 100.27) \mathbf{j} \end{pmatrix} \\ &= 1.0302 \mathbf{i} - 33.73 \mathbf{j}\end{aligned}$$

Therefore, the acceleration of the particle is $\boxed{1.0302 \mathbf{i} - 33.73 \mathbf{j}}$.

[Comment](#)

Was this solution helpful?

26

1

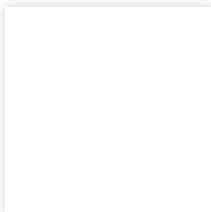
Chapter 11, Problem 143P	3 Bookmarks	Show all steps: ON
--------------------------	-------------	--------------------

Recommended solutions for you in Chapter 11

Chapter 11, Problem 186RP

Knowing that slider block A starts from rest and moves to the left with a constant acceleration of 1 ft/s^2 , determine (a) the...

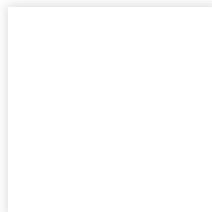
[See solution](#)



Chapter 11, Problem 59P

The system shown starts from rest, and each component moves with a constant acceleration. If the relative acceleration of block...

[See solution](#)



[See more problems in subjects you study](#)

COMPANY ▾

LEGAL & POLICIES ▾

CHEGG PRODUCTS AND SERVICES ▾

CHEGG NETWORK ▾

CUSTOMER SERVICE ▾



© 2003-2021 Chegg Inc. All rights reserved.