Chapter 5
Due: 11:59pm on Sunday, October 2, 2016

To understand how points are awarded, read the Grading Policy for this assignment.

A Mass on a Turntable: Conceptual

Description: An object is sitting on a rotating turntable. The student is asked for the direction of velocity, acceleration, and net force. Based on Mechanics Baseline Test.

A small metal cylinder rests on a circular turntable that is rotating at a constant rate, as illustrated in the diagram.

Part A

Which of the following sets of vectors best describes the velocity, acceleration, and net force acting on the cylinder at the point indicated in the diagram?

- a
- b
- c
- d
- e

**Hint 1. The direction of acceleration can be determined from Newton's second law**

According to Newton's second law, the acceleration of an object has the same direction as the net force acting on that object.
Part B

Let $R$ be the distance between the cylinder and the center of the turntable. Now assume that the cylinder is moved to a new location $R/2$ from the center of the turntable. Which of the following statements accurately describe the motion of the cylinder at the new location?

Check all that apply.

**Hint 1. Find the speed of the cylinder**

Find the speed $v$ of the cylinder at the new location. Assume that the cylinder makes one complete turn in a period of time $T$.

Express your answer in terms of $R$ and $T$.

ANSWER:

$\frac{\pi R}{T}$

Now compare your result with the speed of the cylinder before it is moved.

**Hint 2. Find the acceleration of the cylinder**

Find the magnitude of the acceleration $a$ of the cylinder at the new location. Assume that the cylinder makes one complete turn in a period of time $T$.

Express your answer in terms of $R$ and $T$.

**Hint 1. Centripetal acceleration**

Recall that the acceleration of an object that moves in a circular path of radius $r$ with constant speed $v$ has magnitude given by

$$a = \frac{v^2}{r}.$$ 

Note that both the velocity and radius of the trajectory change when the cylinder is moved.

ANSWER:
\[ a = \frac{2\pi^2 R}{T^2} \]

Now compare your result with the acceleration of the cylinder before it is moved.

ANSWER:

- The speed of the cylinder has decreased.
- The magnitude of the acceleration of the cylinder has decreased.

The Window Washer

**Description:** Window washer holding himself in place using pulleys and string attached to the platform he sits on.

A window washer of inertia \( M \) is sitting on a platform suspended by a system of cables and pulleys as shown. He is pulling on the cable with a force of magnitude \( F \). The cables and pulleys are ideal (massless and frictionless), and the platform has negligible inertia.

**Part A**

Find the magnitude of the minimum force \( F \) that allows the window washer to move upward.

**Express your answer in terms of the inertia \( M \) and the magnitude of the acceleration due to gravity \( g \).**

**Hint 1. Find a simple expression for the tension**

Find an expression for the tension \( T \) in the cable on which the man is pulling.

**Express your answer in terms of some or all of the variables \( M \), \( F \), and \( g \).**

ANSWER:
Hint 2. Upward force on the platform

The tension along the cable $T$ is equal to the force $F$. The 3 sections of the cable (strands) are separated by the pulleys. What is the force exerted on the platform $N$, by the pulley to the left of the diagram in the upward direction? Remember that the pulley to the left is supported by two strands of the cable.

Express your answer in terms of $T$, the tension in the cable.

ANSWER:

$$N = 2T$$

Hint 3. Upward forces on window washer

What forces pull the window washer upward?

ANSWER:

- A force equal to $F$ and a force equal to $Mg$
- A force equal to $F$ and the force exerted by the platform on the window washer equal to $N$.
- The force exerted by the platform on the window washer equal to $N$ and a force equal to $Mg$
- A force equal to $F$ and the force exerted by the platform on the window washer equal to $N$ and a force equal to $Mg$

Hint 4. All forces on window washer

What objects exert forces on the window washer?

ANSWER:

- Only the platform and the string being pulled
- Only the platform and Earth
- Only Earth and the cable supporting the platform
- Only the cable being pulled and the cable supporting the platform
- Only the platform; Earth; and the cable.

ANSWER:

$$F = \frac{Mg}{3}$$

Exercise 5.6
Description: A large wrecking ball is held in place by two light steel cables. (a) If the mass \( m \) of the wrecking ball is \( m \), what is the tension \( T_B \) in the cable that makes an angle of 40° with the vertical? (b) What is the tension \( T_A \) in the...

A large wrecking ball is held in place by two light steel cables.

**Part A**

If the mass \( m \) of the wrecking ball is 3900 kg, what is the tension \( T_B \) in the cable that makes an angle of 40° with the vertical?

**Express your answer to two significant figures and include the appropriate units.**

**ANSWER:**

\[
T_B = \frac{m \cdot 9.80}{\cos(40)} = 5.0 \times 10^4 \text{ N}
\]

Also accepted: \( \frac{m \cdot 9.80}{\cos(40)} = 4.99 \times 10^4 \text{ N}, \frac{m \cdot 9.81}{\cos(40)} = 4.99 \times 10^4 \text{ N}, \frac{m \cdot 9.80}{\cos(40)} = 5.0 \times 10^4 \text{ N} \)

**Part B**

What is the tension \( T_A \) in the horizontal cable?

**Express your answer to two significant figures and include the appropriate units.**

**ANSWER:**

\[
T_A = m \cdot 9.80 \tan(40) = 3.2 \times 10^4 \text{ N}
\]

Also accepted: \( m \cdot 9.80 \tan(40) = 3.21 \times 10^4 \text{ N}, m \cdot 9.81 \tan(40) = 3.21 \times 10^4 \text{ N}, m \cdot 9.80 \tan(40) = 3.2 \times 10^4 \text{ N} \)

**Exercise 5.8**

**Description:** A m-kg car is held in place by a light cable on a very smooth (frictionless) ramp, as shown in the figure. The cable makes an angle of 31.0 degree(s) above the surface of the ramp, and the ramp itself rises at 25.0 degree(s) above the horizontal. (...
A 1170-kg car is held in place by a light cable on a very smooth (frictionless) ramp, as shown in the figure. The cable makes an angle of 31.0° above the surface of the ramp, and the ramp itself rises at 25.0° above the horizontal.

Part A
Draw a free-body diagram for the car.

Draw the force vectors with their tails at the front bumper of the car. The location and orientation of your vectors will be graded. The exact length of your vectors will not be graded.

ANSWER:

Part B
Find the tension in the cable.

ANSWER:
Part C

How hard does the surface of the ramp push on the car?

ANSWER:

$$N = m \cdot 9.8 \cdot (0.906) - \frac{m \cdot 9.8 \cdot (0.423)}{0.857} \cdot (0.515) = 7470 \text{ N}$$

Exercise 5.15

Description: A load of bricks with mass $m_1$ hangs from one end of a rope that passes over a small, frictionless pulley. A counterweight of mass $m_2$ is suspended from the other end of the rope, as shown in the figure. The system is released from rest. Use $g \text{ m/s}^2$...

A load of bricks with mass $m_1 = 15.2 \text{ kg}$ hangs from one end of a rope that passes over a small, frictionless pulley. A counterweight of mass $m_2 = 28.2 \text{ kg}$ is suspended from the other end of the rope, as shown in the figure. The system is released from rest. Use $g = 9.80 \text{ m/s}^2$ for the magnitude of the acceleration due to gravity.

Part A

What is the magnitude of the upward acceleration of the load of bricks?

ANSWER:

$$\frac{m_2 - m_1}{m_2 + m_1}g = 2.94 \text{ m/s}^2$$

Part B

What is the tension in the rope while the load is moving?
Exercise 5.20 - Copy

Description: A w-N physics student stands on a bathroom scale in an m-kg (including the student) elevator that is supported by a cable. As the elevator starts moving, the scale reads N. (a) Find the magnitude of the acceleration of the elevator. (b) Find the...

A 586-N physics student stands on a bathroom scale in an 889-kg (including the student) elevator that is supported by a cable. As the elevator starts moving, the scale reads 437 N.

Part A

Find the magnitude of the acceleration of the elevator.

ANSWER:

\[ a = \frac{-N + w}{w} = -9.8 = 2.49 \text{ m/s}^2 \]

Part B

Find the direction of the acceleration of the elevator.

ANSWER:

- upwards
- downwards

Part C

What is the acceleration if the scale reads 631 N?

ANSWER:

\[ a = \frac{N_2 - w}{w} = -9.8 = 0.753 \text{ m/s}^2 \]

Part D

What is the tension in the cable in part A?

ANSWER:
Exercise 5.34

Description: Consider the system shown in the figure. Block A weighs $w_A$ and block B weighs $w_B$. Once block B is set into downward motion, it descends at a constant speed. (a) Calculate the coefficient of kinetic friction between block A and the tabletop. (b) A ...

Consider the system shown in the figure. Block A weighs 41.3 N and block B weighs 32.5 N. Once block B is set into downward motion, it descends at a constant speed.

Part A

Calculate the coefficient of kinetic friction between block A and the tabletop.

ANSWER:

\[ \mu = \frac{w_B}{w_A} = 0.787 \]

Part B

A cat, also of weight 41.3 N, falls asleep on top of block A. If block B is now set into downward motion, what is its acceleration magnitude?

ANSWER:

\[ a = \frac{-w_B + \frac{w_B}{w_A} (w_A + w_{cat})}{w_A + w_{cat} + w_B} - 9.8 = 2.77 \text{ m/s}^2 \]

Part C

A cat, also of weight 41.3 N, falls asleep on top of block A. If block B is now set into downward motion, what is its acceleration direction?
Exercise 5.48

Description: A flat (unbanked) curve on a highway has a radius of $R$. A car rounds the curve at a speed of $v$. (a) What is the minimum coefficient of static friction that will prevent sliding? (b) Suppose that the highway is icy and the coefficient of...

A flat (unbanked) curve on a highway has a radius of 225.0 m. A car rounds the curve at a speed of 24.0 m/s.

Part A

What is the minimum coefficient of static friction that will prevent sliding?

**ANSWER:**

$$\mu_{\text{min}} = \frac{v^2}{9.8R} = 0.261$$

Also accepted: $\frac{v^2}{9.81R} = 0.261$, $\frac{v^2}{9.8R} = 0.261$

Part B

Suppose that the highway is icy and the coefficient of friction between the tires and pavement is only one-third what you found in the previous part. What should be the maximum speed of the car so it can round the curve safely?

**Express your answer with the appropriate units.**

**ANSWER:**

$$v_{\text{max}} = v\sqrt{\frac{1}{3}} = 13.9 \frac{\text{m}}{\text{s}}$$

Exercise 5.51

Description: In one of the versions of the "Giant Swing", the seat is connected to two cables, one of which is horizontal. The seat swings in a horizontal circle at a rate of $f$. (a) If the seat weighs $w_1$ and a $w_2$-N person is sitting in it, find ...

In one of the versions of the "Giant Swing", the seat is connected to two cables, one of which is horizontal. The seat swings in a horizontal circle at a rate of 40.0 rev/min.
Part A

If the seat weighs 245 N and a 809-N person is sitting in it, find the tension in the horizontal cable.

Express your answer with the appropriate units.

**ANSWER:**

\[ T_1 = \frac{w_1 + w_2}{9.8} \cdot 4\pi^2 \cdot 7.5 f^2 - (w_1 + w_2) \tan(40) = 1.33 \times 10^4 \text{ N} \]

Also accepted: \( \frac{w_1 + w_2}{9.8} \cdot 4\pi^2 \cdot 7.5 f^2 - (w_1 + w_2) \tan(40) = 1.33 \times 10^4 \text{ N} \), \( \frac{w_1 + w_2}{9.8} \cdot 4\pi^2 \cdot 7.5 f^2 - (w_1 + w_2) \tan(40) = 1.33 \times 10^4 \text{ N} \)

Part B

Find the tension in the inclined cable.

Express your answer with the appropriate units.

**ANSWER:**

\[ T_2 = \frac{w_1 + w_2}{\cos(40)} = 1380 \text{ N} \]

**Exercise 5.53**

**Description:** One problem for humans living in outer space is that they are apparently weightless. One way around this problem is to design a space station that spins about its center at a constant rate. This creates "artificial gravity" at the outside rim of the station.

One problem for humans living in outer space is that they are apparently weightless. One way around this problem is to design a space station that spins about its center at a constant rate. This creates "artificial gravity" at the outside rim of the station.
Part A

If the diameter of the space station is 700 m, how many revolutions per minute are needed for the "artificial gravity" acceleration to be 9.80 m/s²?

ANSWER:

\[ f = \frac{60}{2\pi \sqrt{\frac{d}{2g}}} = 1.60 \text{ rev/min} \]

Part B

If the space station is a waiting area for travelers going to Mars, it might be desirable to simulate the acceleration due to gravity on the Martian surface (3.70 m/s²). How many revolutions per minute are needed in this case?

ANSWER:

\[ f = \frac{60}{2\pi \sqrt{\frac{d}{2g}}} = 0.982 \text{ rev/min} \]

Problem 5.62

Description: In the figure a worker lifts a weight \( w \) by pulling down on a rope with a force \( \vec{F} \). The upper pulley is attached to the ceiling by a chain, and the lower pulley is attached to the weight by another chain. The weight is lifted at constant speed...

In the figure a worker lifts a weight \( w \) by pulling down on a rope with a force \( \vec{F} \). The upper pulley is attached to the ceiling by a chain, and the lower pulley is attached to the weight by another chain. The weight is lifted at constant speed. Assume that the rope, pulleys, and chains all have negligible weights.

Part A

In terms of \( w \), find the tension in the lower chain.

ANSWER:
Part B

In terms of $w$, find the tension in upper chain.

ANSWER:

$$w$$

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Part C

In terms of $w$, find the magnitude of the force $\vec{F}$ if the weight is lifted at constant speed.

ANSWER:

$$\frac{w}{2}$$

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Problem 5.79

**Description:** Block A in weighs $w_1$, and block B weighs $w_2$. The coefficient of kinetic friction between all surfaces is $\mu_k$. (a) Find the magnitude of the horizontal force $\vec{F}_{\text{vec}}$ necessary to drag block B to the left at constant speed if A rests on B...

Block A in weighs 1.20 N, and block B weighs 3.65 N. The coefficient of kinetic friction between all surfaces is 0.300.

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Part A

Find the magnitude of the horizontal force $\vec{F}$ necessary to drag block B to the left at constant speed if A rests on B and moves with it (figure (a)).

Express your answer with the appropriate units.

ANSWER:
Part B

Find the magnitude of the horizontal force $\vec{F}$ necessary to drag block $B$ to the left at constant speed if $A$ is held at rest (figure (b)).

Express your answer with the appropriate units.

ANSWER:

\[
\vec{F} = \mu_k (w_1 + w_2) + \mu_k w_1 = 1.82 \text{N}
\]

Problem 5.90

Description: Two blocks connected by a cord passing over a small, frictionless pulley rest on frictionless planes (the figure). (a) Which way will the system move when the blocks are released from rest? (b) What is the acceleration of the blocks? (c) What is...

Two blocks connected by a cord passing over a small, frictionless pulley rest on frictionless planes (the figure).

Part A

Which way will the system move when the blocks are released from rest?

ANSWER:

- the blocks will slide to the left
- the blocks will slide to the right

Part B

What is the acceleration of the blocks?
Part C

What is the tension in the cord?

ANSWER:

\[ T = 424 \text{ N} \]

Problem 5.105

**Description:** On the ride "Spindletop" at the amusement park Six Flags Over Texas, people stood against the inner wall of a hollow vertical cylinder with radius 2.5 m. The cylinder started to rotate, and when it reached a constant rotation rate of 0.60 rev/s, the floor on which people were standing dropped about 0.5 m. The people remained pinned against the wall.

On the ride "Spindletop" at the amusement park Six Flags Over Texas, people stood against the inner wall of a hollow vertical cylinder with radius 2.5 m. The cylinder started to rotate, and when it reached a constant rotation rate of 0.60 rev/s, the floor on which people were standing dropped about 0.5 m. The people remained pinned against the wall.

**Part A**

Draw a force diagram for a person on this ride, after the floor has dropped. (Assume the vertical axis of the cylinder to be at the left.)

**Draw the force vectors with their tails at the dot. The orientation of your vectors will be graded. The exact length of your vectors will not be graded but the relative length of one to the other will be graded.**

ANSWER:
Part B

What minimum coefficient of static friction is required if the person on the ride is not to slide downward to the new position of the floor?

Express your answer using two significant figures.

ANSWER:

$$\mu_{\text{min}} = 0.28$$

Part C

Does your answer in part B depend on the mass of the passenger? (Note: When the ride is over, the cylinder is slowly brought to rest. As it slows down, people slide down the walls to the floor.)

ANSWER:

- yes
- no

Problem 5.107 - Copy

Description: A small bead can slide without friction on a circular hoop that is in a vertical plane and has a radius of 0.100 m. The hoop rotates at a constant rate of $f$ about a vertical diameter (the figure). (a) Find the angle $\beta$ at which the bead is in...
A small bead can slide without friction on a circular hoop that is in a vertical plane and has a radius of 0.100 m. The hoop rotates at a constant rate of 3.40 rev/s about a vertical diameter (the figure).

Part A

Find the angle $\beta$ at which the bead is in vertical equilibrium. (Of course, it has a radial acceleration toward the axis.)

ANSWER:

\[
\beta = \arccos \left( \frac{\frac{5\pi}{12}}{0.100} \right) \cdot \frac{180}{\pi} = 77.6^\circ
\]

Part B

Is it possible for the bead to "ride" at the same elevation as the center of the hoop?

ANSWER:

- [ ] yes
- [x] no