February 18, Week 6

Today: Chapter 4, Forces

Exam #1 is in mailboxes

Homework Assignment #5 - Due March 1.

Mastering Physics: 10 problems from chapters 4 and 5.

Written Questions: 5.74

Help sessions with Jonathan:

M: 1000-1100, RH 111 T: 1000-1100, RH 114
Th: 0900-1000, RH 114

Force Examples

Forces to be identified in any problem:

Force Examples

Forces to be identified in any problem:

Weight - $\vec{\mathbf{w}}$

Force Examples

Forces to be identified in any problem:

Weight - $\vec{\mathbf{w}}$, the downward force on an object due to gravity.

Force Examples

Forces to be identified in any problem:

Weight - $\vec{\mathbf{w}}$, the downward force on an object due to gravity.

Normal Force - $\vec{\mathbf{n}}$

Force Examples

Forces to be identified in any problem:

Weight - $\vec{\mathbf{w}}$, the downward force on an object due to gravity.

Normal Force - $\vec{\mathbf{n}}$, the perpendicular force exerted by one solid object onto another solid object.

Force Examples

Forces to be identified in any problem:

Weight - $\vec{\mathbf{w}}$, the downward force on an object due to gravity.

Normal Force - $\vec{\mathbf{n}}$, the perpendicular force exerted by one solid object onto another solid object.

Friction - $\vec{\mathbf{f}}$

Force Examples

Forces to be identified in any problem:

Weight - $\vec{\mathbf{w}}$, the downward force on an object due to gravity.

Normal Force - $\vec{\mathbf{n}}$, the perpendicular force exerted by one solid object onto another solid object.

Friction - $\vec{\mathbf{f}}$, force which slows a moving object, always opposed to the motion $\Rightarrow$ opposite to $\vec{\mathbf{v}}$.

Force Examples

Forces to be identified in any problem:

Weight - $\vec{\mathbf{w}}$, the downward force on an object due to gravity.

Normal Force - $\vec{\mathbf{n}}$, the perpendicular force exerted by one solid object onto another solid object.

Friction - $\vec{\mathbf{f}}$, force which slows a moving object, always opposed to the motion $\Rightarrow$ opposite to $\vec{\mathbf{v}}$.

Tension - $\vec{\mathbf{T}}$

Force Examples

Forces to be identified in any problem:

Weight - $\vec{\mathbf{w}}$, the downward force on an object due to gravity.

Normal Force - $\vec{\mathbf{n}}$, the perpendicular force exerted by one solid object onto another solid object.

Friction - $\vec{\mathbf{f}}$, force which slows a moving object, always opposed to the motion $\Rightarrow$ opposite to $\vec{\mathbf{v}}$.

Tension - $\vec{\mathbf{T}}$, pulling force exerted by rope, chain, or spring, always at same angle as rope.

Newton's First Law

First Law - The Law of Inertia

An object at rest stays at rest, an object in uniform motion stays if uniform motion if (and only if) the net force acting on the object is zero.

Newton’s First Law

First Law - The Law of Inertia

An object at rest stays at rest, an object in uniform motion stays if uniform motion if (and only if) the net force acting on the object is zero.

Uniform motion - Straight line and constant speed, *i.e*, constant velocity.

Newton's First Law

First Law - The Law of Inertia

An object at rest stays at rest, an object in uniform motion stays if uniform motion if (and only if) the net force acting on the object is zero.

Uniform motion - Straight line and constant speed, *i.e*, constant velocity.

Inertia - The property of all matter to stay in motion if already in motion; to stay at rest if already at rest.

First Law Example

Example: A $6860\,N$ car is traveling with a constant $30\,m/s$ speed on a straight road. If the ground is exerting a forward $350\,N$ force*, what is the magnitude and direction of all forces acting on the car? (* We'll learn later that this is due to the car's engine.)

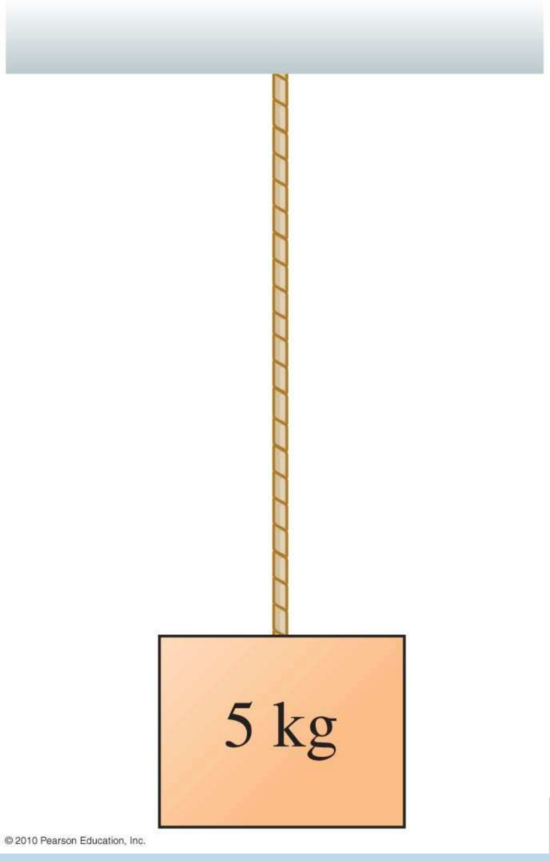
First Law Example

Example: A $6860\,N$ car is traveling with a constant $30\,m/s$ speed on a straight road. If the ground is exerting a forward $350\,N$ force*, what is the magnitude and direction of all forces acting on the car? (* We'll learn later that this is due to the car's engine.)

Free-Body Diagram - f. b. d. sketch of all the *forces* acting on an object using a convenient coordinate system.

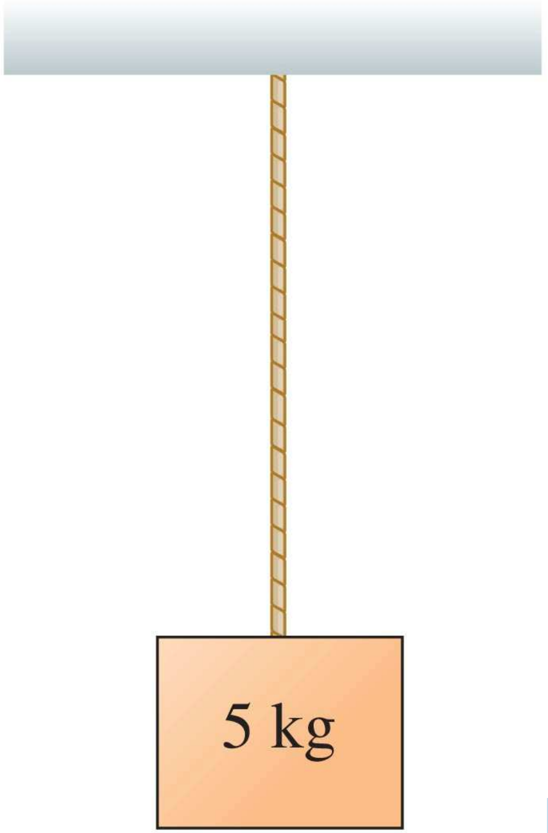
First Law Exercise

A $5\,kg$ mass is hung from the ceiling using a "massless" rope. What is the magnitude of the tension force exerted by the rope on the mass? **Hint:** A $5\,kg$ mass has a weight of $49\,N$ on earth where this problem is taking place.



First Law Exercise

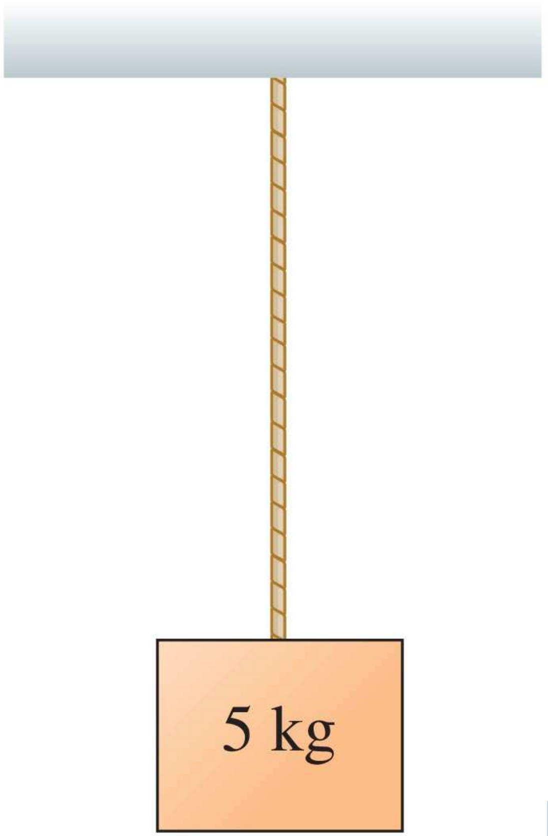
A $5\,kg$ mass is hung from the ceiling using a "massless" rope. What is the magnitude of the tension force exerted by the rope on the mass? **Hint:** A $5\,kg$ mass has a weight of $49\,N$ on earth where this problem is taking place.



(a) $0\,N$

First Law Exercise

A $5\,kg$ mass is hung from the ceiling using a "massless" rope. What is the magnitude of the tension force exerted by the rope on the mass? **Hint:** A $5\,kg$ mass has a weight of $49\,N$ on earth where this problem is taking place.

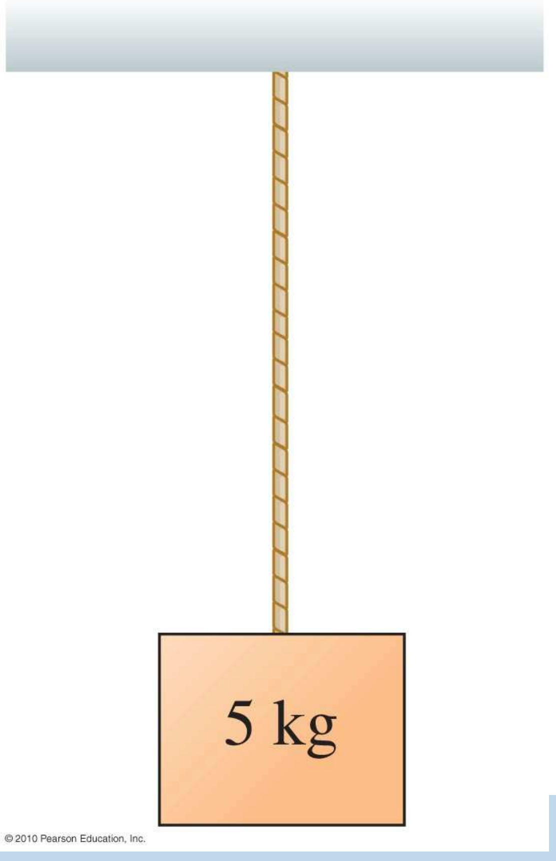


(a) $0\,N$

(b) $24.5\,N$

First Law Exercise

A $5\,kg$ mass is hung from the ceiling using a "massless" rope. What is the magnitude of the tension force exerted by the rope on the mass? **Hint:** A $5\,kg$ mass has a weight of $49\,N$ on earth where this problem is taking place.



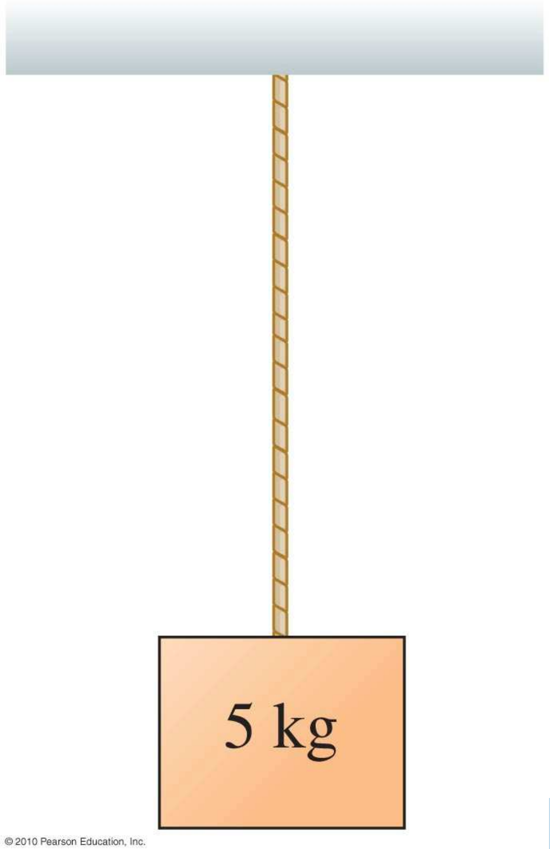
(a) $0\,N$

(b) $24.5\,N$

(c) $49\,N$

First Law Exercise

A $5\,kg$ mass is hung from the ceiling using a "massless" rope. What is the magnitude of the tension force exerted by the rope on the mass? **Hint:** A $5\,kg$ mass has a weight of $49\,N$ on earth where this problem is taking place.



(a) $0\,N$

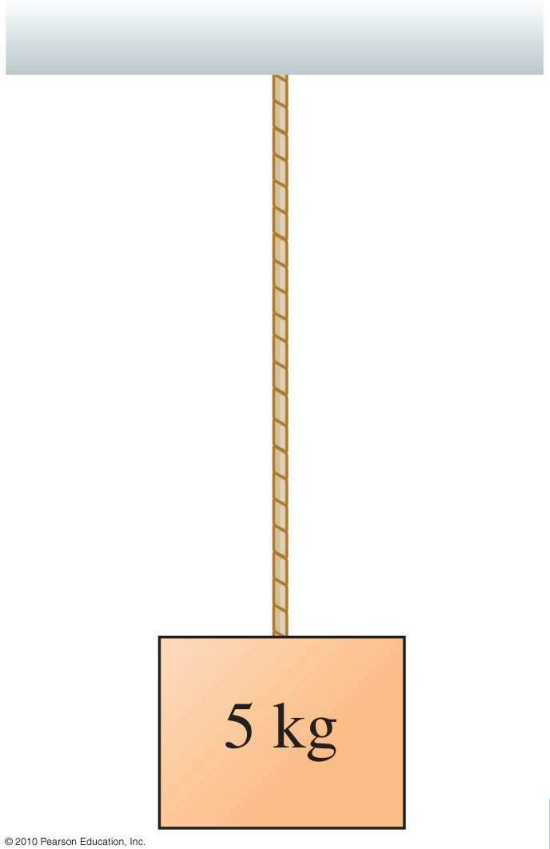
(b) $24.5\,N$

(c) $49\,N$

(d) $98\,N$

First Law Exercise

A $5\,kg$ mass is hung from the ceiling using a "massless" rope. What is the magnitude of the tension force exerted by the rope on the mass? **Hint:** A $5\,kg$ mass has a weight of $49\,N$ on earth where this problem is taking place.



(a) $0\,N$

(b) $24.5\,N$

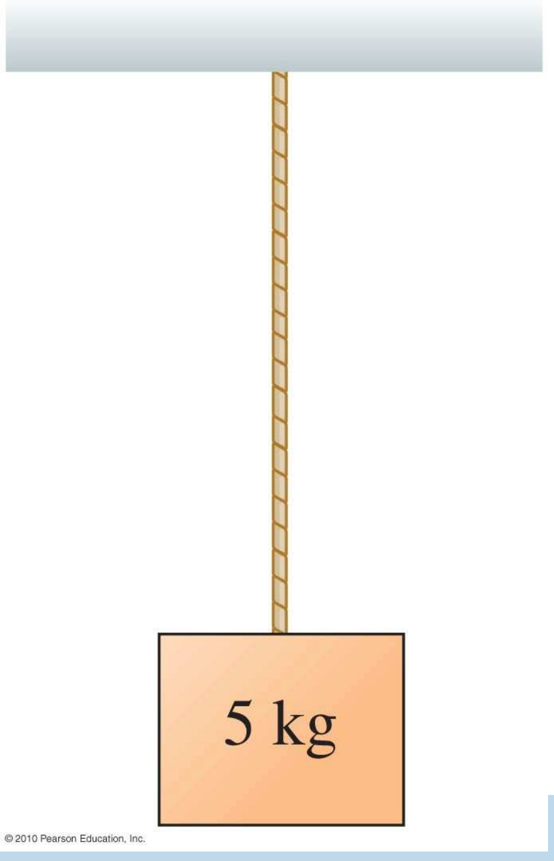
(c) $49\,N$

(d) $98\,N$

(e) Not enough information to determine

First Law Exercise

A $5\,kg$ mass is hung from the ceiling using a "massless" rope. What is the magnitude of the tension force exerted by the rope on the mass? **Hint:** A $5\,kg$ mass has a weight of $49\,N$ on earth where this problem is taking place.



(a) $0\,N$

(b) $24.5\,N$

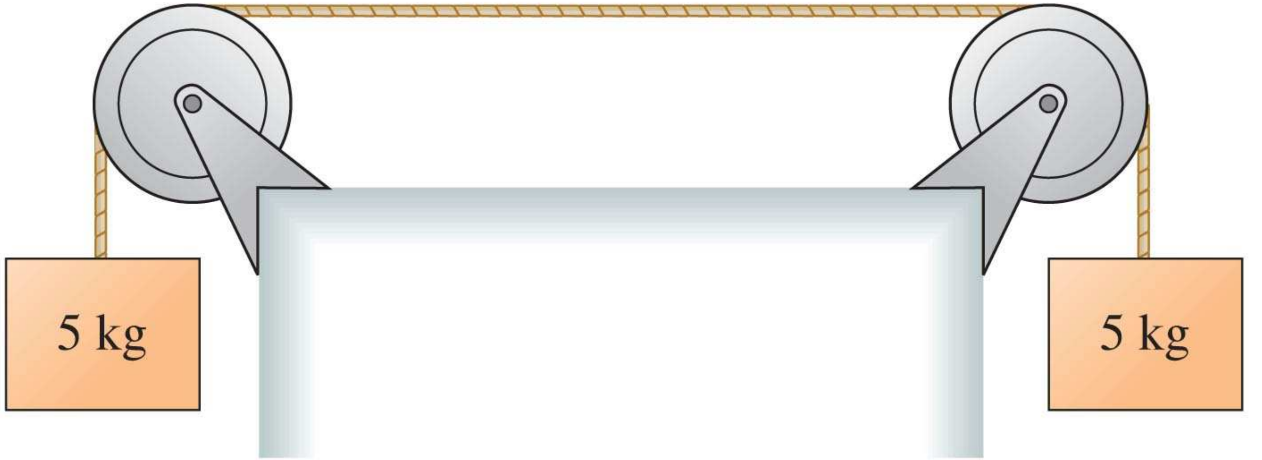
(c) $49\,N$

(d) $98\,N$

(e) Not enough information to determine

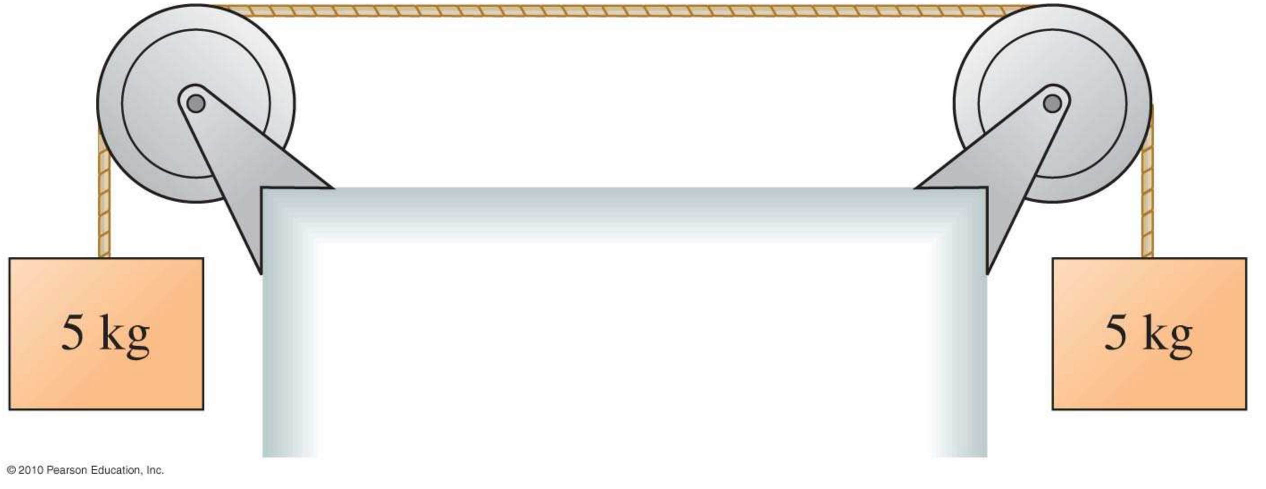
First Law Exercise

Two $5\,kg$ masses are connected to each over pulleys using a rope. What is the tension force that the rope exerts on the right-hand mass if they are both at rest?



First Law Exercise

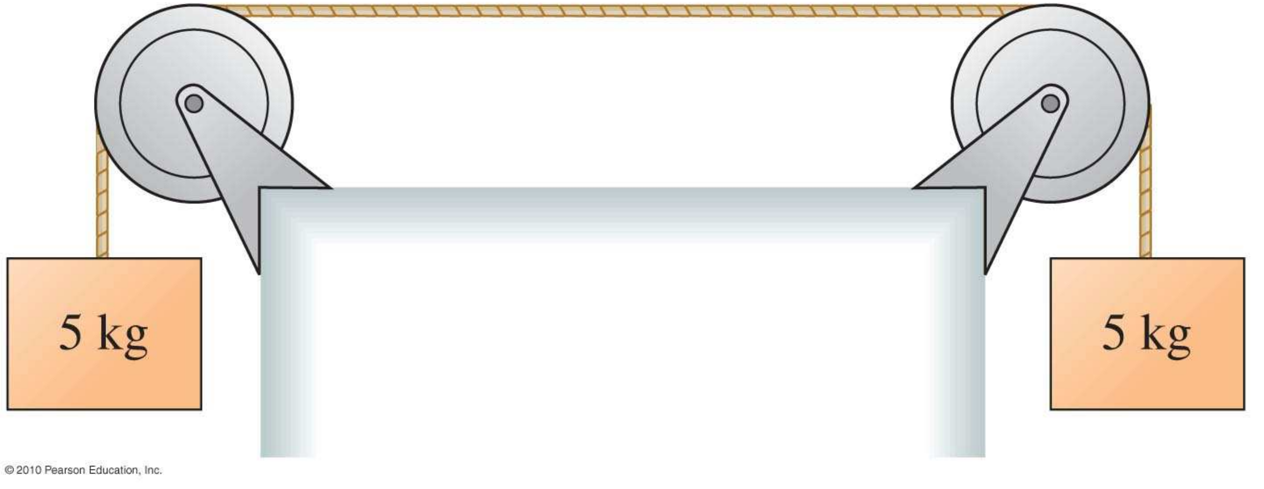
Two $5\,kg$ masses are connected to each over pulleys using a rope. What is the tension force that the rope exerts on the right-hand mass if they are both at rest?



(a) $0\,N$

First Law Exercise

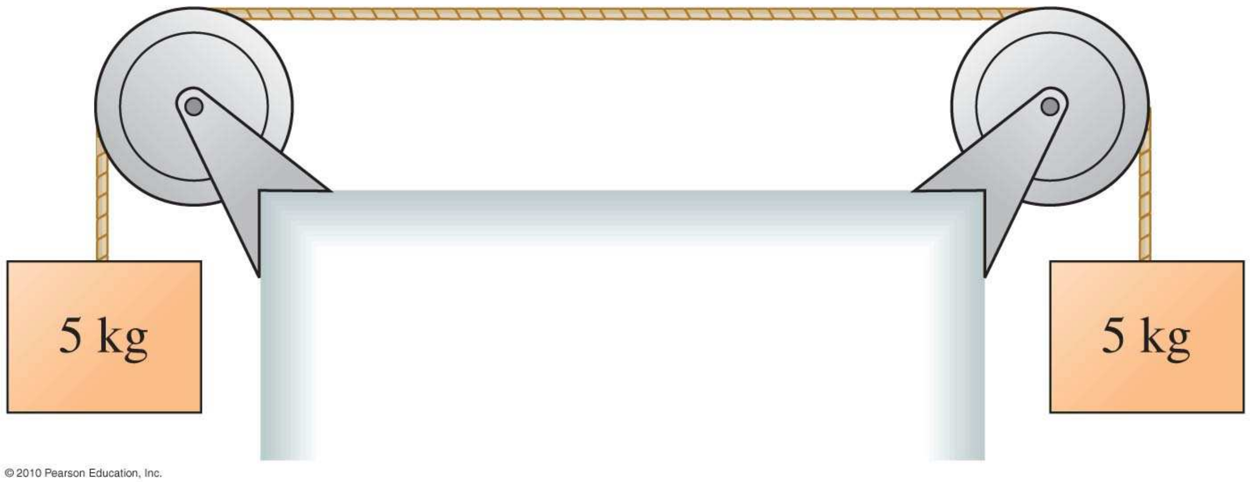
Two $5\,kg$ masses are connected to each over pulleys using a rope. What is the tension force that the rope exerts on the right-hand mass if they are both at rest?



(a) $0\,N$ (b) $24.5\,N$

First Law Exercise

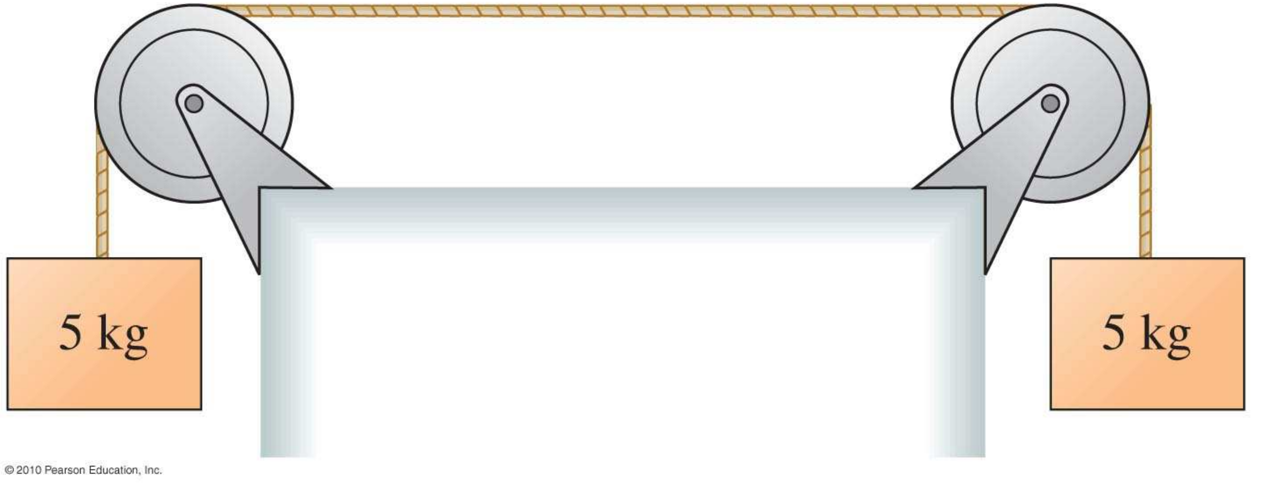
Two $5\,kg$ masses are connected to each over pulleys using a rope. What is the tension force that the rope exerts on the right-hand mass if they are both at rest?



(a) $0\,N$ (b) $24.5\,N$ (c) $49\,N$

First Law Exercise

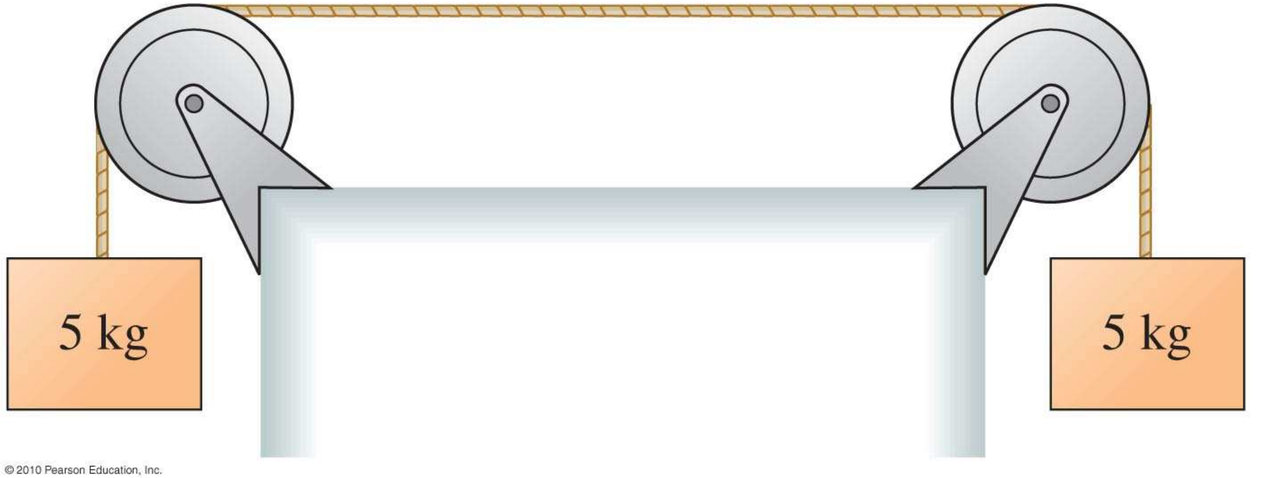
Two $5\,kg$ masses are connected to each over pulleys using a rope. What is the tension force that the rope exerts on the right-hand mass if they are both at rest?



(a) $0\,N$ (b) $24.5\,N$ (c) $49\,N$ (d) $98\,N$

First Law Exercise

Two $5\,kg$ masses are connected to each over pulleys using a rope. What is the tension force that the rope exerts on the right-hand mass if they are both at rest?

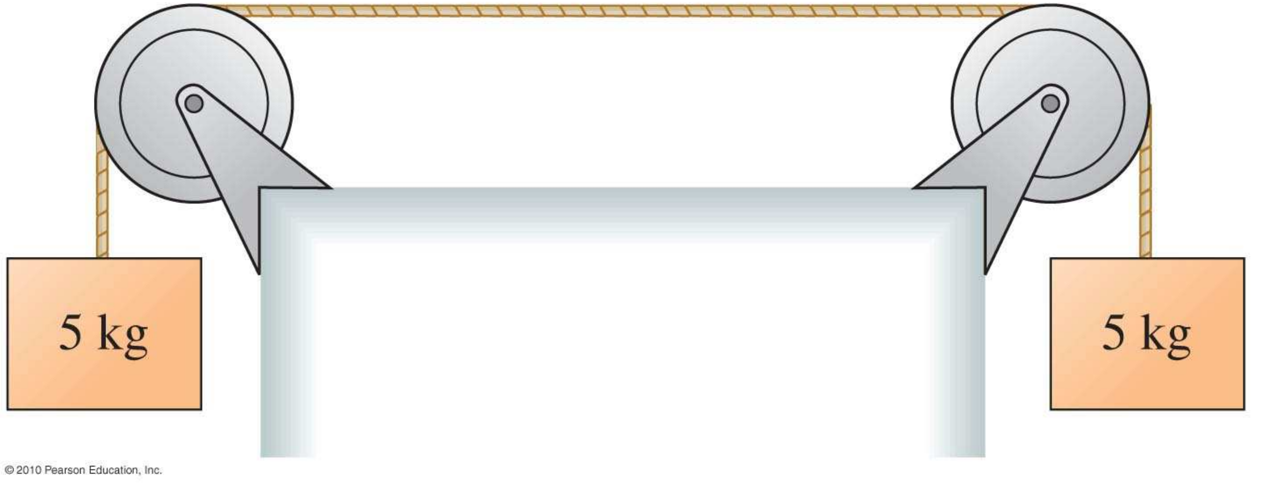


(a) $0\,N$ (b) $24.5\,N$ (c) $49\,N$ (d) $98\,N$

(e) Not enough information to determine

First Law Exercise

Two $5\,kg$ masses are connected to each over pulleys using a rope. What is the tension force that the rope exerts on the right-hand mass if they are both at rest?



(a) $0\,N$ (b) $24.5\,N$ (c) $49\,N$ (d) $98\,N$

(e) Not enough information to determine

Newton's Second Law

The first law tells us that if $\Sigma\overrightarrow{\mathbf{F}} = 0$ then we have a constant $\overrightarrow{\mathbf{v}}$

Newton’s Second Law

The first law tells us that if $\Sigma\overrightarrow{\mathbf{F}} = 0$ then we have a constant $\overrightarrow{\mathbf{v}}$

Constant $\overrightarrow{\mathbf{v}} \Rightarrow \overrightarrow{\mathbf{a}} = 0$.

Newton's Second Law

The first law tells us that if $\Sigma\overrightarrow{\mathbf{F}} = 0$ then we have a constant $\overrightarrow{\mathbf{v}}$

Constant $\overrightarrow{\mathbf{v}} \Rightarrow \overrightarrow{\mathbf{a}} = 0$.

So if $\Sigma\overrightarrow{\mathbf{F}} \neq 0 \Rightarrow ?$

Newton’s Second Law

The first law tells us that if $\Sigma\overrightarrow{\mathbf{F}} = 0$ then we have a constant $\overrightarrow{\mathbf{v}}$

Constant $\overrightarrow{\mathbf{v}} \Rightarrow \overrightarrow{\mathbf{a}} = 0$.

So if $\Sigma\overrightarrow{\mathbf{F}} \neq 0 \Rightarrow \overrightarrow{\mathbf{a}} \neq 0$.

Newton's Second Law

The first law tells us that if $\Sigma\overrightarrow{\mathbf{F}} = 0$ then we have a constant $\overrightarrow{\mathbf{v}}$

Constant $\overrightarrow{\mathbf{v}} \Rightarrow \overrightarrow{\mathbf{a}} = 0$.

So if $\Sigma\overrightarrow{\mathbf{F}} \neq 0 \Rightarrow \overrightarrow{\mathbf{a}} \neq 0$.

Forces cause acceleration

Newton's Second Law

The first law tells us that if $\Sigma\overrightarrow{\mathbf{F}} = 0$ then we have a constant $\overrightarrow{\mathbf{v}}$

Constant $\overrightarrow{\mathbf{v}} \Rightarrow \overrightarrow{\mathbf{a}} = 0$.

So if $\Sigma\overrightarrow{\mathbf{F}} \neq 0 \Rightarrow \overrightarrow{\mathbf{a}} \neq 0$.

Forces cause acceleration

Newton found that the acceleration is:

Newton's Second Law

The first law tells us that if $\Sigma\overrightarrow{\mathbf{F}} = 0$ then we have a constant $\overrightarrow{\mathbf{v}}$

Constant $\overrightarrow{\mathbf{v}} \Rightarrow \overrightarrow{\mathbf{a}} = 0$.

So if $\Sigma\overrightarrow{\mathbf{F}} \neq 0 \Rightarrow \overrightarrow{\mathbf{a}} \neq 0$.

Forces cause acceleration

Newton found that the acceleration is:

(a) In the same direction as the net force

Newton's Second Law

The first law tells us that if $\Sigma\overrightarrow{\mathbf{F}} = 0$ then we have a constant $\overrightarrow{\mathbf{v}}$

Constant $\overrightarrow{\mathbf{v}} \Rightarrow \overrightarrow{\mathbf{a}} = 0$.

So if $\Sigma\overrightarrow{\mathbf{F}} \neq 0 \Rightarrow \overrightarrow{\mathbf{a}} \neq 0$.

Forces cause acceleration

Newton found that the acceleration is:

(a) In the same direction as the net force

(b) Directly proportional to the net force

Newton's Second Law

The first law tells us that if $\Sigma\overrightarrow{\mathbf{F}} = 0$ then we have a constant $\overrightarrow{\mathbf{v}}$

Constant $\overrightarrow{\mathbf{v}} \Rightarrow \overrightarrow{\mathbf{a}} = 0$.

So if $\Sigma\overrightarrow{\mathbf{F}} \neq 0 \Rightarrow \overrightarrow{\mathbf{a}} \neq 0$.

Forces cause acceleration

Newton found that the acceleration is:

(a) In the same direction as the net force

(b) Directly proportional to the net force

(c) Inversely proportional to the mass

Newton's Second Law

The first law tells us that if $\Sigma\overrightarrow{\mathbf{F}} = 0$ then we have a constant $\overrightarrow{\mathbf{v}}$

Constant $\overrightarrow{\mathbf{v}} \Rightarrow \overrightarrow{\mathbf{a}} = 0$.

So if $\Sigma\overrightarrow{\mathbf{F}} \neq 0 \Rightarrow \overrightarrow{\mathbf{a}} \neq 0$.

Forces cause acceleration

Newton found that the acceleration is:

(a) In the same direction as the net force

(b) Directly proportional to the net force

(c) Inversely proportional to the mass

Measure of the amount of matter inside an object

Second Law II

$$\vec{\mathbf{a}} = \frac{\Sigma \vec{\mathbf{F}}}{M}$$

Second Law II

$$\vec{\mathbf{a}} = \frac{\Sigma \vec{\mathbf{F}}}{M} \Rightarrow \boxed{\Sigma \vec{\mathbf{F}} = M \vec{\mathbf{a}}}$$

Second Law II

$$\vec{\mathbf{a}} = \frac{\Sigma\vec{\mathbf{F}}}{M} \Rightarrow \boxed{\Sigma\vec{\mathbf{F}} = M\vec{\mathbf{a}}}$$

Units: Newton is a unit simplification.

Second Law II

$$\vec{\mathbf{a}} = \frac{\Sigma \vec{\mathbf{F}}}{M} \Rightarrow \boxed{\Sigma \vec{\mathbf{F}} = M \vec{\mathbf{a}}}$$

Units: Newton is a unit simplification.

$$Ma$$

Second Law II

$$\overrightarrow{\mathbf{a}} = \frac{\Sigma \overrightarrow{\mathbf{F}}}{M} \Rightarrow \boxed{\Sigma \overrightarrow{\mathbf{F}} = M \overrightarrow{\mathbf{a}}}$$

Units: Newton is a unit simplification.

$$Ma \Rightarrow kg \cdot m/s^2$$

Second Law II

$$\overrightarrow{\mathbf{a}} = \frac{\Sigma \overrightarrow{\mathbf{F}}}{M} \Rightarrow \boxed{\Sigma \overrightarrow{\mathbf{F}} = M \overrightarrow{\mathbf{a}}}$$

Units: Newton is a unit simplification.

$$Ma \Rightarrow kg \cdot m/s^2$$

$$\Sigma F$$

Second Law II

$$\vec{\mathbf{a}} = \frac{\Sigma \vec{\mathbf{F}}}{M} \Rightarrow \boxed{\Sigma \vec{\mathbf{F}} = M \vec{\mathbf{a}}}$$

Units: Newton is a unit simplification.

$$Ma \Rightarrow kg \cdot m/s^2$$

$$\Sigma F \Rightarrow N$$

Second Law II

$$\overrightarrow{\mathbf{a}} = \frac{\Sigma \overrightarrow{\mathbf{F}}}{M} \Rightarrow \boxed{\Sigma \overrightarrow{\mathbf{F}} = M \overrightarrow{\mathbf{a}}}$$

Units: Newton is a unit simplification.

$$Ma \Rightarrow kg \cdot m/s^2$$

$$\Sigma F \Rightarrow N$$

$$\boxed{N = kg \cdot m/s^2}$$

Second Law Examples

Example: A $6860\,N$ car is in free-fall, what it its mass?

Second Law Examples

Example: A $6860\,N$ car is in free-fall, what it its mass?

Example: A $6860\,N$ car is sitting stationary on the ground, what is its mass?

Second Law Examples

Example: A $6860\,N$ car is in free-fall, what it its mass?

Example: A $6860\,N$ car is sitting stationary on the ground, what is its mass?

$$\boxed{w = Mg}$$