Chapter 5

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The laws of motion

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Lecture 02

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Some Particular Forces

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Some Particular Forces

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- The Gravitational Force
- The Normal Force
- Forces of Tension

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The Gravitational Force

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The gravitational force, $\vec{F_g}$, is the force that the earth exerts on an object.

This force is directed toward the center of the earth (downward).

From Newton's Second Law:

$$\vec{F_g} = m\vec{g}$$

Its magnitude is called the weight of the object.

- $Weight = |\vec{F_g}| = mg$
- SI units of weight are Newton
- Kilogram is NOT a unit of weight.

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More About Weight

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Because it is dependent on g, the weight varies with location.

- g, and therefore the weight, is less at higher altitudes.
- This can be extended to other planets.

Weight is not an inherent property of the object.

- The weight is a property of a *system* of items: the object and the Earth.

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The Normal Force, $\vec{n}$

6

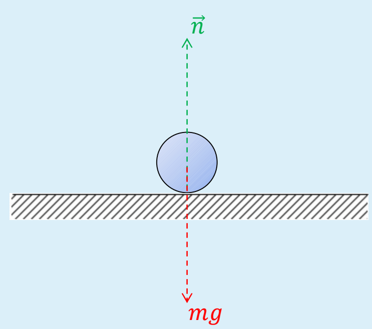
Whenever an object rests on a surface, the surface pushes on the object with a force called the normal force.

Normal means perpendicular.

The normal force is the force that prevents the object from falling through the surface.

It is always perpendicular to the surface.

It is NOT always equals the weight.



6

Forces of Tension, $\vec{T}$

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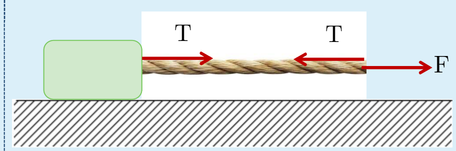
When a rope is attached to a body and pulled, the rope is said to be in tension.

The rope's function is to transfer force between two bodies.

The tension in the rope is defined as the force that the rope exerts on the body.



7

One - and two - dimensional forces

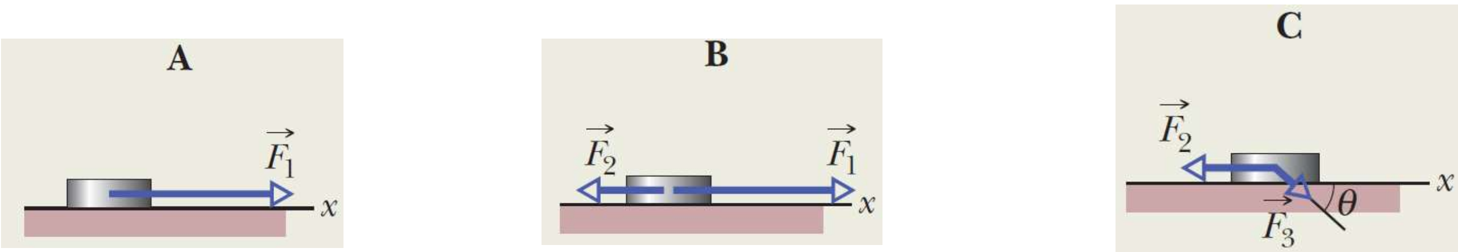
Saturday, 30 January, 2021 12:30

Lecturer: Mustafa Al-Zyout, Philadelphia University, Jordan.

R. A. Serway and J. W. Jewett, Jr., *Physics for Scientists and Engineers*, 9th Ed., CENGAGE Learning, 2014.
J. Walker, D. Halliday and R. Resnick, *Fundamentals of Physics*, 10th ed., WILEY,2014.
H. D. Young and R. A. Freedman, *University Physics with Modern Physics*, 14th ed., PEARSON, 2016.
H. A. Radi and J. O. Rasmussen, *Principles of Physics For Scientists and Engineers*, 1st ed., SPRINGER, 2013.

Parts A, B, and C of the figure show three situations in which one or two forces act on a puck that moves over frictionless ice along an x axis. The puck's mass is $m = 0.2\ kg$. Forces $\vec{F}_1$ and $\vec{F}_2$ are directed along the axis and have magnitudes $F_1 = 4\ N$ and $F_2 = 2\ N$. Force $\vec{F}_3$ is directed at angle $\theta = 30^\circ$ and has magnitude $F_3 = 1\ N$. In each situation:

- what is the acceleration of the puck,
- what is the normal force?



Solution

In each situation we can relate the acceleration to the net force acting on the puck with Newton's second law $\sum \vec{F} = m\vec{a}$. However, because the motion is along only the x axis, we can simplify each situation by writing the second law for x components only:

$\sum \vec{F}_x = m\vec{a}_x$.

Also, because the normal force is along only the y axis, and there is NO motion along this axis, we can simplify each situation by writing the second law for y components only:

$\sum \vec{F}_y = 0$.

Situation A

(1) $F_1 = ma_x \Rightarrow a_x = \dfrac{F_1}{m} = \dfrac{4.0N}{0.20kg} = 20m/s^2$

The positive answer indicates that the acceleration is in the positive direction of the x axis.

(2) $n - mg = 0 \Rightarrow n = mg = 0.2 \times 9.8 = 1.96N$

Situation B

$\vec{F}_1$in the positive direction of x and $\vec{F}_2$ in the negative direction. Thus:

(1) $F_1 - F_2 = ma_x \Rightarrow a_x = \dfrac{F_1 - F_2}{m} = \dfrac{4.0N - 2.0N}{0.20kg} = 10m/s^2$

Thus, the net force accelerates the puck in the positive direction of the x axis.

(2) $n - mg = 0 \Rightarrow n = mg = 0.2 \times 9.8 = 1.96N$

Situation C

Force $\vec{F}_3$ is not directed along the direction of the puck's acceleration; only x component $\vec{F}_{3,x}$ is. (Force $\vec{F}_3$ is two dimensional but the motion is only one dimensional). Thus:

(1) $F_{3,x} - F_2 = ma_x \Rightarrow a_x = \frac{F_{3,x} - F_2}{m} = \frac{F_3 \cos\theta - F_2}{m}$

$\Rightarrow a_x = \frac{(1.0N)(\cos 30°) - 2.0N}{0.20kg} = -5.7m/s^2$

Thus, the net force accelerates the puck in the negative direction of the x axis.

(2) $n - mg - F_3 \sin\theta = 0 \Rightarrow n = mg + F_3 \sin\theta = (0.2 \times 9.8) + (1 \times \sin 3\,0°) = 2.46N$