PHY 107
Force and Motion 1

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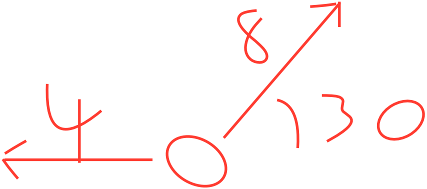
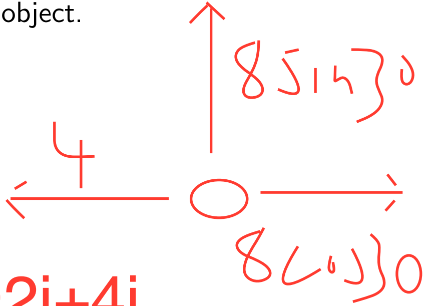
OUTLINE

- Force in Newtonian mechanics
- Newton's First Law and Inertial Frame
- Newton's Second Law
- Some particular forces
- Newton's Third Law
- Application/Examples

Force in Newtonian Mechanics

What can cause an object to accelerate?
Force (a push or a pull on the object)
Force will change the velocity of that object.





R= 2.92i+4j

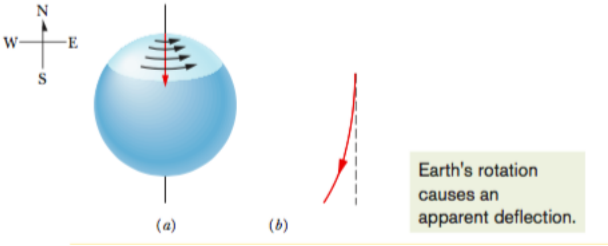
Newton's First Law and Inertial Frame

If no net force acts on a body ($\overrightarrow{F_{net}} = 0$), the body's velocity cannot change, the body can't accelerate.

There may be multiple forces acting on a body, but if their net force is zero, the body can't accelerate

Inertial Frame: One in which Newton's Laws hold e.g. ground is an inertial frame provided we can ignore Earth's astronomical motions (such as its rotation)

Puck sliding:



Newton's Second Law

The net force on a body is equal to the product of the body's mass and acceleration.

We draw a free-body diagram in which the only body shown is the one for which we are summing forces

XYZ coordinate system:

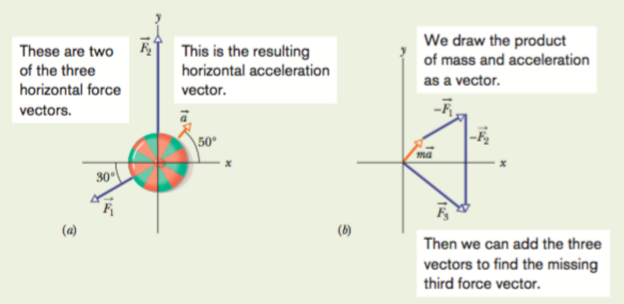
$F_{net,x} = ma_x$, $F_{net,y} = ma_y$, $F_{net,z} = ma_z$

Internal force: Total mechanical energy (KE + PE) stays constant e.g. gravitational force, spring force

External forces are capable of changing the total mechanical energy of an object, they are sometimes referred to as nonconservative forces e.g. friction

Newton's Second Law

EXAMPLE A 2 kg cookie tin is accelerated at $3m/s^2$ in the direction shown by $\overrightarrow{a}$, over a frictionless horizontal surface. The acceleration is caused by three horizontal forces, only two of which are shown: $\overrightarrow{F_1}$ of magnitude 10 and $\overrightarrow{F_2}$ of magnitude 20 N.

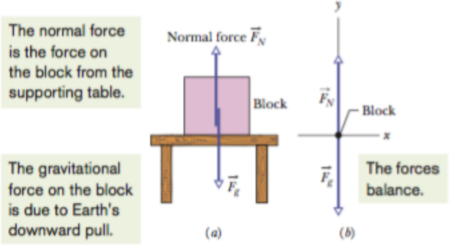


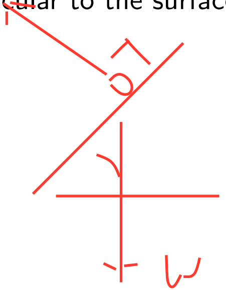
Newton's Second Law

$\overrightarrow{F_{net}} = m\overrightarrow{a}$
$\overrightarrow{F_1} + \overrightarrow{F_2} + \overrightarrow{F_3} = m\overrightarrow{a}$
x components:
$\overrightarrow{F_{3,x}} = m\overrightarrow{a_x} - \overrightarrow{F_{1,x}} - \overrightarrow{F_{2,x}}$
$= macos(50) - F_1 cos(-150) - F_2 cos(90)$
y components:
$\overrightarrow{F_{3,y}} = m\overrightarrow{a_y} - \overrightarrow{F_{1,y}} - \overrightarrow{F_{2,y}}$
$= masin(50) - F_1 sin(-150) - F_2 sin(90)$
$\overrightarrow{F_3} = 13\hat{i} - 10\hat{j}$

Some particular forces

The following forces must be noted in a given problem...
Normal Force: When a body presses against a surface, the surface (even a seemingly rigid one) deforms and pushes on the body with a normal force F_N that is perpendicular to the surface.

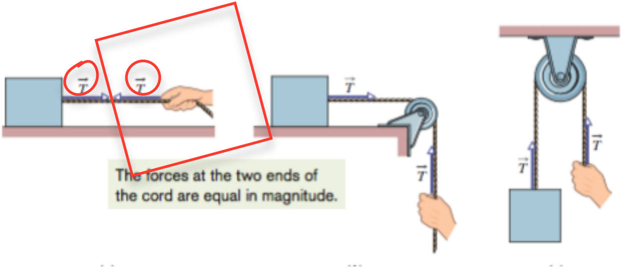




Friction: Motion resisted by a bonding between the body and the surface

Some particular forces

Tension

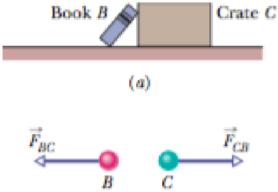


Cord is massless and unstretchable

Massless, frictionless pulley: If the cord wraps halfway around a pulley, the net force on the pulley from the cord has the magnitude 2T.

Newton's Third Law

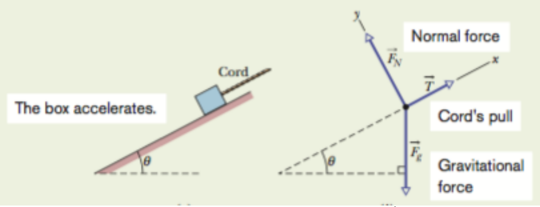
When two bodies interact, the forces on the bodies from each other are always equal in magnitude and opposite in direction.



The book and crate are stationary, but the third law would still hold if they were moving and even if they were accelerating.

Application/Examples

Cord accelerates block up a ramp A cord pulls on a box of sea biscuits up along a frictionless plane inclined at $\theta = 30$. The box has mass $m = 5$ kg, and the force from the cord has magnitude $T = 25$ N. What is the box's acceleration component a along the inclined plane?

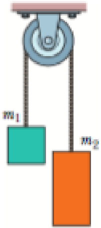


Apply Newton's second law: $\overrightarrow{F_{net}} = m\vec{a}$

$T - mgsin(\theta) = ma$

Application/Examples

Atwood's Machine Two blocks are connected by a cord (of negligible mass) that passes over a frictionless pulley (also of negligible mass). The arrangement is known as Atwood's machine. One block has mass $m_1 = 1.3$ kg; the other has mass $m_2 = 2.8$ kg .Find (a) the magnitude of the block's acceleration and (b) the tension in the cord



Draw FBD: $m_2 g - T = m_2 a$

$T - m_1 g = m_1 a$

Some Important problems

Book: Fundamentals of Physics by Halliday/Resnik (Extended 9th edition)
Newton's Second Law: 7,10
Applying Newton's Laws: 17,32,34

Reference

Fundamentals of Physics by Halliday and Resnik