Ms. Rosenthal P.3

Forces and Motion

IB 11

Observations:

1. A force is **not** necessary for an object to remain at rest or to be in constant motion in a straight line (i.e. constant velocity)

Two natural states of motion: 1) stationary or at rest
2) constant velocity motion

2. A force **is** necessary for an object to speed up, slow down, or change direction (i.e. an object to accelerate)

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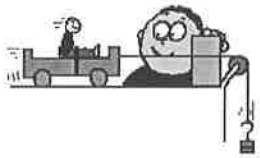
3. Why do you feel thrown backwards when a car starts up quickly from rest? Are you really thrown backward? What is actually going on?



You remain at rest, but the car moves forward underneath you.

4. Why do you feel thrown forward when a speeding car stops abruptly? Are you really thrown forward? What is actually going on?

You are moving forward and will not stop until a force acts upon you (seatbelt stops forward motion)

Definitions:

1) inertia is the tendency for an object to remain at rest or stay in constant velocity motion.
2) mass is the measure of the amount of inertia an object has
3) inertia is a measure of the resistance an object has to changing its motion.

A

B

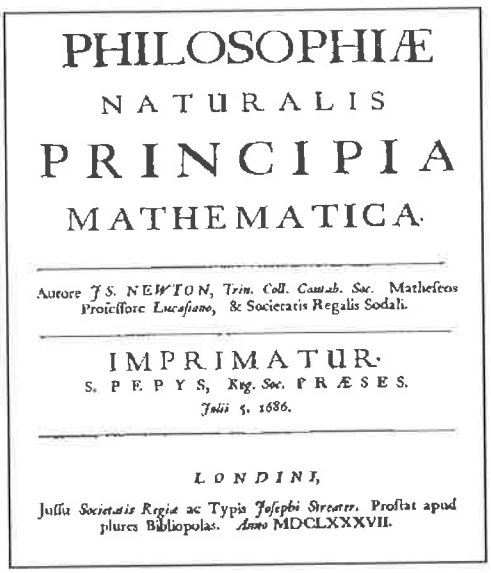
a) Which object has more of a tendency to remain at rest? A

b) Which object has more of a resistance to changing its state? A

c) Which object has more inertia? A

d) Which object has more mass? A

Isaac Newton



PHILOSOPHIÆ
NATURALIS
PRINCIPIA
MATHEMATICA

Autore *J. S. NEWTON, Trin. Coll. Cantab. Soc.* Matheseos Professore *Lucasiano*, & Societatis Regalis Sodali.

IMPRIMATUR.
S. PEPYS, *Reg. Soc.* PRÆSES.
Julii 5. 1686.

LONDINI,
Justu *Societatis Regiæ* ac Typis *Josephi Streater*. Prostat apud plures Bibliopolas. *Anno* MDCLXXXVII.

Above is the title page of Isaac Newton's greatest work and one of the most influential books in all of science.

1. What is the title in English? Mathematical Principles of Natural Philosophy
2. By what title is it commonly known? The Principia
3. When was it published? 1687
4. What did it contain?
   a) Three Laws of Motion
   b) Law of Universal Gravitation

Sir Isaac Newton
(1643-1727)
English scientist

Newton's Three Laws of Motion (original version translated from Latin)

"Every object persists in its state of rest or uniform motion in a straight line unless it is compelled to change that state by forces impressed on it."

"The alteration of motion is ever proportional to the motive force impressed; and is made in the direction of the right line in which that force is impressed."

"To every action there is always opposed an equal reaction: or the mutual actions of two bodies upon each other are always equal, and directed to contrary parts."

Newton's First Law of Motion (Law of Inertia)

An object at rest remains at rest and an object in motion remains in motion at a constant speed in a straight line (constant velocity) unless acted on by unbalanced forces.

Net Forces = ØN $\Sigma F = ØN$

Newton's Second Law of Motion (Force Law)

When unbalanced forces act on an object, the object will accelerate in the direction of the resultant force. The acceleration is directly proportional to the resultant force and inversely proportional to the mass of the object.

$a = \frac{F_{NET}}{m}$ $F_{NET} = ma$

Newton's Third Law of Motion (Action-Reaction Law)

When two objects (A and B) interact, the force that A exerts on B is equal and opposite to the force that B exerts on A.

interactions between two objects

Fundamental Forces

- **gravitational** (4) — 10^{40} weaker than nuclear force. long range
  attraction between all matter

- **electromagnetic** (2) — long range
  attraction between positive + negative charges

- **strong nuclear** (1) — short range
  holds the nucleus of the atom together
  atomic scale

- **weak nuclear** (3) — short range
  involved in radioactive decay

On the chart above, rank the fundamental forces from strongest to weakest.

Identifying Forces: Free-Body Diagrams

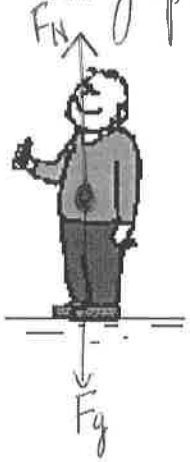
What is a "**free-body diagram?**"

Diagram showing all forces acting upon a single object.

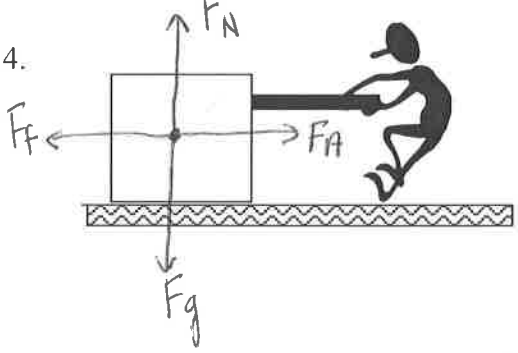
1.

2.

3.



4.



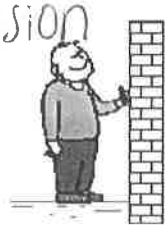
F_g: gravitational force

F_A: applied force

F_N: normal force ($\perp$ to surface)

F_f: friction

4. What is the cause of the normal force? electromagnetic force of repulsion between electrons on both surfaces



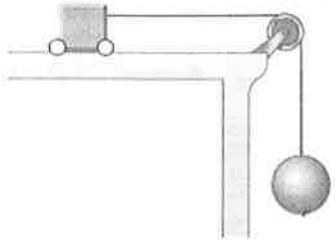
5. What is the cause of the frictional force? electromagnetic force of attraction between two surfaces

Balanced and Unbalanced Forces

IB 11

A weight is hung over a pulley by a string that is attached to a cart. The weight is dropped.

⊖ ⟷ ⊕



1. What will happen to the cart? Why?

accelerate in ⊕ direction due to unbalanced forces

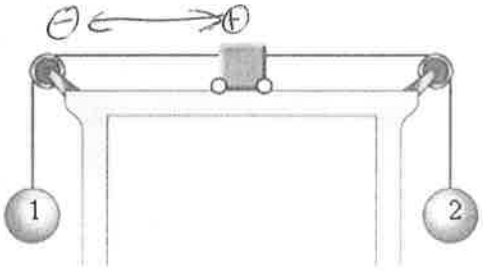
2. What will change if a heavier weight is used?

acceleration of the cart will increase

3. What will change if a heavier cart is used?

acceleration of the cart will decrease

A second weight is now hung over a pulley by a string pulling on the cart in the opposite direction.



4. What will happen to the cart if weight #1 is heavier than weight #2?

acceleration in ⊖ direction $\Sigma F \neq \emptyset$

5. What will happen to the cart if weight #2 is heavier than weight #1?

acceleration in ⊕ direction $\Sigma F \neq \emptyset$

6. What will happen to the cart if both weights are the same?

cart will not accelerate $F_1 = F_2$ $F_{NET} = \emptyset$

Net force (F_{net}): resultant of all forces acting on an object

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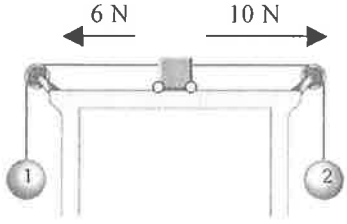
⊖ ⟷ ⊕

In each case below, determine the net force acting on the cart (magnitude and direction).

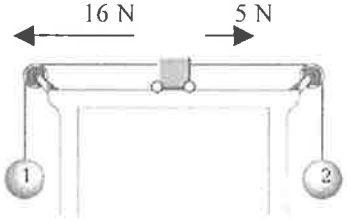
7.



$\Sigma F = 10N + -6N = 4N$

$\vec{a}$ in ⊕ direction

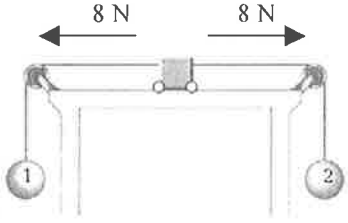
8.



$\Sigma F = -16N + 5N = -11N$

$\vec{a}$ in ⊖ direction

9.



$\Sigma F = -8N + 8N = \emptyset N$

no $\vec{a}$