

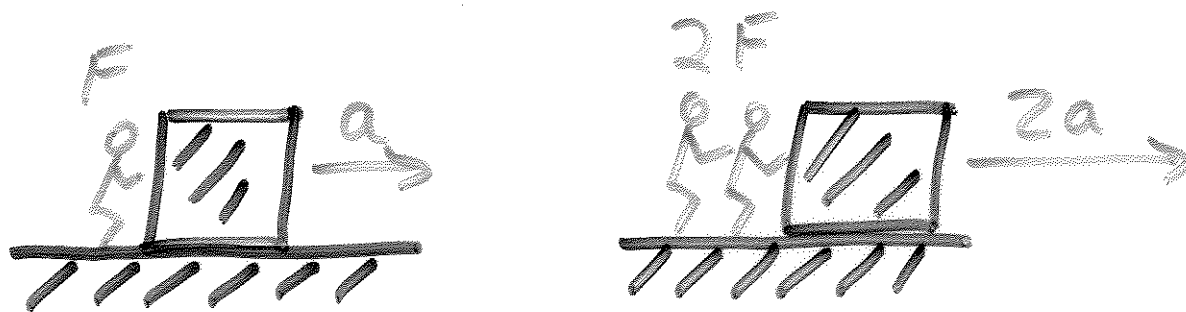
# FORCES

NEWTON'S 1<sup>ST</sup> LAW: IF THE NET (TOTAL) FORCE IS ZERO, THEN VELOCITY DOES NOT CHANGE.

NET FORCE  $\Rightarrow$  ACCELERATION

ACCELERATION

IS PROPORTIONAL TO  
NET FORCE APPLIED

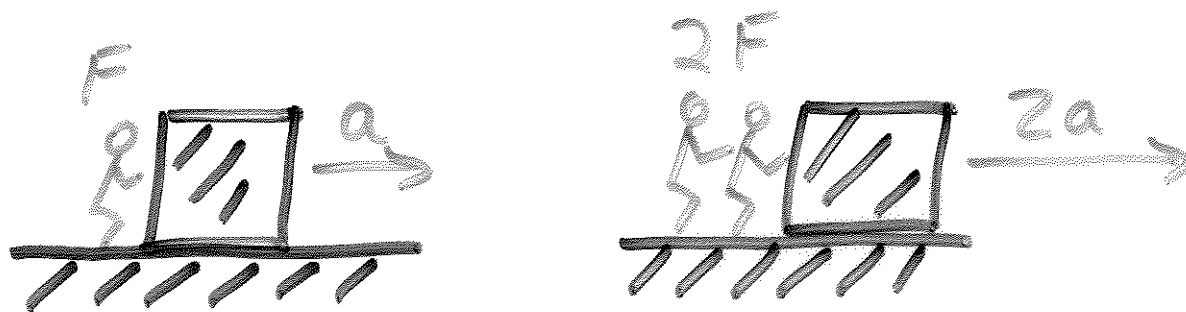


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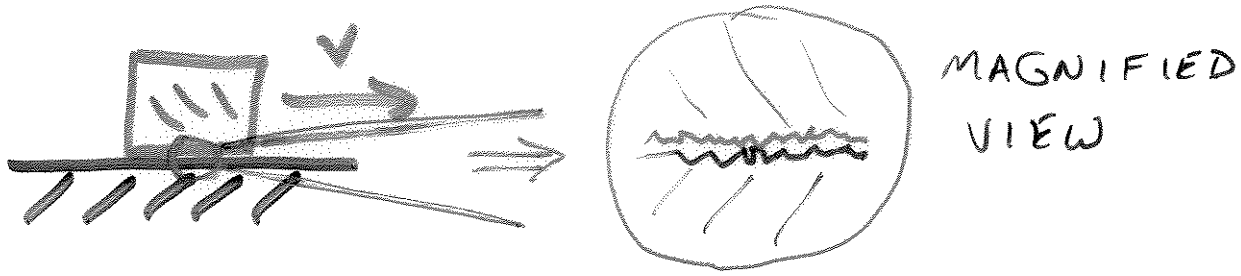
NET FORCE  $\Rightarrow$  ACCELERATION

ACCELERATION IS PROPORTIONAL TO NET FORCE APPLIED



# FRICTION: IS A FORCE

ALL SURFACES ARE BUMPY



FRICTION OPPOSES MOTION

ONCE AN OBJECT IS

SLIDING, FRICTION DECREASES

SLIDING FRICTION IS LESS THAN STATIC (NONMOVING) FRICTION

IT TAKES A BIGGER PUSH TO START SOMETHING MOVING THAN TO KEEP IT MOVING

# FRICTION AND DRIVING

IF FRICTION OPPOSES MOTION  
THEN WHY ARE FRICTIONLESS  
(SLIPPERY) ROADS BAD?

# ANTI LOCK BRAKES

EMERGENCY STOP:

JAM THE BRAKES → LOCKS THE TIRES

THE TIRES SLIDE.

→ FRICTION DECREASES

→ YOU SKID AND DIE

## QUIZ

A JUMBO JET CRUISES AT 10,000m AT A CONSTANT VELOCITY OF 1000 km/hr (ABOUT 600 MPH). THE THRUSTING FORCE OF THE ENGINES IS 100,000 N ( $10^5$  N).

WHAT IS THE ACCELERATION OF THE JET?

WHAT IS THE NET (TOTAL) FORCE ON THE JET?

WHAT IS THE FORCE OF AIR RESISTANCE ON THE JET?

IGNORE GRAVITY

# MASS vs WEIGHT

MASS: THE AMOUNT OF MATTER  
IN AN OBJECT. A MEASURE  
OF INERTIA OR HOW HARD IT  
IS TO MAKE SOMETHING  
START, STOP OR CHANGE MOTION.

WEIGHT: THE FORCE OF GRAVITY  
ON AN OBJECT

IT'S EASY TO LOSE WEIGHT!  
JUST MOVE TO THE MOON!

MASS UNIT: KILOGRAM (KG)  
ON EARTH, 1 KG WEIGHS 10 N (NEWTON)  
OR ABOUT 2.2 POUNDS

# MASS RESISTS ACCELERATION

$$\text{ACCELERATION} \sim \frac{1}{\text{MASS}}$$

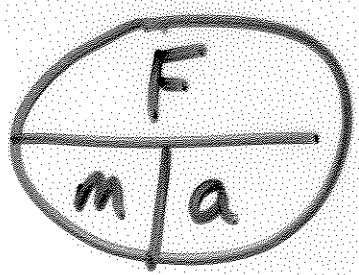
## NEWTON'S 2<sup>ND</sup> LAW

DEFINITION  
IS IN  
TEXTBOOK

THE ACCELERATION OF AN OBJECT IS PROPORTIONAL TO THE NET FORCE ACTING ON THE OBJECT AND IS IN THE DIRECTION OF THE FORCE AND IS INVERSELY PROPORTIONAL TO THE MASS OF THE OBJECT.

$$\text{ACCELERATION} \sim \frac{\text{NET FORCE}}{\text{MASS}}$$

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



# CHECKUP

LAST TIME WE DEFINED ACCELERATION AS THE TIME RATE OF CHANGE OF VELOCITY

$$a = \frac{\text{CHANGE IN } V}{\text{time}}$$

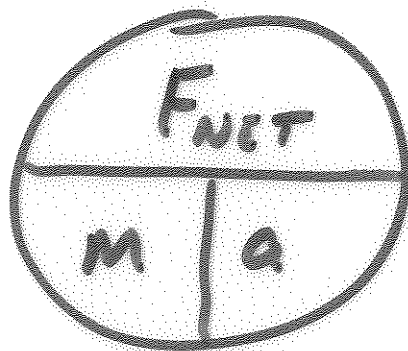
NOW WE SAY IT IS THE RATIO OF FORCE TO MASS

$$a = F/m$$

WHICH IS IT?

UNRESCAPE N!

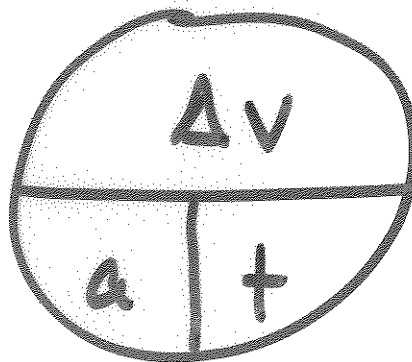
$$F_{NET} = ma$$



THE CAUSE OF ACCELERATION

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$$\Delta v = at$$



THE EFFECT OF ACCELERATION

YOU APPLY A FORCE OF 1N  
TO A <sup>STATIONARY</sup> MASS OF 10 kg.  
WHAT IS THE ACCELERATION?

- a)  $0 \text{ m/s}^2$
  - b)  $0.1 \text{ m/s}^2$
  - c)  $1 \text{ m/s}^2$
  - d)  $10 \text{ m/s}^2$
  - e) OTHER
- 

HOW FAST WILL THE MASS BE  
MOVING AFTER 5s?

- a)  $0.1 \text{ m/s}$
- b)  $0.5 \text{ m/s}$
- c)  $10 \text{ m/s}^2$
- d)  $5 \text{ m/s}^2$
- e)  $5 \text{ m/s}$
- f)  $0.5 \text{ m/s}^2$

# Quiz

IF YOU CAN PRODUCE AND MAINTAIN A CONSTANT NET FORCE OF ONE NEWTON (1N) ON AN AIRCRAFT CARRIER FOR AN INFINITE AMOUNT OF TIME, WHAT WOULD BE ITS MAXIMUM SPEED?

- a) 0 m/s
- b) BETWEEN 0 AND 1 m/s
- c) 1 m/s
- d) ABOUT 10 m/s
- e) ALMOST THE SPEED OF LIGHT [AS FAST AS YOU WANT]

# FREE FALL

Fig = Force of gravity

$$F_s = mg \Rightarrow a = \frac{F_s}{m} = g = 10 \text{ m/s}^2$$

YOUR WEIGHT

EXPENSIVE FALL (NOT FREE)

IN REALITY WE NEED TO INCLUDE

## AIR RESISTANCE

LIKE OTHER KINDS OF FRICTION  
IT SLOWS YOU DOWN

$$\Rightarrow a = \frac{F_g - F_{air}}{m} < 10 \text{ m/s}^2$$

AIR RESISTANCE INCREASES WITH  
VELOCITY

$\Rightarrow$  TERMINAL VELOCITY

# TERMINAL VELOCITY

RAIN DROPS

BUGS

MICE

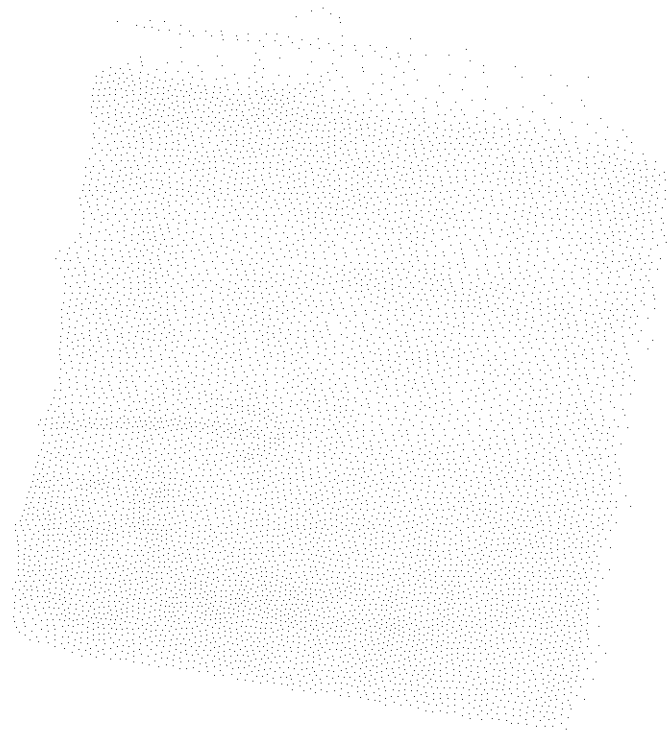
CATS

PEOPLE

PEOPLE WITH PARACHUTES

# ESTIMATION

WHAT IS THE TERMINAL  
VELOCITY OF A RAINDROP?



# QUIZ

A CAR WITH A 100HP ENGINE CAN GO FROM 0 TO 60 MPH IN 5S.

WHAT IS ITS ACCELERATION?

- a)  $10 \text{ m/s}^2$       b)  $10 \text{ MPH/s}$       c) 5s  
 d)  $12 \text{ MPH/s}$       e) OTHER

IF THE ENGINE IS REPLACED WITH A DIFFERENT ENGINE THAT CAN ONLY DELIVER HALF THE FORCE, THE NEW ACCELERATION IS

- a)  $\frac{1}{4}$  AS MUCH      b)  $\frac{1}{2}$       c) SAME  
 d) DOUBLE      e) OTHER