Newton's Laws of Motion

Chapter 2: pages 37-53

Review questions 1, 5-10, 14, 17, 21-24, 30

Peer Led Team Learning

- ES105x PLTL CRN 21823
- Tuesdays, 7:30 to 9 PM, NS 101
- Jody Berg, senior ES major who had this class from me
- Please pick up blue sheet and take it to the registrar
- Or attend tonight to see if you want it, and get blue sheet from Jody

Example of rt=d calculation

$$\frac{80km}{h} \bullet 4h = 320km$$

- Notice that hours cancels because it is above and below the fraction bar

Car traveling

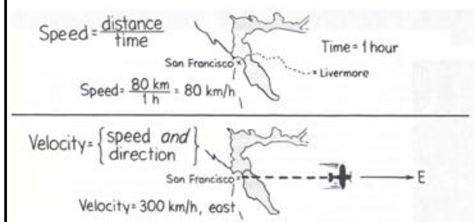
- 60 km/h for 4 h

$$\frac{60km}{h} \bullet 4h = 240km$$

- 60 km/h for 10 h

$$\frac{60km}{h} \bullet 10h = 600km$$

Speed and Velocity

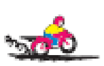


Radio Response Card Transmitters "Clickers" (but they don't click)

- **DO NOT** push the 'GO' button, please. It resets the frequency it transmits on, so my receiver does not get the signal
- Wait until the polling box turns green and says 'polling open' before you enter your response
- If you need one, raise your hand now

Acceleration

- $\text{Acceleration} = \frac{\text{Change in velocity}}{\text{Time interval}}$



CHANGE of speed over time, not the RATE of speed

- **RATE OF CHANGE**

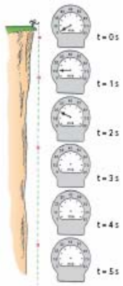
Delta Δ

- Δ is the fourth letter in the Greek alphabet
- Used in equations to represent change
- Δv = change in velocity
  - Find final velocity, find initial velocity, and subtract
- Δt = change in time, or time interval from beginning to end
- Units of time appear twice in denominator

Acceleration of gravity

- 9.81 m/s^2 at sea level
- Round off to 10 m/s^2 for ease of calculation in lecture. Use more precise value for lab
- …or if you are trying to launch a rocket to space, etc.

Acceleration of Gravity



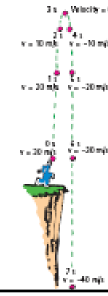
- Acceleration same for each second of travel
- Free falling objects

Acceleration of Gravity

- Free fall of object
- Speed increases 10 m/s for every second of fall
- $\frac{10\ \text{m/s}}{\text{s}} = \frac{10\text{m}}{\text{s}^2}$

Time elapsed (seconds)	Speed (meters/ second)
0	0
1	10
2	20
3	30
4	40

Acceleration of Gravity

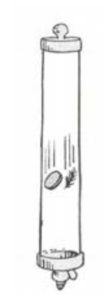


- Upward throw 30 m/s
- Gravity acts against it
- Slows to stop at 10 m/s^2
- Falls and gains speed at 10 m/s^2
- Neglecting air resistance

Galileo's investigation of motion

- Surface area changes air resistance
- Objects reach terminal velocity due to air resistance
- In vacuum, this is not a factor

Acceleration



- Neglect air resistance for these equations

a= Δv/ Δt → v=at

- acceleration is velocity divided by time
- velocity acquired is acceleration multiplied by time

Examples of acceleration

- Driving on Monmouth Avenue at 20 mi./h
- Increase to 45 mi./h in 25 seconds—change in speed is:
- Divide change of speed by time

$$\frac{45mi.}{h} - \frac{20mi.}{h} =$$

$$\frac{25mi.}{h}$$

$$a = \frac{25mi./h}{25s} = 1mi./h \cdot s$$

Acceleration $a = \frac{25mi./h}{25s} = 1mi./h \cdot s$

Notice that time units appear in denominator twice

Because it is an amount of time over which the change of speed occurs

Does not need to be the same units, (but it's neater if it is: could change miles per hour into miles per second…)

How to Convert mi./h to m/s

$$\frac{25mi.}{h} \bullet \frac{1h}{60\text{ min}} \bullet \frac{1\text{ min}}{60\text{ sec}} \bullet \frac{1610m}{mi.} = \frac{11.2m}{s}$$

$$a = \frac{11.2m/s}{25s} = 0.44\frac{m}{s^2}$$

Acceleration

- Car can go from stopped to 90 km/h in 10 seconds
- Be sure to **REDUCE** to lowest terms

$$\frac{90km/h}{10s}$$

$$= 9km/h \cdot s$$

$$\left(\frac{\mathbf{90km}}{\mathbf{hr}} = \frac{\mathbf{25m}}{\mathbf{s}} \quad \frac{\mathbf{25m / s}}{\mathbf{10s}} = 2.5\frac{\mathbf{m}}{\mathbf{s^2}} \right)$$

Acceleration

- Car goes from 60 km/h to 80 km/h in 10 seconds
- First find amount of change of speed
- Then divide by time

$$\Delta v = \frac{80km}{h} - \frac{60km}{h} = \frac{20km}{h}$$

$$\frac{20km/h}{10s} = 2km/h \cdot s$$

$$\left(\frac{20km}{hr} = \frac{5.5m}{s} \qquad \frac{5.5m/s}{10s} = 0.55\frac{m}{s^2}\right)$$

Acceleration

- Bicycle goes from rest to 5 km/h in 2.5 seconds

$$\frac{5km/h}{2.5s} = 2km/h \cdot s$$

$$\left(\frac{5km}{hr} = \frac{1.39m}{s} \qquad \frac{1.39m/s}{2.5s} = 0.55\frac{m}{s^2}\right)$$

Sir Isaac Newton

- Born 1642
- 1665 began individual studies
- Proved universal gravitation
- Invented the Calculus
- Reflector telescope 1672
- *Mathematical Principles of Natural Philosophy* ("*Principia*")

First Law of Motion

- "Every object continues in its state of rest, or of uniform motion in a straight line, unless it is compelled to change that state by forces impressed upon it."
- "CONTINUES" = INERTIA

- http://www.physicsclassroom.com/mmedia/newtlaws/cci.html

Mass

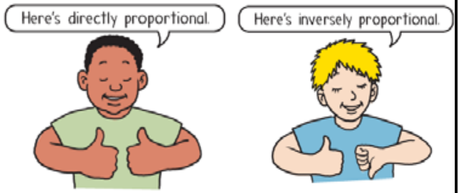
- How much matter
- Measure of inertia

Second Law of Motion

- "The acceleration of an object is directly proportional to the net force acting on the object, is in the direction of the net force, and is inversely proportional to the mass of the object."
- Means "acceleration" ~ $\frac{\text{Force}}{\text{mass}}$
- "~" (say "is proportional to")

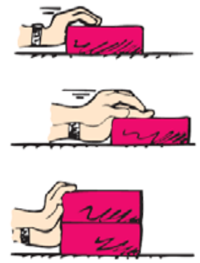
Second Law

$$a = \frac{F}{m}$$



- Acceleration is directly proportional to force
- Acceleration is inversely proportional to mass

Increase forces



- Force on brick creates acceleration
- Twice force on brick creates more acceleration
- Double mass of bricks requires double force to push

Acceleration equation

$$a = \frac{F}{m}$$

- If there is double the force
- Also need to double the mass
- To maintain constant acceleration
- Direct proportion—constant ratio

Acceleration

$$\frac{\Delta v}{t}$$

- Change in velocity over time
- Definition of acceleration

Acceleration

- Change in velocity over time $a = \frac{\Delta v}{t}$

$$a = \frac{F}{m}$$

- Force over mass AND velocity over time?
- How can this be?

Acceleration

Force **causes** acceleration

Force over mass $a = \frac{F}{m}$

Solve for the force: $F = ma$