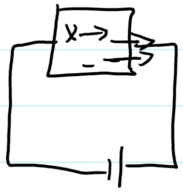
Electric Current

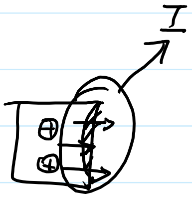


- Electric current in meaning of phenomena:
  — Directional motion of charges
- Electric current in meaning of I
  — the rate of flow of charge

Electric Variables

Definition

Current (I) in $\boxed{I = \frac{Q}{t}}$ rate of flow of charge.

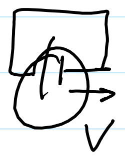


$I = \frac{V}{R}$ is only a statement Unit ⇒ [A] $1A = \frac{1C}{1s}$

Definition

Voltage (V) across $\boxed{V = \frac{E}{Q}}$ energy/work done per unit charge

$V = IR$ is only a statement unit ⇒ [V] $1V = \frac{1J}{1C}$



✳ It's not p.d. (p.d. 'will be'), voltage 'is'

$[V/m] = [(J/C)/m] = [Nm/Cm] = [N/C] = [kgmA/s]$

Resistance (R)

$R = \frac{V}{I}$ is a statement, but should be answered as definition: voltage per current

Units ⇒ [Ω]

Power (P) $P = \frac{E}{t}$

$P = \frac{E}{t} = \frac{VQ}{t} = VI$ ⇒ statement only use in electricity

$P = I^2R$ / $\frac{V^3}{R}$ are only statement

Energy (E) $E = Pt$

$E = Pt = IVt = I^2Rt = V^2Rt$

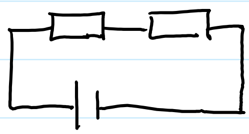
11/29 Series and Parallel

Wednesday, November 29, 2017 10:00 AM

componehet – any part put into circuit

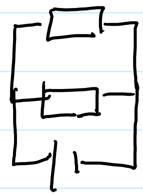
Connections

Series



$V = V_1 + V_2$ } $R = R_1 + R_2$

parallel



$V = V_1 = V_2$

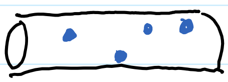
$I = I_1 + I_2$ } $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{R_1 + R_2}{R_1 R_2}$

Home: parallel ⇒ robustness and voltage

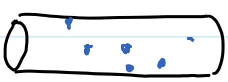
Drift Velocity

Speed of electrons in circuit / ions in electrolyte (cm/s)

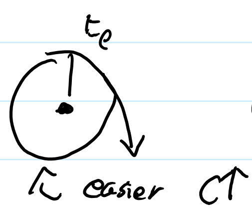
Fe

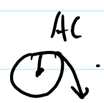


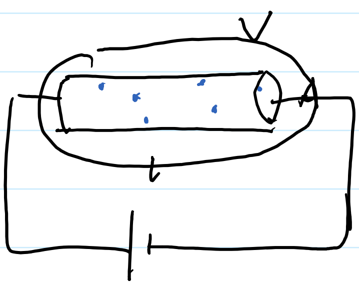
Al



$C = \frac{n}{V}$ is different







$I = \frac{Q}{t}$

$Q = Ne$ N – numbers of e^- in wire [no unit]

$N = nV$ n – concentration of e^- [m^{-3}]
number density

$V = AL$ A – cross section area, L – length

$I = \frac{nALe}{t}$ drift velocity $= nAve$ / $nAvq$

$v = \frac{I}{nAq} \Rightarrow v \propto I$ & $v \propto \frac{1}{A}$ & $v \propto \frac{1}{n}$

12/1 Drift Velocity

2017年12月1日 星期五 08:23

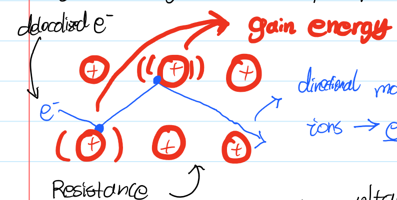
- electrons charge is quantised quantum → a certain amount

discrete
$e = +1.6\times10^{-19}C$ → smallest charge
$2e = +3.2\times10^{-19}C$ → second smallest
← no intermediate charge

therefore ⇒ $\frac{1C}{e} = \frac{Q}{e}$ = whole number always!

any other charge is the multiple of whole number

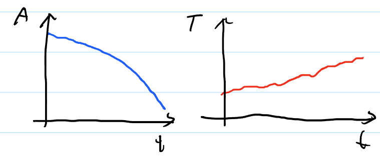
delocalised e^-



gain energy

directional moving e^- → collide against ions → e^- slow down

Resistance + voltage applied

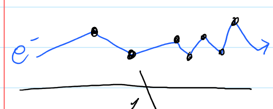


⇒ current goes smaller (e^- slow down)

conductor heated (gain energy)

← take reading as fast as possible

Superconductor is the only possibility that electricity don't gain energy for it

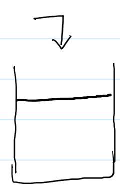


collision happened

Drift $\bar{V} = \frac{l}{t}$ ⇐ average velocity, not instantaneous.

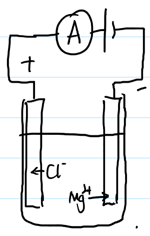
not in a straight line

$MgCl_2$



electrolyte

⇒



$I = nqVA$

for Mg: $I = \frac{1}{2}n \cdot 2qVA$

Cl: $I = n \cdot qVA$

$\therefore V_{Cl} = V_{Mg}$

Resistance (R) [Ω]

factors affecting resistance

- length (L)

$R \propto l$ ⇒ more e^- collide on ions ⇒ $R\uparrow \Leftarrow l\uparrow$

- Area (A)

$R \propto \frac{1}{A}$

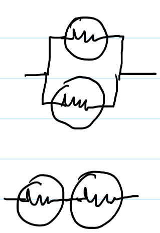
e^- easier to manver

e^- harder to manver

harder for e^- to sqeeze through ⇒ collide more

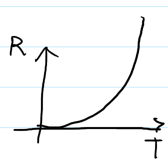
parallel $R = \frac{R_1+R_2}{R_1R_2}$ $A\uparrow$

series $R = R_1+R_2$ $l\uparrow$



- Temperature (T)

~~$R \propto T$~~ ⇒ no direct relationship

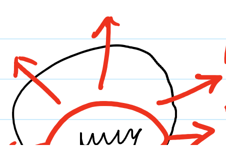


if temperature rises, resistance rises.

ions vibration increase

- Type of metal / conductor

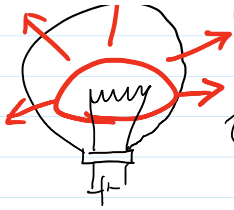
Small ⇒ usual Application



heat loss 75%

heated to glowing 25%

- small ⇒ usual Application
- larger ⇒ iron/cooker/bulb



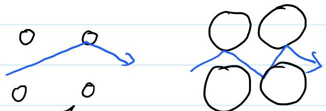
heat loss ...

heated to glowing

unefficient device

25% is highest efficiency

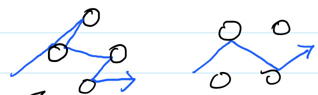
because of ions arrangement & spacing



spacing affecting

silver & gold has smallest resistance (copper is also good)

Tungsten has highest resistance



arrangement affecting

$R \propto \rho$ resistivities

Therefore ⇒ $R = \rho \frac{l}{A}$ This is actually the defintion of resistance, but

$R = \frac{V}{I}$ CIE's decesion.

magnitude (numerical value)

$\rho = \frac{RA}{l}$ $A \to 1m^2$, $l \to 1m$ $\Rightarrow |\rho| = |R| \Rightarrow$

$|R| = |\frac{V}{I}| = |\rho|$

↳ show the resistance of $1m^3$ cubic of material

$1m^3$ cubic

opposite faces

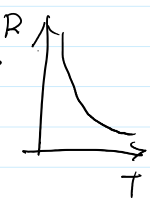
⇒ ρ is the numerical value of resistance between opposite faces of unit volume cubic

Substances
- conductor ρ ← small value $\times 10^{-8}$
- semiconductor ρ ← intermediate $\times 10^{3}$
- insulator ρ ← a very big value $\gg \times 10^{8}$

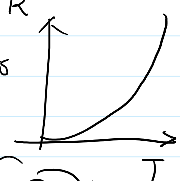
$\rho = \frac{RA}{l} = [\frac{\Omega m^2}{m}] = [\frac{\Omega m^2}{m}]$ ⇒ 4ρ ⇒ $A \times 2$, $l/2$ ⇒ $\rho \times 4$

Semi conductors ⇒

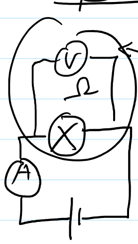
Temperature increase resistance decrease



conductors



Resistance of ammeters and voltmeters.



$R_{Ⓐ}$ should be as small as possible.

6A

100000 Ω

$R_{total} = \frac{R_1 R_2}{R_1 + R_2} \approx 1\Omega$. (don't change)

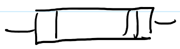
$R_{Ⓥ}$ should be as large as possible

Resistors

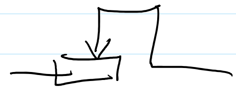
Resistors just increase the resistance ⇒ control the voltage & current

Resistors

Resistors just increase the resistance ⇒ control the voltage & current



fixed value resistors



Variable resistor (rheostat)

fuses (melts when too high)

12/6 Ohm's Law

Wednesday, December 6, 2017 10:00 AM

Ohm's law
- Ohm's law (for the external part of circuit) ⇒ IGCSE
- Ohm's law for the full circuit

$I = \frac{Q}{t}$ → move faster

$V = \frac{E}{Q}$ → push stronger, more energy

$R \mapsto$ collision $R = \rho \frac{l}{A}$ definition

⇒ $I \propto V$ current related to voltage, but

however: $V \propto I$ is wrong! voltage is independent to current, it is relate with batteries.

$R \uparrow$ ⇒ more collision ⇒ slow down e^- ⇒ $I \downarrow$ ⇒ $I \propto \frac{1}{R}$

combine

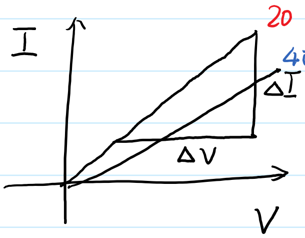
again: $R \propto \frac{1}{I}$ is wrong! ⇒ Resistance is properties of conductor

$$\boxed{I = \frac{V}{R}}$$

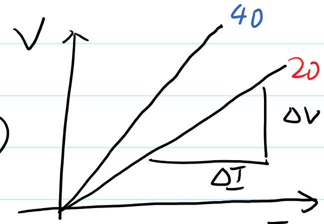
Ohm's law (temperature remains the same)

Ohm's law state that for a conductor at constant temperature, the current in the conductor is proportional to the potential difference across it [ ] [ ]

So, $R = \frac{V}{I}$ should be write as the definition of resistance.

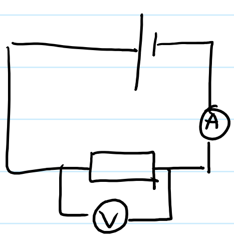


$\frac{\Delta I}{\Delta V} = \frac{1}{R}$ (recipical)



$\frac{\Delta V}{\Delta I} = R$

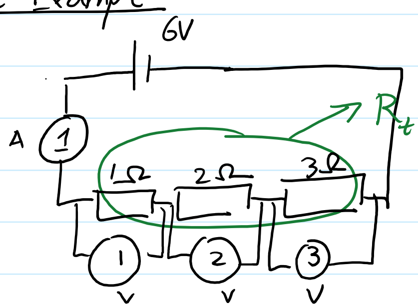
(physically this is wrong, it's only mathematically correct)



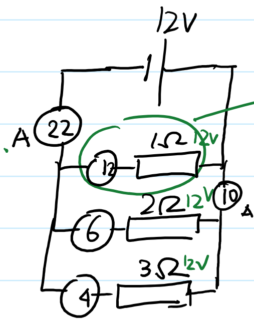
← circuit used for measuring resistance

$I = \frac{V}{R}$

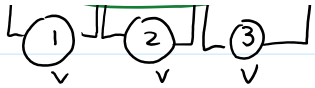
Worked Example

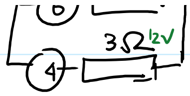


$R_t = 6\Omega$



use $I = \frac{V}{R}$ individually

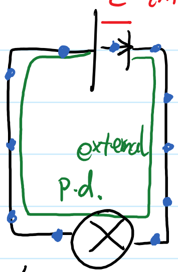




Ohm's law for the full circuit

e^- move by e.m.f. in batteries

$\mathcal{E}$ internal



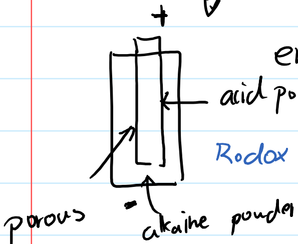
e^- move in circuit by p.d.

energy convert to other form, in this case, light & heat

$$\text{p.d. (V)} = \frac{E}{Q} = \frac{\text{energy convered from electrical to other form}}{\text{charge}}$$

$$\text{e.m.f. } (\mathcal{E}) = \frac{E}{Q} = \frac{\text{energy convered from other form to electrical}}{\text{charge}}$$ offical but wrong

Inofficially $\mathcal{E} = \frac{\text{total energy to move e}}{\text{charge for whole circuit}}$ (inside + outside)



energy required to move e^- from (+) to (−)

$$E_t = E_{in} + E_{out} \Rightarrow \frac{E_t}{Q} = \frac{E_{in}}{Q} + \frac{E_{out}}{Q}$$

$\mathcal{E}$ Ir   IR

$$\mathcal{E} = Ir + IR$$

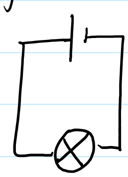
interal resistance ⇒ resistance of power pack

e.m.f.   terminal p.d.   loss volts

$$\mathcal{E} = IR + Ir = V + Ir$$

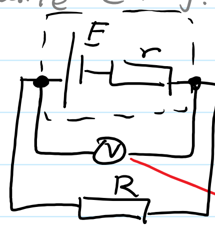
Ohm's law for the full circuit

if interal resistance neglected ⇒ $V = IR$



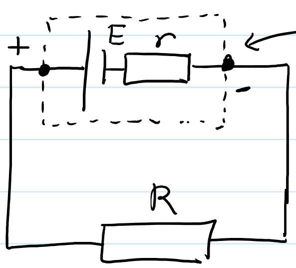
notice: $\mathcal{E} \simeq E$ in CIE

better to write e.m.f.



read terminal p.d.

but if not, then $\mathcal{E} = IR + Ir$, and



dotted line combine for powerpack

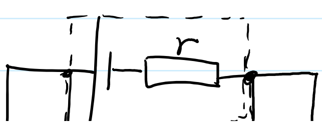
$\mathcal{E}$ can not be taken, but need calculated

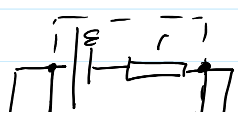
$$V < \mathcal{E} \Rightarrow V = \mathcal{E} - Ir$$

some energy used in powerpack

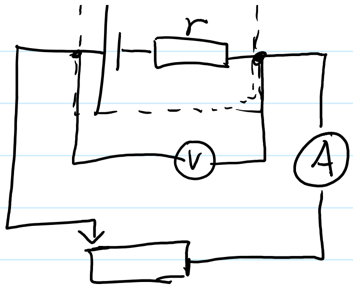
terminal p.d. = e.m.f − loss volts

Experiment to find $\mathcal{E}$ and internal resistance r

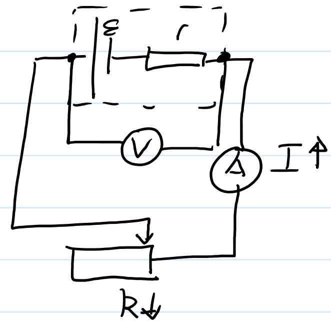




$$\mathcal{E} = V - Ir$$



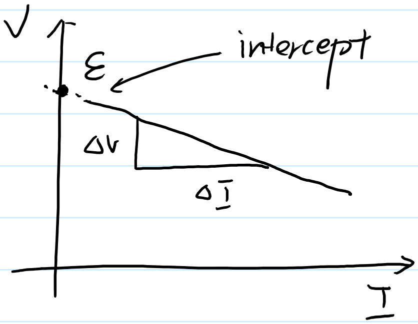
$\Rightarrow$



$\varepsilon = V - Ir$

$Ir \uparrow$ $\quad \varepsilon$ constant

$V \downarrow$



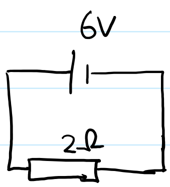
$$V = -Ir + \varepsilon$$

$$r = \frac{\Delta V}{\Delta I} = \text{gradient}$$

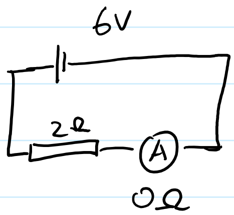
12/11 Internal Resistance

Monday, December 11, 2017 3:44 PM

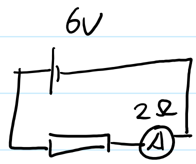
Ammeter
R as small as possible



$I = \frac{V}{R} = 3A$



$\frac{I}{R} = 3A$

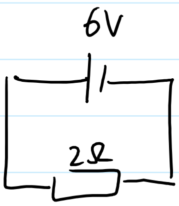


$\frac{I}{R} = 1.5A$

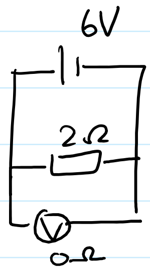
(I read is smaller before connecting)

- ammeter connect in series
- R_{total} in Circuit grows, current will be smaller than before connecting

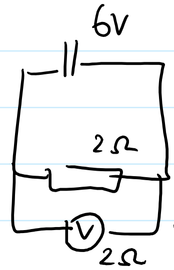
Voltmeter
R as large as possible



$V = 6V$



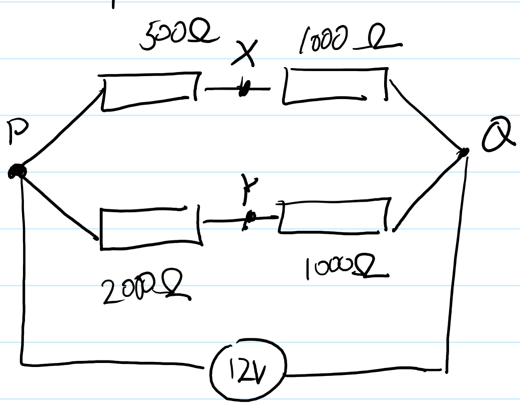
$V_R = 6V$



$V_R = 3V$

- Voltmeter conned in parallel
- R_{total} decrease, voltage will be smaller than before connecting

Example 1



$R_{T_1} = R_1 + R_2 = 1500\Omega$ $I_1 = \frac{V}{R} = \frac{12}{1500} = 0.008A$

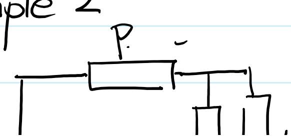
$R_{T_2} = R_3 + R_4 = 3000\Omega$ $I_2 = \frac{V}{R} = \frac{12}{3000} = 0.004A$

$V_1 = 0.008 \times 500 = 4V$ $V_2 = 0.008 \times 1000 = 8V$

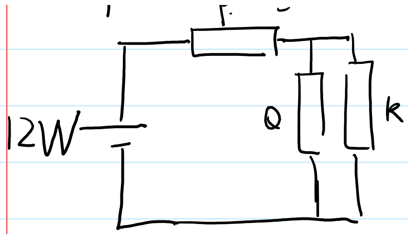
$V_3 = 0.004 \times 2000 = 8V$ $V_4 = 0.004 \times 1000 = 4V$

$X - Y = V_1 - V_3 = -4V$

Example 2



$R_P = R_Q = R_R = R$



$R_P = R_Q = R_R = R$

find P_P, P_Q, P_R

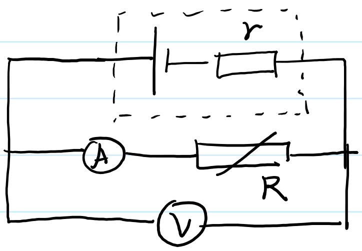
$P_P = I^2 R \qquad P_Q = (\frac{1}{2}I)^2 R = \frac{1}{4} I^2 R = P_R$

$I^2 R + \frac{1}{4} I^2 R + \frac{1}{4} I^2 R = 12W$

$\frac{3}{2} I^2 R = 12W$

$I^2 R = 8W \qquad \therefore P_P = 8W,\ P_Q = P_R = 2W$

Example 3



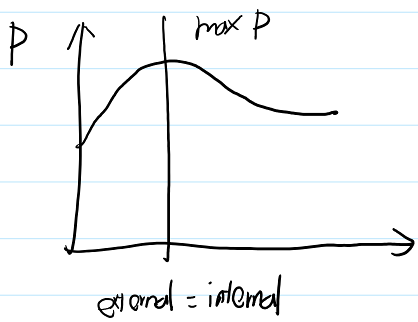
$r = 3\Omega$, $\mathcal{E} = 3.0A$

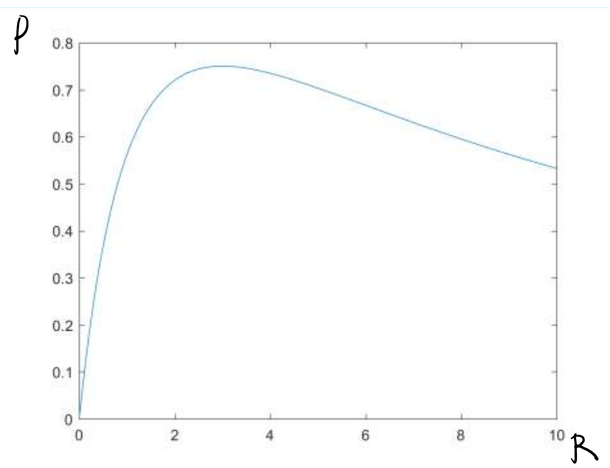
calculate P on R if

- $R = 2\Omega$
- $R = 3\Omega$
- $R = 4\Omega$

$P = I^2 R$

$I = \frac{\mathcal{E}}{R + r}$





12/13 Circuit Component

Wednesday, December 13, 2017 10:19 AM

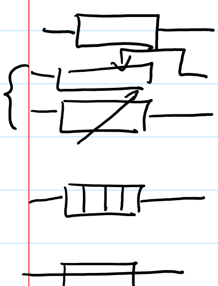
Component: any thing we connect to the circuit

(not a linear relationship) can not take tangent

Ohm's law apply for all of them, but non-ohmic conductor — non-ohmic conductor

resistor — ohmic conductor

bulb | Dide | LDR | thermistor — Semi Conductor

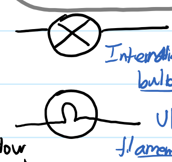


fixed value resistor

variable resistor

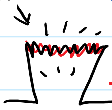
heater

fuse



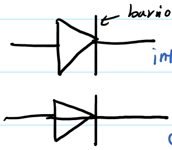
International bulb

UK filament bulb



glow

heating effect → incandescent (hot to glow)

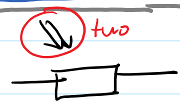


barrier

international

UK

purpose:
—allow current to flow in one way only



two

R

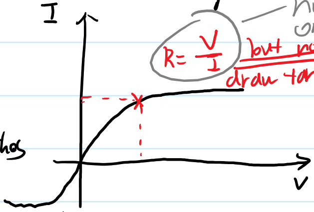
light Intensity

R

T

purpose of
- fixed value resistor
— to control voltage and circuit in different branches in a complex circuit
- heater
— to convert current into heat
- fuse
— to disconnect at certain current (1/2/5/13A)

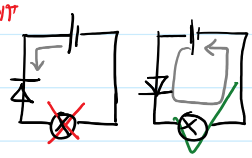
V-I relationship



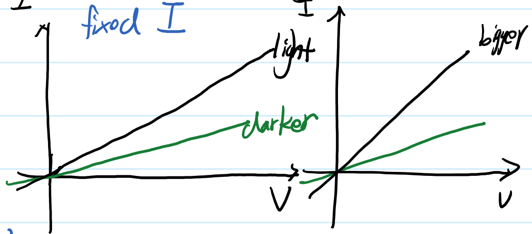
I

V

$R = \frac{V}{I}$ number only but not draw tangent



arrow must show conventional current (+ → −)



I

fixed I

light

darker

V

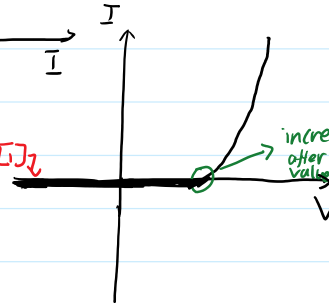
I

bigger

V

V

I



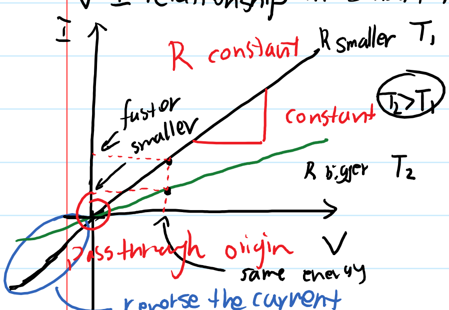
I

V

[I]₂

increase after certain value

V-I relationship in constant T



I

R constant

R smaller T_1

faster smaller

constant

$T_2 > T_1$

R bigger T_2

pass through origin

V

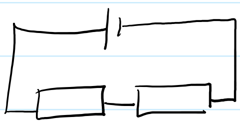
same energy

reverse the current

12/15 Kirchhoff's Law

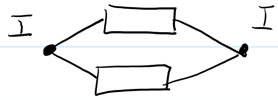
Friday, December 15, 2017 8:56 AM

Kirchhoff's law



$V = V_1 + V_2$

1st kirrcheff's law:



$I = I_1 + I_2$

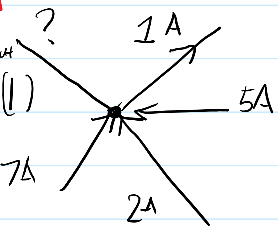
$$\boxed{\sum I_{enter} = \sum I_{leave}}$$ definition

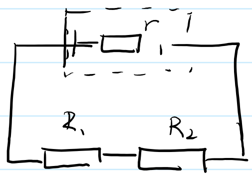
conservation of charge
no e^- create at junction

8A

Σ_{in} Σ_{out}

$(7+2+5)-(1)$
$=13A$





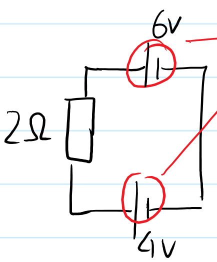
$\varepsilon = IR_1 + IR_2 + Ir$

2nd kirrcheff's law:

$$\boxed{\sum \varepsilon = \sum_{0}^{n} IR + Ir}$$ definition

internal resistance

conservation of energy

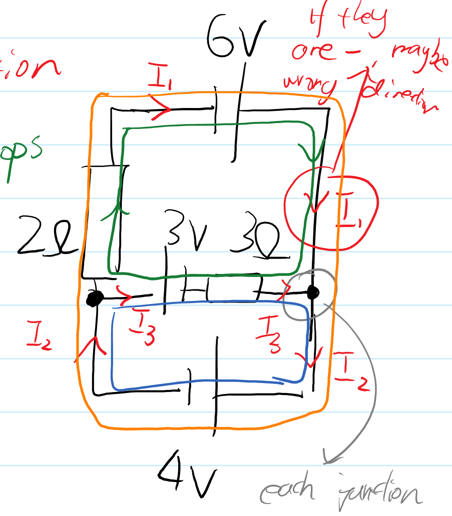


reverse direction

$6-4 = 2V = IR \Rightarrow I = 1A$

minus

loops



if they are −, maybe wrong direction

each junction should have in and out

step to solve:

1. draw current (if not done already) ⇒ use conventional current
2. write 1st kirchhoff's law for the junction — $I_1 + I_3 = I_2$
3. choose a loop and write 2nd kirchheff's law — solve equation

   use letter to show correct loop

should be the same direction of loop

$6+3 = -I_3 \times 3 + I_1 \times 2$

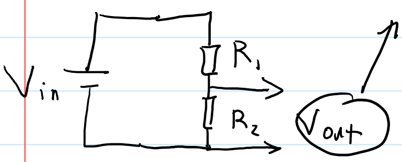
$6-4 = I_1 \times 2$

$$\begin{cases} I_1 + I_3 = I_2 \\ 6+3 = -I_3 \times 3 + I_1 \times 2 \\ 6-4 = I_1 \times 2 \end{cases} \Rightarrow \begin{cases} I_1 = 1A \\ I_2 = -1.5A \\ I_3 = -2.5A \end{cases}$$

⇒ these two direction will be actually reverse

1/5 Potential Divider

Friday, January 5, 2018 8:26 AM



Used in application

$$\boxed{V_{out} = \frac{R_2}{R_1+R_2} V_{in}}$$

Potential divider formula

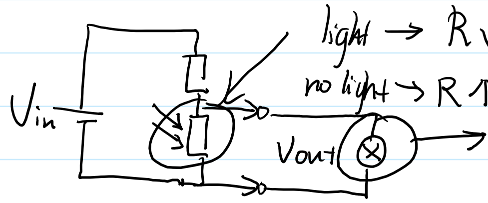
$$I = \frac{V_{in}}{R_1+R_2} \Rightarrow V_{out} = IR_2$$

$$V_{out} = \frac{V_{in}}{R_1+R_2} \cdot R_2 \Rightarrow V_{out} = \frac{R_2}{R_1+R_2} V_{in}$$

Where to used?

Direct Sensing

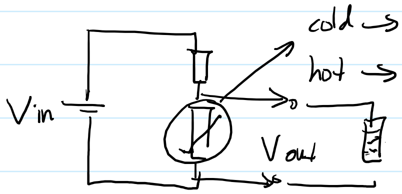
- Robots
- street light
- temperature
- etc....



light → R↓ → V↓ → close light

no light → R↑ → V↑ → open light

→ street light



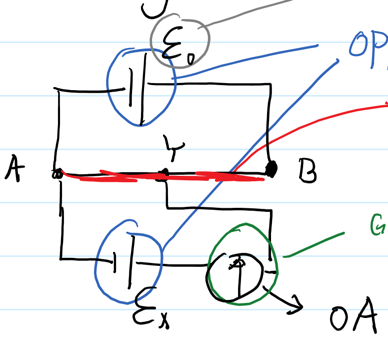
cold → R↑ → V↑ → heat

hot → R↓ → V↓ → no heat

Potentiometer circuit

a simplier way to check the $\mathcal{E}$

→ standard cell known $\mathcal{E}$

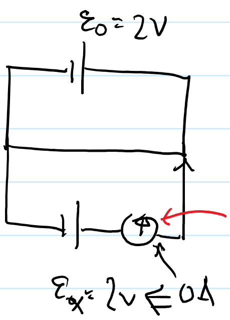


oppose each other

→ resistivity wire (bare wire)

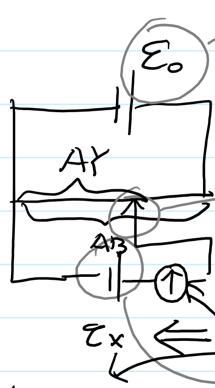
$$\mathcal{E}_x = \frac{AY}{AB}\mathcal{E}_0$$

Galvanometer → sensitive ameter



← but if it read something

⇒



→ driver cell

jockey (to move in position)

move until OA

cell with unknown $\mathcal{E}$

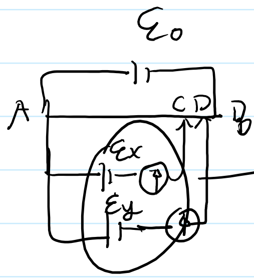
$\mathcal{E}_x$ calculate

$$\mathcal{E}_x = \frac{R_x}{R}\mathcal{E}_0 = \frac{\cancel{\rho}\, l_x / \cancel{A}}{\ldots}\mathcal{E} = \frac{l_x}{l}\mathcal{E}_0$$

$$\mathcal{E}_x = \frac{R_x}{R_0}\mathcal{E}_0 = \frac{\cancel{\rho}\frac{l_x}{\cancel{A_x}}}{\cancel{\rho}\frac{L_0}{\cancel{A}}}\mathcal{E}_0 = \frac{l_x}{L_0}\mathcal{E}_0$$

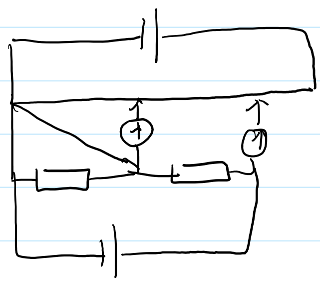
$r_0 = r_x$

assumption: internal resistance identical ⇒ if not ~~→ no accuracy~~



→ now only these two need to be the same $r_x = r_y$

$$\frac{\mathcal{E}_x}{\mathcal{E}_y} = \frac{AC}{AD}$$ ⇒ if knowing $\mathcal{E}_x / \mathcal{E}_y$, we can find another



← compare R_1 & R_2

1/15 Subatomic Particles

Wednesday, January 10, 2018 9:36 AM

atomic mass unit / universal atomic mass unit 1.66×10^{-27} kg

notice the different !

Subatomic particles	charge / elementary charge	mass / amu	charge / C	mass / kg
e^-	-1	$\approx 0\ (\frac{1}{1860})$	-1.6×10^{-19}	9.11×10^{-31}
p^+ } nucleons	$+1$	$1\ (1.006)$	$+1.6\times10^{-19}$	1.67×10^{-27}
n	0	1	0	1.67×10^{-27}

slightly larger on sixth s.f.

made up nucleus

amu → $\boxed{\frac{1}{12} \text{ of } {}^{12}_{6}C \text{ mass}}$ → mass number / nucleon number

e^- doesn't contribute mass of atom significantly

nucleus → mass concentrated

⚠ particles are require to be called in correct name

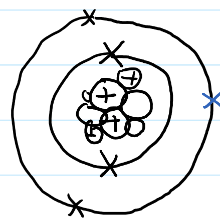
A 27 → mass / nucleon number → $\Sigma p^+ + n$

Al → element symbol

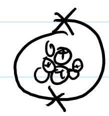
N 13 → proton / atomic number / number of e^- → $\Sigma p^+ / \Sigma e^-$ → atoms are neutral

- atom – (used to be) smallest neutral particle of a substance
- molecule – 2 or more atom bonded together to form neutral
- ion – former atom which gain / lost electrons
- isotope – type of atom which has the same number of p^+, but different n

↳ minimum 3 of isotope



Bi^- anion



Bi^+ cation

${}^{26.98}_{13}Al$ → 'isotope ⇒ average isotopic mass

${}^{14}_{6}C$ ${}^{12}_{6}C$ ${}^{13}_{6}C$

doesn't affect → different mass

defined element

1/17 Structure of Atoms

Wednesday, January 17, 2018 9:31 AM

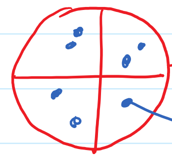
Thomson's Model

originally they think that atom is undividable

$\frac{m}{Q}$

In 1897 Tomson discover e^- and find charge/mass

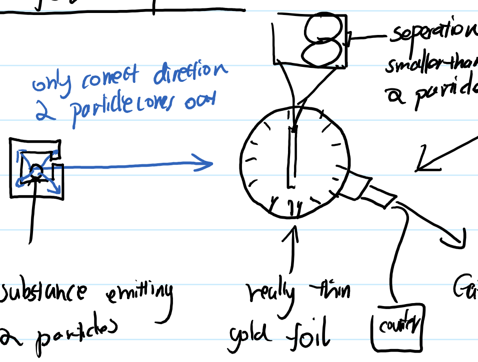
plump pudding model — J.J. Tomson's



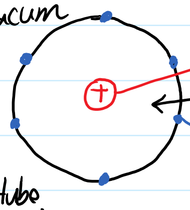
big postive charge

e^- balanced the postive charge

Rutherford Experiment



planetary model — Rutherford

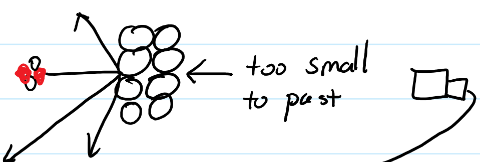


positively charge small nucleus

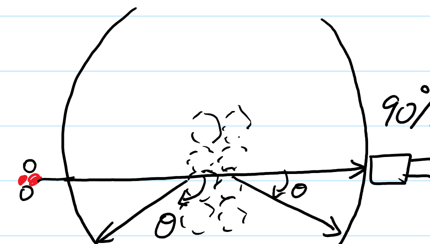
huge gap

e^- orbiting at shell

if the plumb pudding is correct than.

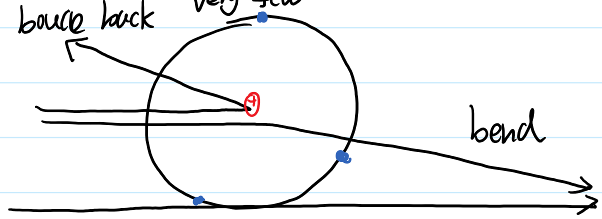


but →



proof: inside emptyness →

↳ planetary model



Ob	Con
most α particles went straight through the foil	atoms are mostly spaced
a few are deflect at angle less than 90°	Nucleus is very small and is very dense and its all postive charge
Very few are deflect at angle greater than 90°	

Radioactive Decay

Radiation { heat

C-12 C-14 → →

all the element heavier than Pb are naturely unstable and be radioactive

wants to loss 2 n

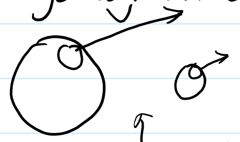
naturally unstable and ...

Radiation { heat / radioactive

C-12 $6p^+/6n$

C-14 $6p^+/8n$ → wants to loss 2 n to get stable. → before Pb only heavy isotope are unstable

only 3 things can come out { α - $2p^+2n$; β - e^- e^- ; γ - photon (loose weight slightly)



Radioactive Decay — Some isotopes and heavy chemical elements are unstable — their nucleui split (desintegate) emitting radiation — i.e. α, β, γ

Types of radiation	Description	speed	Penetrating	E/M field	Range (depends)	Ionizing Ability
α (alpha)	$2p^+ + 2n$ stuck together / helium nucleus / doubleionized Helium atom (He^{2+})	$\approx 0.5C$	lowest paper few cm of air	yes	In: most; out: least	highest (largest)
β (beta)	fast moving e^-	range 0.6C-0.9C	medium Al foil (mm)	yes	In: Medium; out	middle/low
γ (gamma)	highest f and highest E e/m. wave	$3.0\times10^8 m/s$	highest few cm of Pb few m of concrete; can reduce to safe	No	In: least; out: Most	low/middle

ionizing radiation → knock out ions

why? → radiation from nucleus (Not from Orbit!)

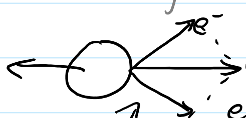
Ingested

e⁻ escaped

positive ions

proton   neutron   e⁻

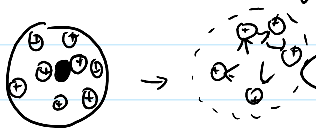
momentum gives the range



e⁻ moves different ways

up to 5 e⁻ emitted → different range

in the cell



burst / leak of cytoplasm → also DNA will have mutation → mitosis → tumor; → myphosis kill itself

1/19 Nuclear Declay

Friday, January 19, 2018 8:48 AM

mass number is conserved

$\alpha \Rightarrow \; ^{228}_{30}Th \longrightarrow \; ^{4}_{2}He + \; ^{224}_{88}Ra$ ← Nuclear Equation

mass is not consered!
energy released

type of asking:

$^{228}_{30}Th \longrightarrow \; ^{\_}_{\_}\alpha + \; ^{\_}_{\_}Ra$ [4]

$\beta \Rightarrow \; ^{224}_{88}Ra \longrightarrow \; ^{0}_{-1}e + \; ^{224}_{\cancel{87}}Ac$

negative charges

$^{243}_{95}Am \longrightarrow \; ^{4}_{2}\alpha + \boxed{^{0}_{0}\gamma} + \; ^{239}_{93}Pa$

γ is $^{0}_{0}$ but must write here

Conservation Laws during nuclear processes

Conserved	Not Conserved
• momentum	• mass NOT conserved
• mass – energy $E=mc^2$	• energy NOT conserved
• nucleon / mass number	
• charge	

Mass – Energy selection

artificially

$^{235}_{95}U \rightarrow {}^{4}_{2}\alpha + {}^{231}_{93}Pu$

a reverse example:

Big Bang

mass bigger → mass convert to energy → K.e. appear

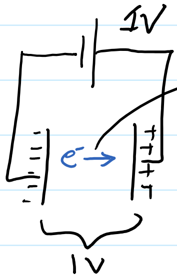
due to rounding

$^{16}_{8}O - {}^{0}_{-1}e \rightarrow {}^{16}_{9}F$

some mass here

Alternative units for energy

eV (electron-volt)



1eV

amount of energy given to e^- in a field with 1V p.d. / accelerate by field of 1V

$V=\frac{E}{Q} \Rightarrow E=VQ$

[J = V × C]

$1eV = \underbrace{1\times 1.6\times10^{-19}C}_{e} \times 1V \Rightarrow 1.6\times10^{-19}J$

$1MeV = 1\times10^6\ 1eV = 1.6\times10^{-13}J$

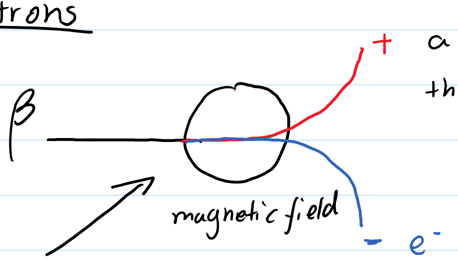
more frequent unit

Positrons

	charge	mass
e^-	−1	$\frac{1}{1860}$
e^+	+1	$\frac{1}{1860}$

a particle that's the antiparticles of the electron ⇒ same mass / opposite charge

$\boxed{\text{positron.}}$



discovered at 1931 by Carl Anderson

$E=mc^2 = 2\times9.1\times10^{-31}kg\times(9\times10^{16})$

disappear releasing pure energy

$e^- + e^+ \rightarrow 2\gamma$

$p + \bar{p} \rightarrow 2\gamma$

$\boxed{n + \bar{n}} \rightarrow 2\gamma$

Annihilation

whatever particles have their antiparticles

antiphoton

antiparticles

they don't distinguish by charge

if they touch and disappear

they don't distinguish by charge

so we only know that when they touch

antiphoton

antineutron

if they touch and disappear, then they are antiparticles

Every particles has its own antiparticles (represents by dash above except e^+)

particles + antiparticles → Annihilation (pure energy release in γ)

mass totally convert into energy

note this could also happen by reverse : $2\gamma \rightarrow e^+ + e^-$ / $p + \bar{p}$ / $n + \bar{n}$

pair production

classifiing Particles

particles

- fundamental
  - not make from smaller particles
  - more than 4
  - quarks (anti quarks)
  - e^- electron (and e^+) — tiny neutron
  - ν_e eletron neutrino ($\bar{\nu}_e$)
  - ν_μ muon neatrino ($\bar{\nu}_\mu$)
  - } lepton
- non-fundamental
  - made from smaller particles e.g. Quarks
  - 3 quarks / 2 quarks
  - p = uud
  - n = udd
  - } hardon

Quarks — 6 type

flavour	symbol	charge/e
up	u	+2/3
down	d	−1/3
strange	s	−1/3
charm	c	+2/3
top	t	+2/3
bottom	b	−1/3

why the charge is still quantised even the quarks are fraction of elementary charge

Quarks are not in there own

they are all in the way to make a charge that makes elementary charge

closer look to β decay

directly means

β decay ⇒ β^- decay $^1_0n \rightarrow {}^1_1p + {}^0_{-1}e^- + {}^0_0\bar{\nu}_e$

β^-

This is the complete reaction

high penetration

not easy to detect (a Nobel prize) $\bar{\nu}_e$ & ν_e to know

- fundamental particles
- disappear when stop — existence move
- move at c
- no charge
- very small but not negleable mass

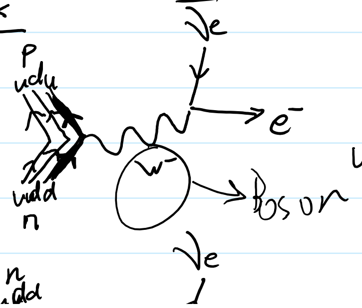
can not stop

but also

β^+ decay $^1_1p \rightarrow {}^1_0n + {}^0_1e^+ + {}^0_0\nu_e$

In terms of quark

β^- decay



udd → udu + $\bar{\nu}_e$ + β^-

d → u

n

$d \rightarrow u$

β^+ decay

$udu \rightarrow udd + \nu_e + \beta^+$

$u \rightarrow d$

1/24

Wednesday, January 24, 2018 9:35 AM

Particles
- lepton (fundamental) — subject to weak force
  - Quarks — antiquarks ($u, \bar{u}, d, \bar{d}, s, \bar{s}$)
  - electron (e^-) — positron (e^+)
  - electron neutrino (ν_e) — anti electron neutrino ($\bar{\nu}_e$)
  - muon neutrino (ν_μ) — anti muon neutrino ($\bar{\nu}_\mu$)
- hadron (made of quarks) — subject to strong force
  - mesons: 2 quarks, 1 quark + antiquark
    - kaons K: K^+, K^0, K^- → must have s / $\bar{s}$ → or called K-meson
    - pions π: π^+, π^0, π^- → no strange quark → or called π-meson
  - Baryon: 3-quarks
    - proton p: uud
    - neutron n: udd
    - up and down only

quarks never exists on their own → charge quantised

What is $d\bar{s}$? $\xrightarrow{K}$ $-\frac{1}{3}+\frac{1}{3}=0 \Rightarrow K^0$

$u\bar{u}$? $\xrightarrow{\pi}$ $\frac{2}{3}-\frac{2}{3}=0 \Rightarrow \pi^0$ → this is highly unstable → annihilation

$s\bar{s}$ $\xrightarrow{\pi}$ $-\frac{1}{3}+\frac{1}{3}=0 \Rightarrow K^0$

- u $+\frac{2}{3}$
- d $-\frac{1}{3}$
- s $-\frac{1}{3}$

only charge is the same; different mass / spin / color / strangeness

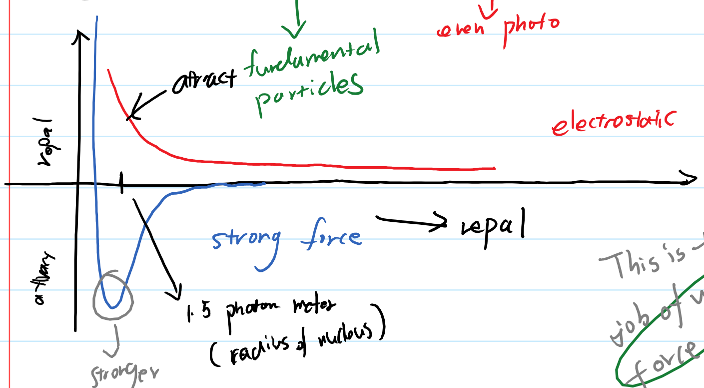
Fundamental Forces

Force we can not explain their origin (we can describe it)

	subject
strong force (strongest)	hold nucleons, quarks together
weak force	responsible for β^-/β^+ decay, acts on lepton
electromagnetic force	anything which has charge
gravitational force	anything which has mass (even photo)

	weak	electromagnetic	strong
quarks	✓	✓	✓
charged lepton	✓	✓	✗
uncharged lepto	✓	✗	✗

fundamental particles



responsible for β decay

$^{14}_{6}C \rightarrow {}^{0}_{-1}\beta + {}^{14}_{7}N$

or

${}^{1}_{0}n \rightarrow {}^{1}_{1}p + {}^{0}_{-1}e^- + {}^{0}_{0}\bar{\nu}_e$

udd $\quad$ uud

This is the job of weak force

1d → 1u

1/29

Monday, January 29, 2018 3:20 PM

GCA

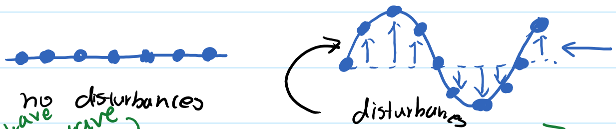
- energy skate park MCQ

Wave

Definition

wave is the pattern of disturbances which transport energy and does NOT transport matter

main properties of waves



- seawave
- mexican wave

Right angle in latin

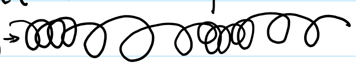
transverse (all e.m. wave) : particles (or fields) vibrate at right angle to the wave's propagation

direction where energy is transported to

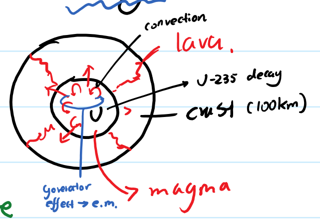
No Fields

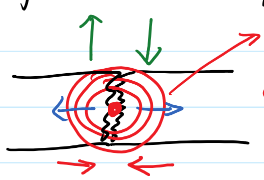
longitual : particles vibrate along the direction of the wave's propagatio

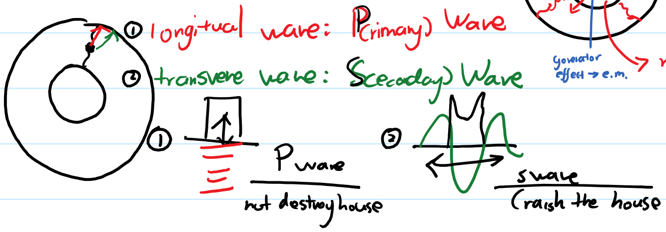
- sound
- slinky spring

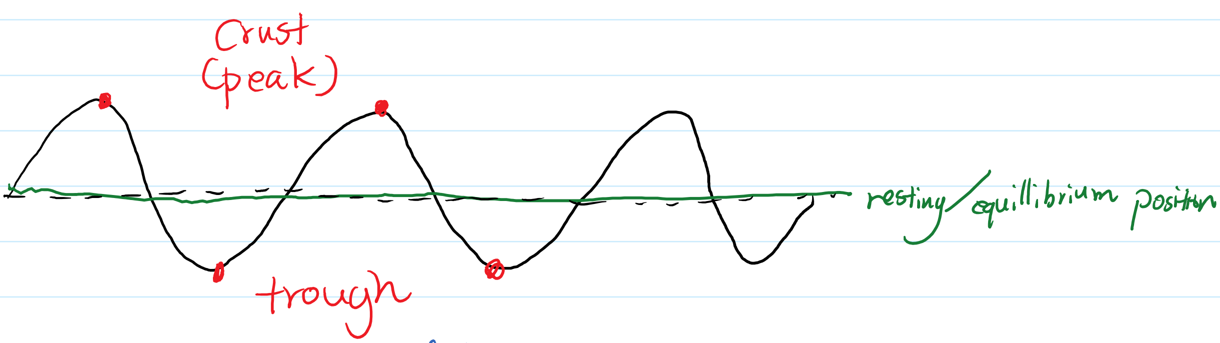


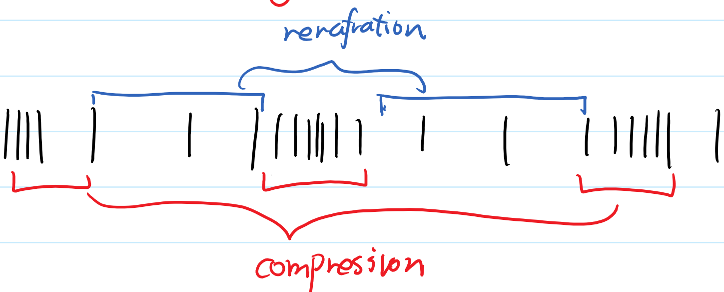
- Seismic wave → Earthquake wave











Variable describing waves

- amplitude(A) [m] — maximum disturbance / maximum displacement / distance from rest to crust
- wave length (λ) [m] — distance between two (nearest) consecutive disturbances / adjacent crest

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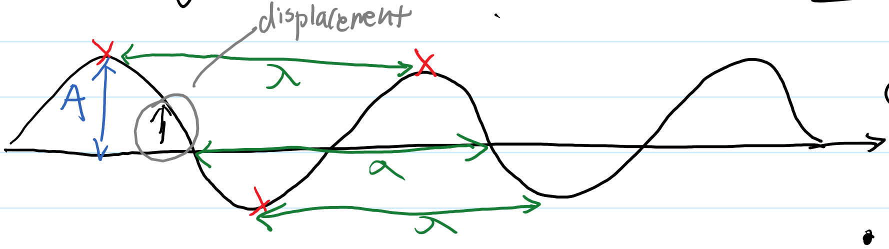
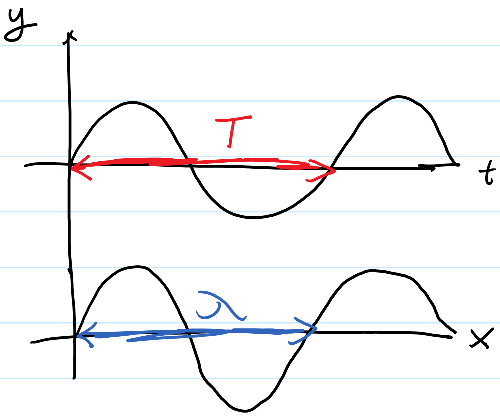


• frequency — number of waves made in one second
(f) [Hz]
[s^{-1}] $T = \frac{1}{f} \Leftrightarrow f = \frac{1}{T}$

• Period — time takes to made one wave
(T) [s]



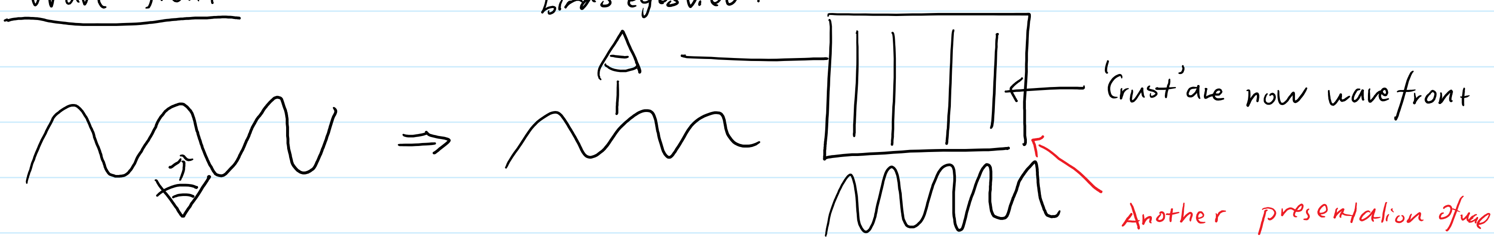
• Velocity (v)

$$\boxed{v = \frac{s}{t} = \frac{\lambda}{T} = f\lambda}$$ wave equation

[m/s]

e.m. wave ⇒ $c = \lambda f$ inverse proportion

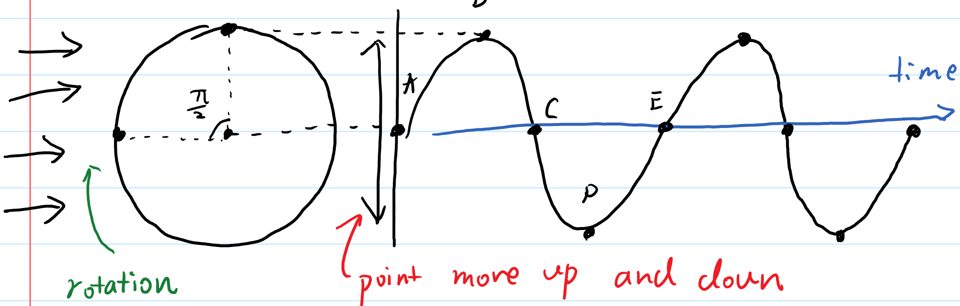
Wave front



wavefront → birds eye view of waves.

Phase shift/difference (ψ)

- radians
- degree
- m (fraction of λ)



time series of projected rotation

$\Rightarrow \psi_{AB} = \frac{\pi}{2}$ rad $= 90^\circ = \frac{1}{4}\lambda$

$\psi_{AE} = \pi$ rad $= 180^\circ = \frac{1}{2}\lambda$

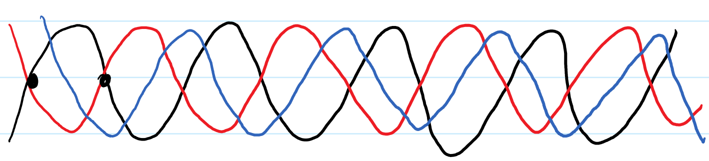
(Unit must be added)

apply to these also by using correct t respond to T

- point

$$\boxed{\Delta\psi = \frac{2\pi}{T} \cdot t}$$

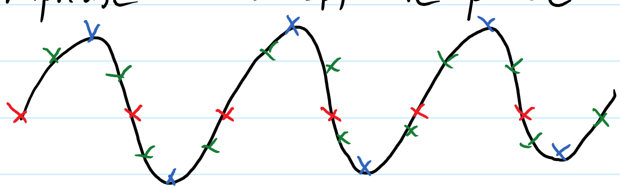
- wave



$\Delta\psi_{RK} = \pi$ (opposite)

$\Delta\psi_{RB} = \frac{\pi}{2}$

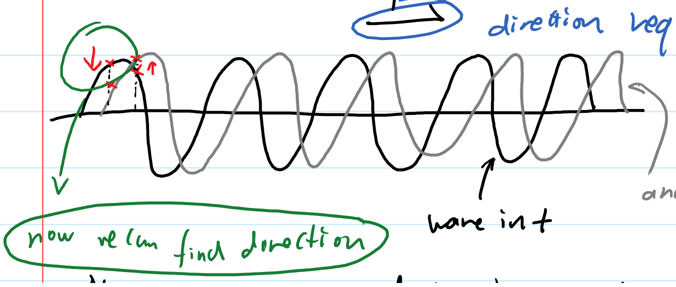
Inphase → moving identically in the same phase
Antiphase → in opposite phase



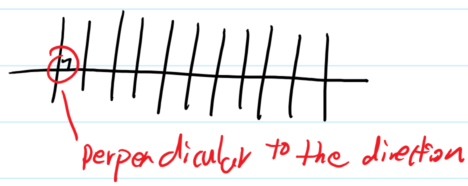
Red Red $\Rightarrow \Delta\psi = 2k\pi$ → inphase
Red blue $\Rightarrow \Delta\psi = (2k+1)\pi$ → antiphase
Red Green $\Rightarrow \Delta\psi =$ any other → out of phase

which direction the particle oscillate?

direction required



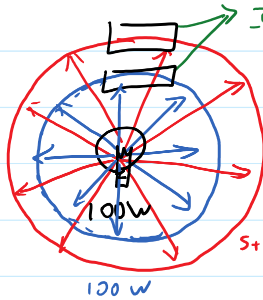
Ray:



Notice: for crust and through are not moving at t (i.e they are stationary point)

Intensity of the wave

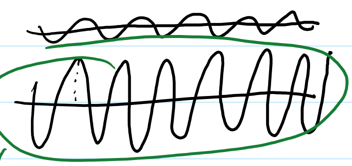
$I = \frac{E/t}{A} = \frac{P}{A}$ (Energy per unit time per unit Area) $\left[\frac{W}{m^2}\right]$



Intensity not the same.

① $I = \frac{1}{d^2}$. Inverse square.

$I = \frac{E/t}{A} = \frac{E}{At} = \frac{P}{A} \Rightarrow A = \pi r^2$



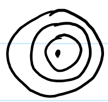
greater intensity

② $I \propto A_{mplitude}^2$ Direct Square

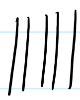
$\frac{I}{A^2}$ = constant

Classifying waves

waves shape of wave front

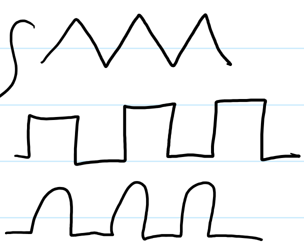


spherical wave front



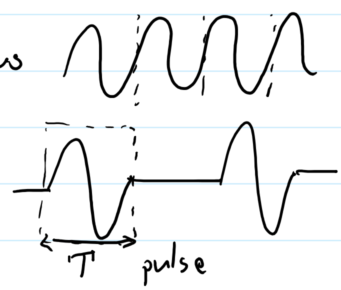
parallel wave front

waves shape of wave



waves
- e.m. → • field (vacum) • C (in vacum) • spectrum
- mechanical → particles
  - • sound
    - frequency (pitch)
    - Amplitude (loudness)

wave
- continous
- pulse



Grouping

e.m.spectrum

Gate X Usually Lets In Most Radiation → decreasing frequency

γ X UV Light IR Micro Radio

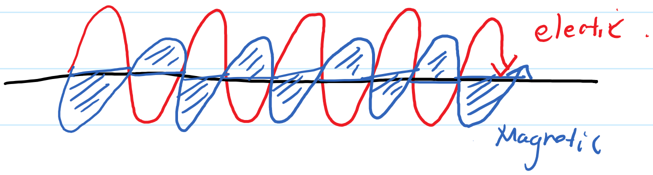
P187

highest f
highest E

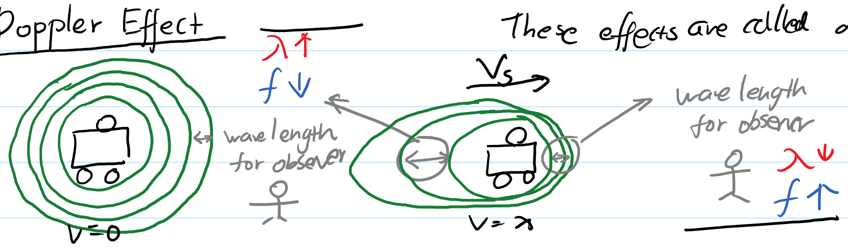
lowest f
lowest E

frequency affect energy of e.m. wave larger than amplitude.

Make E.M. wave.


electric
Magnetic

Doppler Effect



These effects are called doppler effect
⇑ observer hears higher f when sound approach, when goes away hear lower f

- apparent change in frequency, for an observer, when the source of sound is moving

$f_o = \frac{f_s V}{V \pm V_s}$

O - observer
S - source
V - real speed of waves in the medium

$f_o = \frac{f_s V}{V + V_s}$ moving away (smaller f)

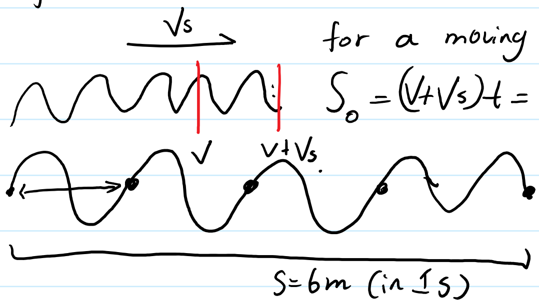
$f_o = \frac{f_s V}{V - V_s}$ moving toward (bigger f)

Derivation

① for 1s $S = Vt = V$ (numerical value)

for a moving source away at V_s

$S_o = (V + V_s)t = V + V_s$ (numerical value)



$N = 4 \Rightarrow \lambda = \frac{S}{N} = \frac{6}{4} = \frac{3}{2}$

③ case a:
$V_s = 0$

$\lambda_o = \frac{S}{N}$ (takes 1s)

$= \frac{V}{f_s}$

$\Longrightarrow$

$\Longleftrightarrow$ transform

case b:
away at V_s

$\lambda_o = \frac{S}{N} = \frac{V + V_s}{f_s}$

$f_o = \frac{V}{\lambda_o} = \frac{V}{\frac{V+V_s}{f_s}} = \frac{f_s V}{V + V_s}$

Vice versa for moving towards you

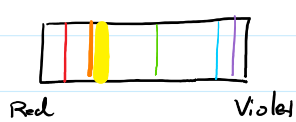
another formula $\boxed{\frac{\Delta\lambda}{\lambda_s} = \frac{V_s}{V}}$

Doppler effects apply to all waves (e.m. waves) but its name only apply to sound.

For light and e.m. wave ⇒ the name is red shift

$\boxed{f_o = \frac{f_s C}{V_s \pm C}}$

spectrum



Richard of york gave battle in Vein

Red orange yellow green blue indigo Violet

lowest f highest f
highest λ lowest λ
Smallest E highest E

GXULIMR

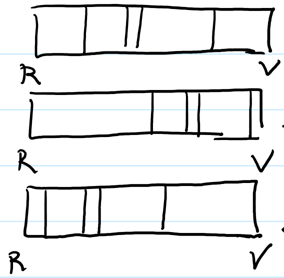
VIBGYOR

lowest f
highest λ
smallest E

highest f
lowest λ
highest E

VIBGYOR

spectrum of emission



white f λ

Blue shift $f\uparrow$ $\lambda\downarrow$ (compressed) shift to violet equally

V_s

Red shift $f\downarrow$ $\lambda\uparrow$ (streched) shift to red equally

V_s

all the star have redshift (moving away) $\rightarrow$ Big Bang