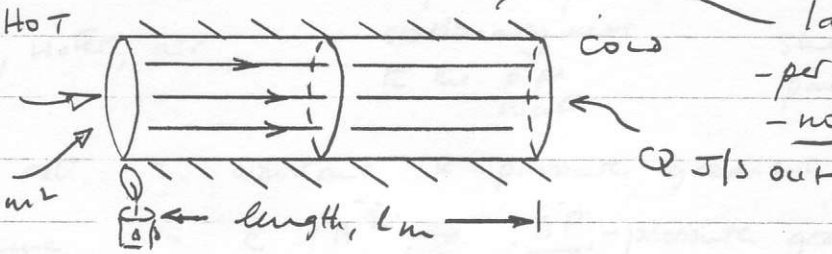
TRANSFER PROCESSES — ①

A Physics

You need to understand the basic similarity between the 3 main transfer processes

	System	from...	to...	transferring
1.	Thermal / heat	hot	cold	heat energy
2.	Electrical	high potential (or voltage)	low	– electrons in a metal – ions in solution
3.	Matter / mass	high pressure	low	substance – liquid – gas.

1. Heat



Rate of heat transfer Q/t (J/s, W) $= kA \times \dfrac{\Delta\theta}{l}$ – temperature gradient (K/m)

kA – constant

2 Electrical

(a) We know $I = \dfrac{V}{R} = \dfrac{1}{R} \times V.$

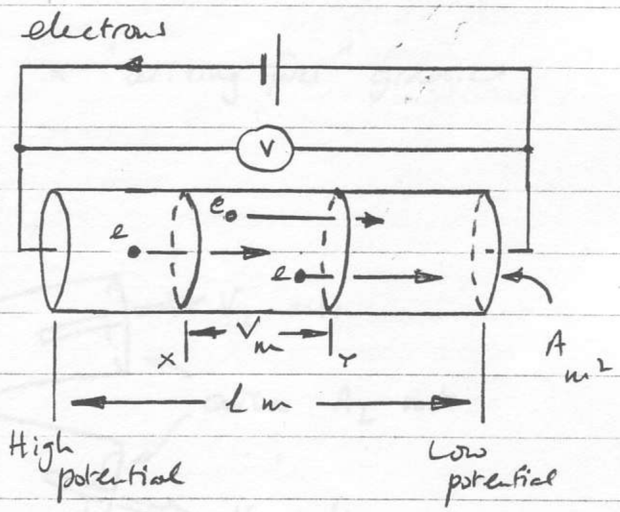
but also $R = \rho A / l$

so $I = \dfrac{A}{\rho} \times \dfrac{V}{l}$ – potential gradient, V/m

$\dfrac{A}{\rho}$ – constant

Sigma $\sigma = \dfrac{1}{\rho}$ = the conductivity (Data sheet)

$= \sigma A \times \dfrac{V}{l}$



(b) Electron drift velocity

Charge transfer by moving electrons ... $I = Q/t$ C/s, A

If electrons have average drift velocity v m/s, then in 1 sec all electrons in length v (m) will pass point Y.

No. of electrons in cylinder = no. in 1 m³ × vol. of cylinder

= n × area × length = nAv.

So charge passing Y/sec = current I = no. of electrons × charge on an electron

$I = nAve$

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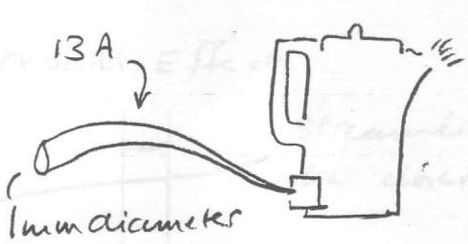
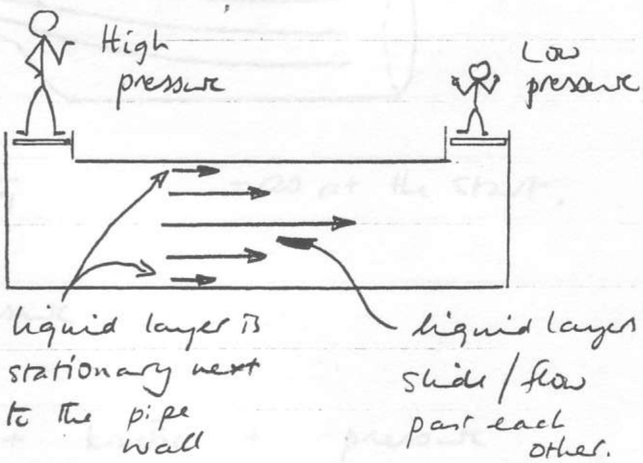
Q. What's the electron drift velocity here?
(n for copper $= 10^{28}$ /m^3
$e = 1.6 \times 10^{-19}$ C)





3. Matter

a) the Basics

Viscosity – resistance to flow

High — Low

Syrup (cold), Syrup (warm), oil, water, air

Liquid flow rate = constant × pressure gradient

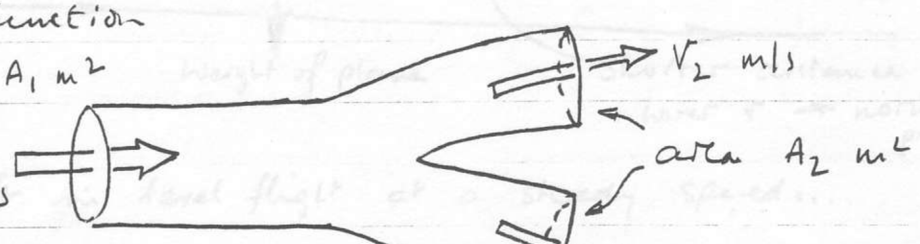
mass kg/s, volume m^3/s $= c \dfrac{A^2}{\eta} \times \dfrac{\Delta P}{l}$ – pressure gradient Pa/m

c: factor for the pipe surface; constant; η: viscosity. (thicker; $\eta \uparrow$)

Summary...

rate of transfer = $\dfrac{\text{constant}}{\text{a "resistance factor"}}$ × "driving force" gradient

b) Flow at a Junction



We assume the liquid cannot be compressed.

Liquid volume in / sec = Liquid volume out / sec

A_1 (v_1) $Av_1 = A_2$ (v_2) $2 \times A_2 v_2$

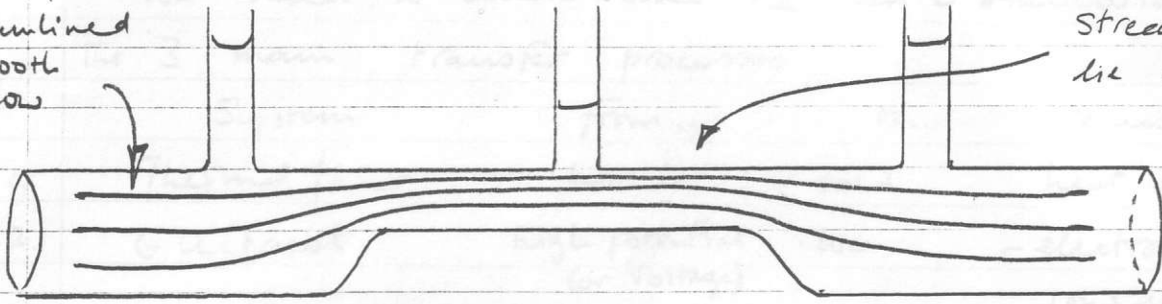
TJH 5.99 or... $A_{total} \times v$ = the same on each side of the junction.

And... since $M = D \times V$ (mass in) $D \times A_1 v_1$ = (mass out) $D \times 2 \times A_2 v_2$

Problems.....

Transfer Processes – 3 A·Physics

c) Flow rate & pressure – the Bernoulli Effect.



- large area
- low velocity
- little K.E
→ high pressure

- small area
- high velocity
- more K.E
→ lower pressure

- as at the start.

key idea...

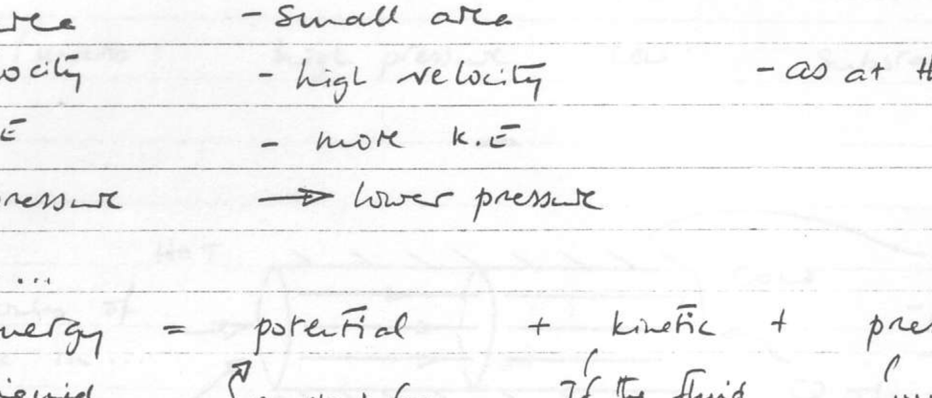
Total energy of the liquid = potential + kinetic + pressure

constant for level flow

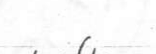
If the fluid speeds up and KE ↑....

.... then the pressure must ↓.

d) Bernoulli at work....



For an aircraft in level flight at a steady speed....



the Carburetter.

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