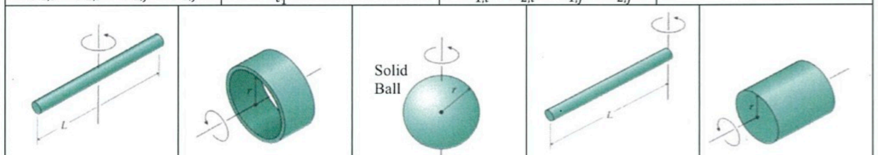
Revision : Thermodynamics

Formula sheet

LINEAR MECHANICS		ROTATIONAL MECHANICS	
$v = v_0 + at$	$x - x_0 = \frac{1}{2}(v_0 + v)t$	$\omega = \omega_0 + \alpha t$	$\theta - \theta_0 = \frac{1}{2}(\omega_0 + \omega)t$
$v^2 = v_0^2 + 2a(x - x_0)$	$x - x_0 = v_0 t + \frac{1}{2}at^2$	$\omega^2 = \omega_0^2 + 2\alpha(\theta - \theta_0)$	$\theta - \theta_0 = \omega_0 t + \frac{1}{2}\alpha t^2$
$\vec{F}_{net} = m\vec{a} = \frac{d\vec{p}}{dt}$	$\vec{w} = m\vec{g}$	$\vec{\tau}_{net} = I\vec{\alpha} = \frac{d\vec{L}}{dt}$	$s = r\theta \quad \omega = \frac{d\theta}{dt} \quad \alpha = \frac{d\omega}{dt}$
$W = \vec{F} \cdot \Delta\vec{r} = F\Delta r \cos\theta$	$f_s \le \mu_s n \quad f_k = \mu_k n$	$\lvert\vec{\tau}\rvert = \lvert\vec{r} \times \vec{F}\rvert = rF\sin\theta$	$\vec{F}_r = m\vec{a}_r = \frac{mv^2}{r}$
$W = \int_{x_1}^{x_2} F\,dx$	$F_s = -kx$ $\Delta U_s = \frac{1}{2}k(x_f^2 - x_i^2)$	$I = \sum_i m_i r_i^2$	$v = r\omega \quad a_t = r\alpha$ $\vec{a}_{net} = \vec{a}_r + \vec{a}_t$
$W_{net} = \Delta K = \frac{1}{2}m(v_f^2 - v_i^2)$	$W_c = -\Delta U \quad U_g = mgy$	$K_R = \frac{1}{2}I\omega^2$	$K_{roll} = \frac{1}{2}I_{cm}\omega^2 + \frac{1}{2}mv_{cm}^2$
$\Delta K + \Delta U = W_{nc} = -F_{fric}d$	$P = \frac{dW}{dt} = \vec{F} \cdot \vec{v}$	$P_R = \frac{dW}{dt} = \vec{\tau} \cdot \vec{\omega}$	$x_{cm} = \frac{\sum_i m_i x_i}{\sum_i m_i}$
$\vec{p} = m\vec{v}$ $\vec{p}_{1,i} + \vec{p}_{2,i} = \vec{p}_{1,f} + \vec{p}_{2,f}$	$\vec{J} = \int_{t_1}^{t_2} \vec{F}\,dt = \Delta\vec{p} = \vec{F}\Delta t$	$\vec{L} = I\vec{\omega}$ $\vec{L}_{1,i} + \vec{L}_{2,i} = \vec{L}_{1,f} + \vec{L}_{2,f}$	$\lvert\vec{L}\rvert = \lvert\vec{r} \times \vec{p}\rvert = mvr\sin\theta$



$I = \frac{1}{12}ML^2$	$I = MR^2$	$I = \frac{2}{5}MR^2$	$I = \frac{1}{3}ML^2$	$I = \frac{1}{2}MR^2$

FLUID MECHANICS			
$p = \frac{F}{A} \quad F_B \propto \rho V g$	$p = p_0 + \rho g h \quad \rho = \frac{m}{V}$	$p + \frac{1}{2}\rho v^2 + \rho g y = const$	$A_1 v_1 = A_2 v_2 = const$

THERMODYNAMICS			
$\frac{\Delta L}{L} = \alpha\Delta T \quad \frac{\Delta V}{V} = \beta\Delta T$	$pV = nRT = Nk_B T$	$\frac{1}{2}m\overline{v^2} = \frac{3}{2}k_B T$	$n = \frac{N}{N_A} = \frac{m}{M}$
$Q = mc\Delta T \quad Q = mL$	$PV = \frac{1}{3}m\overline{v^2}$	$H = \frac{Q}{\Delta t} = -kA\frac{dT}{dx}$	$P_{net} = \sigma A e(T^4 - T_{amb}^4)$

ELECTRICITY			
$F = k_e\frac{q_1 q_2}{r^2}$	$E = k_e\frac{q}{r^2} = \frac{F_e}{q}$	$i = \frac{\Delta q}{\Delta t}, \quad i = \frac{V}{R}$	$P = Vi = i^2 R = \frac{V^2}{R}$
$V_b - V_a = \frac{1}{q}(U_b - U_a) = \frac{-W_{ba}}{q}$	$E = -\frac{V_b - V_a}{d}$	$q = CV$	$v = \sqrt{\frac{F}{\mu}} \quad f_n = \frac{n}{2L}v$
$\frac{1}{R_{eff}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots$ parallel	$R_{eff} = R_1 + R_2 + R_3 + \cdots$ series	$C_{eff} = C_1 + C_2 + C_3 + \cdots$ parallel	$\frac{1}{C_{eff}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \cdots$ parallel

Formula sheet

THERMODYNAMICS			
$\frac{\Delta L}{L} = \alpha \Delta T$ $\quad \frac{\Delta V}{V} = \beta \Delta T$	$pV = nRT = Nk_B T$	$\frac{1}{2} m \overline{v^2} = \frac{3}{2} k_B T$	$n = \frac{N}{N_A} = \frac{m}{M}$
$Q = mc\Delta T$ $\quad Q = m\,L$	$PV = \frac{1}{3} m \overline{v^2}$	$H = \frac{Q}{\Delta t} = -kA \frac{dT}{dx}$	$P_{net} = \sigma A e (T^4 - T_{amb}^4)$

Formula sheet

Acceleration due to gravity at the earth's surface	g	9.80 m/s^2
Avogadro's constant	N_A	6.02 x 10^{23} mol^{-1}
Boltzmann's constant	k_B	1.38 x 10^{-23} J/K
Ideal gas constant	R	8.31 J/mol K
Stefan constant	σ	5.67 x 10^{-8} W/m^2 K^4
Atomic Mass Unit	u	1.66 x 10^{-27} kg
Density of water		1.00 x 10^3 kg/m^3
Density of helium		0.18 kg/m^3
Density of concrete		2200 kg/m^3
Density of Styrofoam		160 kg/m^3
Co-efficient of linear expansion of steel		12 x 10^{-6}
Specific heat of aluminium		900 J/kg °C
Specific heat of ice		2050 J/kg °C
Specific heat of iron		447 J/kg °C
Specific heat of Styrofoam		1300 J/kg °C
Specific heat of water		4186 J/kg °C
Specific heat of wood		1400 J/kg °C
Latent heat of fusion of ice		3.33 x 10^5 J/kg
Latent heat of vaporisation of water		2.26 x 10^6 J/kg
Thermal Conductivity of iron		80.4 W/m °C
Thermal Conductivity of water		0.61 W/m °C
Thermal Conductivity of Styrofoam		0.029 W/m °C
Thermal Conductivity of wood		0.11 W/m °C
Atomic mass of argon, Ar		40 u
Molecular mass of hydrogen, H_2		2.0 u
Molecular mass of nitrogen, N_2		28.0 u
Molecular mass of oxygen, O_2		32.0 u

Conversion factors

1 atm ≡ 1.013 x 10^5 Pa

K = °C + 273

1 litre = 10^{-3} m^3

1 revolution per minute = 2 π radians per 60 seconds

Thermodynamics key facts (1/9)

- Heat is an energy [measured in J] which flows from high to low temperature

- When two bodies are in thermal equilibrium they have the same temperature

- The S.I. unit of temperature is Kelvin (K). This is related to degrees Celsius (℃) by

$$\boxed{T(K) = T(℃) + 273}$$

- Temperature difference ΔT is the same in both units

Thermodynamics key facts (2/9)

- Heat energy needed to raise a temperature

- The specific heat capacity c determines the energy Q needed to raise the temperature of mass m of a substance by ΔT

$$Q = m\, c\, \Delta T$$

- Units of c will be $J\ kg^{-1}\ K^{-1}$

Thermodynamics key facts (3/9)

- Heat energy needed to change phase

- The latent heat L determines the energy Q needed to change the phase of a mass m

$$Q = m\,L$$

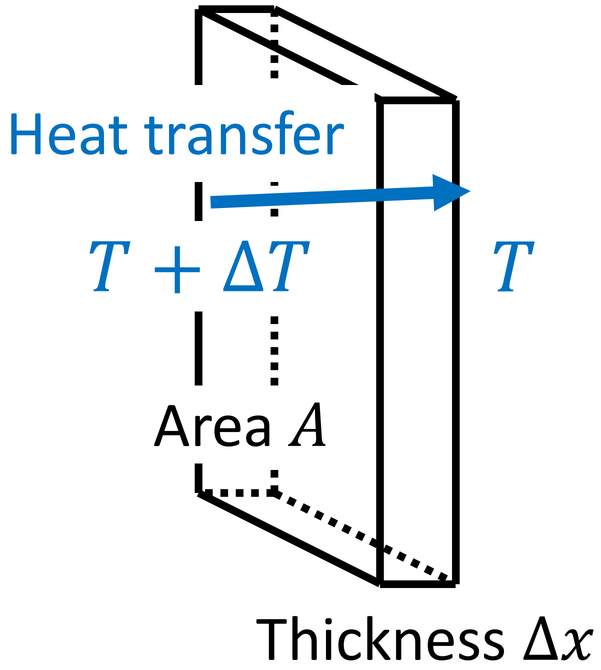
- Units of L will be $J\ kg^{-1}$ - can be fusion or vaporization

- This energy is either absorbed (solid → liquid → gas) or released (gas → liquid → solid)

- A phase change takes place at constant temperature

Thermodynamics key facts (4/9)

- Conduction is heat energy transfer by direct molecular contact

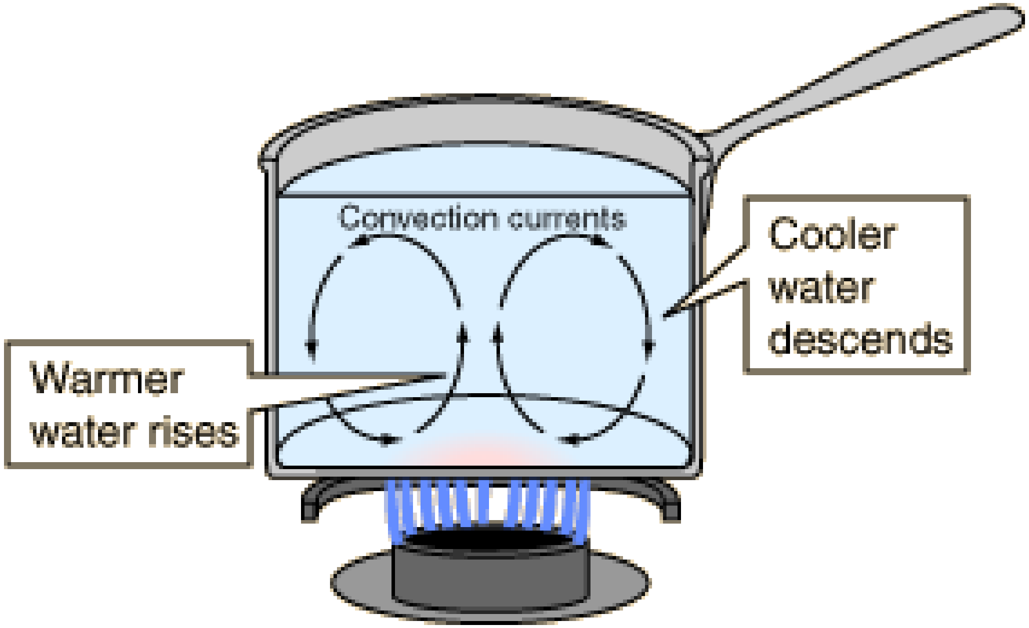


$$\text{Power} = \frac{\Delta Q}{\Delta t} = \kappa\, A\, \frac{\Delta T}{\Delta x}$$

κ = thermal conductivity

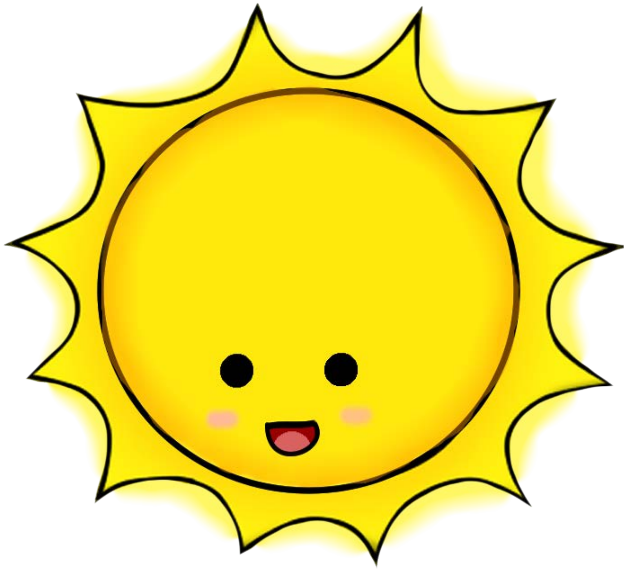
Thermodynamics key facts (5/9)

- Convection is heat energy transfer by the bulk flow of material



Thermodynamics key facts (6/9)

- Radiation is heat energy transfer by emission of electromagnetic radiation

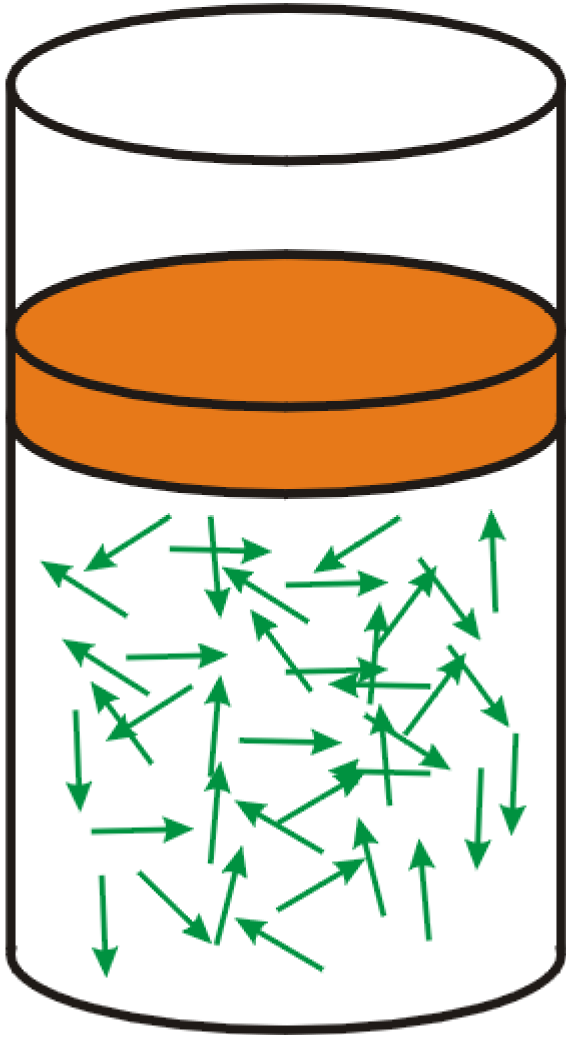


$$\text{Power} = \frac{\Delta Q}{\Delta t} = \sigma\, A\, T^4$$

σ = Stefan-Boltzmann constant,
A = surface area of emitter,
T = temperature of emitter
(assumes emissivity=1)

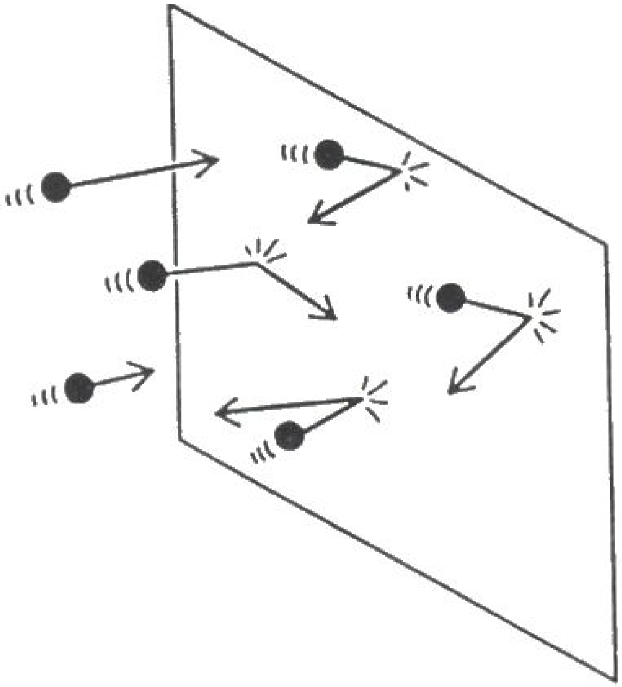
Thermodynamics key facts (7/9)

- Ideal gas law
- 1st form : $P\,V = N\,k_B\,T$
- P = Pressure, V = Volume, N = number of molecules, k_B = Boltzmann's constant, T = temperature [in K]
- 2nd form : $P\,V = n\,R\,T$
- n = number of moles, R = gas constant



Thermodynamics key facts (8/9)

- Kinetic theory of ideal gas
- Pressure is due to molecular collisions
- Average kinetic energy of molecules depends on temperature



$$\overline{\frac{1}{2}mv^2} = \frac{3}{2}k_B T$$

m = mass of molecule,
$\overline{v^2}$ = average square speed,
T = temperature

Thermodynamics key facts (9/9)

- Thermal expansion
- Materials expand due to temperature rise ΔT
- Length L increases by $\Delta L = \alpha\, L\, \Delta T$ where $\alpha =$ coefficient of linear expansion
- Volume V increases by $\Delta V = \beta\, V\, \Delta T$ where $\beta =$ coefficient of volume expansion

Practice exam questions: Section A

4. Two containers hold two different types of gases with the same temperature. Which of the following properties must be identical for both gases?

A. Root mean square velocity.
B. Pressure.
C. Average molecular kinetic energy.
D. Number of molecules.

$$\overline{KE} = \overline{\tfrac{1}{2}mv^2} = \tfrac{3}{2}k_B T$$

Option C

A14. An amount of heat, Q, is added to 1 kg of water, and the water increases temperature by 5° C. If the same amount of heat is added to 2 kg of aluminium, how will its temperature change? *(assume that the water and aluminium do NOT change phase)*

$$Q = m\ c\ \Delta T$$

A. increase by 5° C

B. increase by more than 5° C

C. increase by less than 5° C

D. answer requires the thermal conductivity of aluminium

$$Q = m_{water}c_{water}\Delta T_{water} = 1 \times 4186 \times 5 = 20930\ J$$

$$\Delta T_{Al} = \frac{Q}{m_{Al}c_{Al}} = \frac{20930}{2 \times 900} = 12\ K$$

Option B

Practice exam questions: Section A

A15. When you touch a plastic object and a metal object, the metal object typically feels colder. This is because

A. metals are always colder than plastic

B. metals have larger thermal conductivity than plastic

C. the melting point of metals is much higher than plastics

D. metals have higher specific heat values than plastics

Heat energy loss is by conduction – option B

Practice exam questions: Section A

A16. You have two metal wires made of the same material, with one that is twice as long as the other at room temperature. If you heat them both up to the same high temperature, which of the following is true?

A. The shorter one is still half as long as the other

B. The shorter one is now less than half as long as the other

C. The shorter one is now more than half as long as the other

D. Not enough information to determine

$$\frac{\Delta L}{L} = \alpha \, \Delta T$$

Fractional expansion is the same – option A

A17. The shiny metallic coating on a thermos bottle (i.e. a double-walled, evacuated, glass container) is important in reducing which thermal transfer mechanism?

A. radiation

B. evaporation

C. convection

D. conduction

Reflects radiation – option A

Practice exam questions: Section B

B11. Calculate the energy needed to raise the temperature of a 2.2. kg chunk of aluminium by 18°C.

$$Q = m\ c\ \Delta T = 2.2 \times 900 \times 18 = 3.6 \times 10^{4}\ J$$

1

Practice exam questions: Section B

B12. The filament of a 70 W light bulb is at 2.8×10^3 K. Calculate the filament's surface area. *(assume that the emissivity is 1)*

Stefan-Boltzmann law: $P = \sigma A T^4$

Re-arranging: $A = \frac{P}{\sigma T^4} = \frac{70}{5.67 \times 10^{-8} \times (2800)^4} = 2.0 \times 10^{-5}\ m^2$

2

Practice exam questions: Section B

B13. Calculate the pressure of an ideal gas that has 2.9 mol occupying 2.2 litres at –130° C.

Ideal gas law (using moles): $PV = nRT$

$$V = 2.2\ litres = 2.2 \times 10^{-3}\ m^3$$

$$T = -130 + 273 = 143\ K$$

$$P = \frac{nRT}{V} = \frac{2.9 \times 8.31 \times 143}{2.2 \times 10^{-3}} = 1.6 \times 10^{6}\ Pa$$

2

Practice exam questions: Section C

5. (a) An insulated copper container of mass 0.250 kg contains 0.350 kg water. Both the container and the water are initially at 25.0 ^{0}C.
Then 0.012 kg of ice at 0.0 ^{0}C is added to the container. Eventually the container and contents reach thermal equilibrium at 21.7 ^{0}C.

(i) What is the total heat released (in J) by the copper container **and** the 0.350 kg water as they cool down from 25.0 ^{0}C to 21.7 ^{0}C?

$$Q = m_{water}c_{water}\Delta T + m_{copper}c_{copper}\Delta T$$

$$Q = 0.35 \times 4186 \times 3.3 + 0.25 \times 387 \times 3.3 = 5150\,J$$

2

(ii) Determine the latent heat of fusion of ice.

$$Q = m_{ice}L_f + m_{ice}c_{water}\Delta T = 5150\,J$$

$$L_f = \frac{5150 - (0.012 \times 4186 \times 21.7)}{0.012} = 3.39 \times 10^5\,J/kg$$

Practice exam questions: Section C

(b) A glass window has area 5.0 m^2 and thickness 2.4 mm. The inside of the window is at 24 °C and the outside is at 11 °C.
Calculate the rate of heat loss through the window.

$$\text{Heat loss rate} = \kappa\, A\, \frac{\Delta T}{\Delta x} = 0.80 \times 5.0 \times \frac{13}{2.4 \times 10^{-3}} = 2.2 \times 10^4\ W$$

2

Practice exam questions: Section C

(c) A tank of volume 0.400 m^3 contains 3.00 x 10^{-3} kmol of the monatomic gas, He, at 127 °C.

(i) Calculate the mass of one atom of He.

$$\text{Atomic mass} = 4.0 \times 1.66 \times 10^{-27} = 6.64 \times 10^{-27}\ kg$$

1

(ii) Calculate the root means square speed (v_{rms}) of the He atoms.

$$\frac{1}{2} m {v_{rms}}^2 = \frac{3}{2} k_B T \qquad T = 127 + 273 = 400\ K$$

$$v_{rms} = \sqrt{\frac{3k_BT}{m}} = \sqrt{\frac{3 \times 1.38 \times 10^{-23} \times 400}{6.64 \times 10^{-27}}} = 1.58 \times 10^3\ m\ s^{-1}$$

2

Practice exam questions: Section C

C4. A 1.5 kg iron kettle sits on a 2.2 kW stove burner. If it takes 5.9 minutes to bring the kettle and the water in it from 21° C to the boiling point, calculate how much water is in the kettle.

$$Q = Power \times Time = 2.2 \times 10^3 \times 5.9 \times 60 = 7.8 \times 10^5 \ J$$

$$Q = m \ c \ \Delta T$$

$$m = \frac{Q}{c \ \Delta T} = \frac{7.8 \times 10^5}{4186 \times 79} = 2.4 \ kg$$

Next steps

- Make sure you are comfortable with unit conversions
- Review the thermodynamics key facts
- Familiarize yourself with the thermodynamics section of the formula sheet
- Try questions from the sample exam papers on Blackboard and/or the textbook

Revision : Electricity

Formula sheet

LINEAR MECHANICS		ROTATIONAL MECHANICS	
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$v^2 = v_0^2 + 2a(x - x_0)$	$x - x_0 = v_0 t + \frac{1}{2}at^2$	$\omega^2 = \omega_0^2 + 2\alpha(\theta - \theta_0)$	$\theta - \theta_0 = \omega_0 t + \frac{1}{2}\alpha t^2$
$\vec{F}_{net} = m\vec{a} = \frac{d\vec{p}}{dt}$	$\vec{w} = m\vec{g}$	$\vec{\tau}_{net} = I\vec{\alpha} = \frac{d\vec{L}}{dt}$	$s = r\theta \quad \omega = \frac{d\theta}{dt} \quad \alpha = \frac{d\omega}{dt}$
$W = \vec{F}\cdot\Delta\vec{r} = F\Delta r\cos\theta$	$f_s \le \mu_s n \quad f_k = \mu_k n$	$\lvert\vec{\tau}\rvert = \lvert\vec{r}\times\vec{F}\rvert = rF\sin\theta$	$\vec{F}_r = m\vec{a}_r = \frac{mv^2}{r}$
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$W_{net} = \Delta K = \frac{1}{2}m(v_f^2 - v_i^2)$	$W_c = -\Delta U \quad U_g = mgy$	$K_R = \frac{1}{2}I\omega^2$	$K_{roll} = \frac{1}{2}I_{cm}\omega^2 + \frac{1}{2}mv_{cm}^2$
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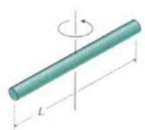
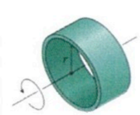
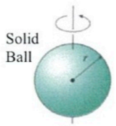
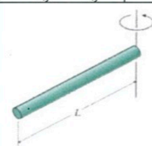
$\vec{p} = m\vec{v}$ $\vec{p}_{1,i} + \vec{p}_{2,i} = \vec{p}_{1,f} + \vec{p}_{2,f}$	$\vec{J} = \int_{t_1}^{t_2}\vec{F}\,dt = \Delta\vec{p} = \vec{F}\Delta t$	$\vec{L} = I\vec{\omega}$ $\vec{L}_{1,i} + \vec{L}_{2,i} = \vec{L}_{1,f} + \vec{L}_{2,f}$	$\lvert\vec{L}\rvert = \lvert\vec{r}\times\vec{p}\rvert = mvr\sin\theta$

 $I = \frac{1}{12}ML^2$	 $I = MR^2$	 $I = \frac{2}{5}MR^2$	 $I = \frac{1}{3}ML^2$	 $I = \frac{1}{2}MR^2$

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$\frac{1}{R_{eff}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots$ parallel	$R_{eff} = R_1 + R_2 + R_3 + \cdots$ series	$C_{eff} = C_1 + C_2 + C_3 + \cdots$ parallel	$\frac{1}{C_{eff}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \cdots$ parallel

Formula sheet

ELECTRICITY			
$F = k_e \frac{q_1 q_2}{r^2}$	$E = k_e \frac{q}{r^2} = \frac{F_e}{q}$	$i = \frac{\Delta q}{\Delta t}$, $i = \frac{V}{R}$	$P = Vi = i^2 R = \frac{V^2}{R}$
$V_b - V_a = \frac{1}{q}(U_b - U_b) = \frac{-W_{ba}}{q}$	$E = -\frac{V_b - V_a}{d}$	$q = CV$	$v = \sqrt{\frac{F}{\mu}}$ $f_n = \frac{n}{2L} v$
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Electricity key facts (1/9)

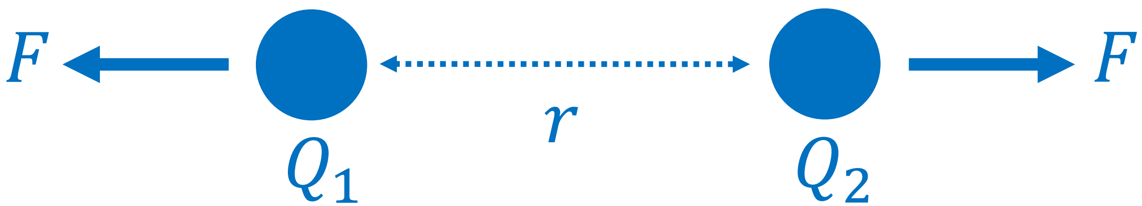
- Electric charge Q is an intrinsic property of the particles that make up matter, and can be positive (e.g. proton) or negative (e.g. electron)
- The S.I. unit of charge is Coulombs (C)
- The elementary charge (on a proton or electron) is $\pm 1.6 \times 10^{-19}\ C$
- Electric current I is the rate of flow of charge

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

I is measured in Amperes (A)

Electricity key facts (2/9)

- Coulomb's Law gives the force felt by two charges Q_1 and Q_2 separated by distance r



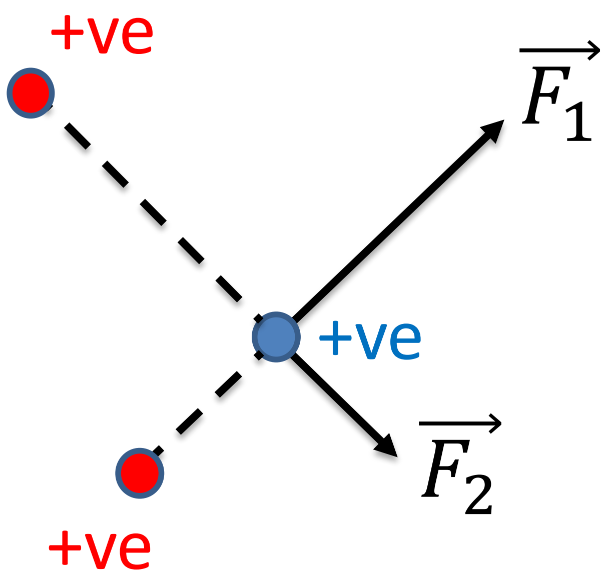
$$F = \frac{k\,Q_1\,Q_2}{r^2}$$

$$k = 9 \times 10^9\ N\ m^2\ C^{-2}$$

- Like charges repel, opposite charges attract

Electricity key facts (2/9)

- Superposition principle for Coulomb's Law : if there are multiple charges, the forces from individual charges sum like vectors



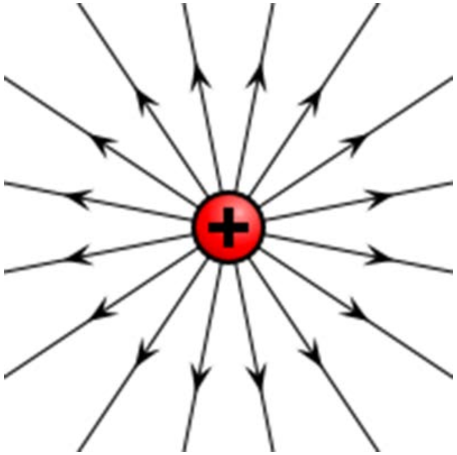
$$\overrightarrow{F_{total}} = \overrightarrow{F_1} + \overrightarrow{F_2}$$

Electricity key facts (3/9)

- The electric field at a point is the force a unit charge ($q = 1\ C$) would experience there

$$\vec{E} = \frac{\vec{F}}{q} \qquad \vec{F} = q\,\vec{E}$$

- Can be represented by electric field lines



Positive charge feels force along electric field line

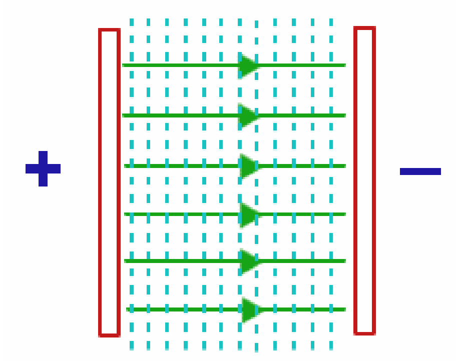
Negative charge feels force the other way

Electricity key facts (4/9)

- The electric potential difference ΔV [in volts] is the work needed to move unit charge ($q = 1\ C$) between 2 points

Work done = Potential Energy difference $= q\ \Delta V$

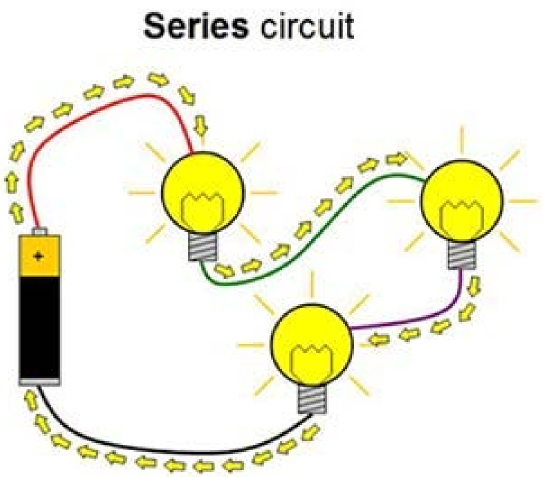
- Electric field is the potential gradient : $E = -\dfrac{\Delta V}{\Delta x}$

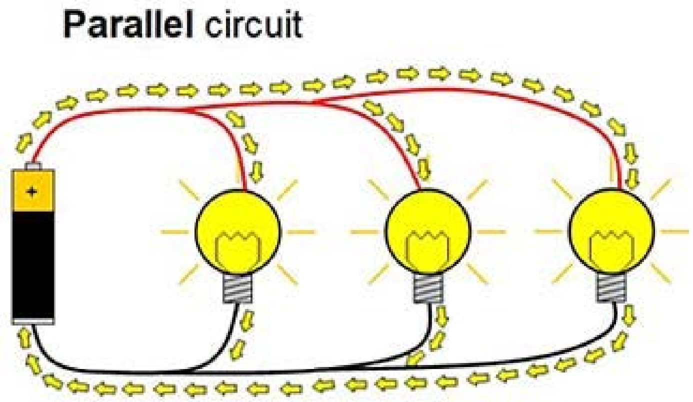


If capacitor with plate separation D is connected to battery with potential V, then $E = V/D$

Electricity key facts (5/9)

- Basic circuit principles : current I is driven by a potential difference V



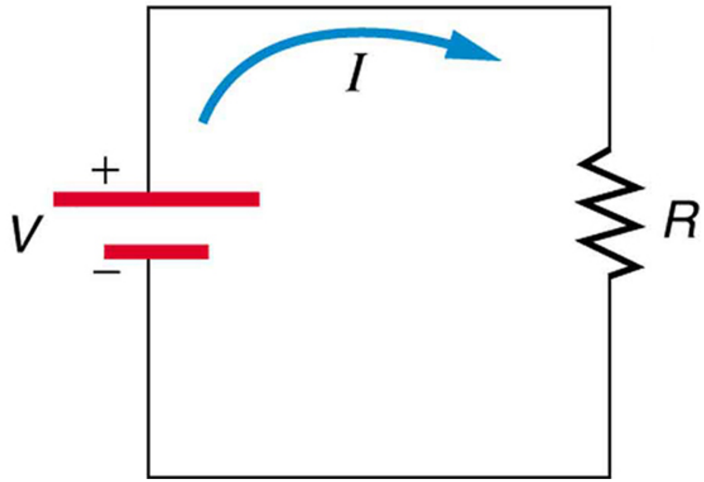


Same current flows through all components of a series circuit

Same voltage is dropped over all components of a parallel circuit

Electricity key facts (6/9)

- Ohm's Law determines the current flowing through a resistance R



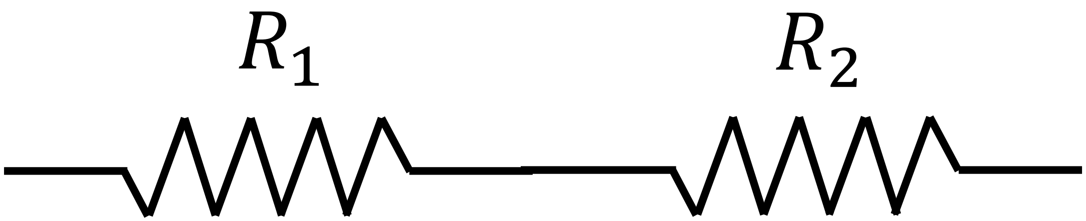
$$I = \frac{V}{R}$$

$$V = I\,R$$

- Resistance is measured in Ohms (Ω)

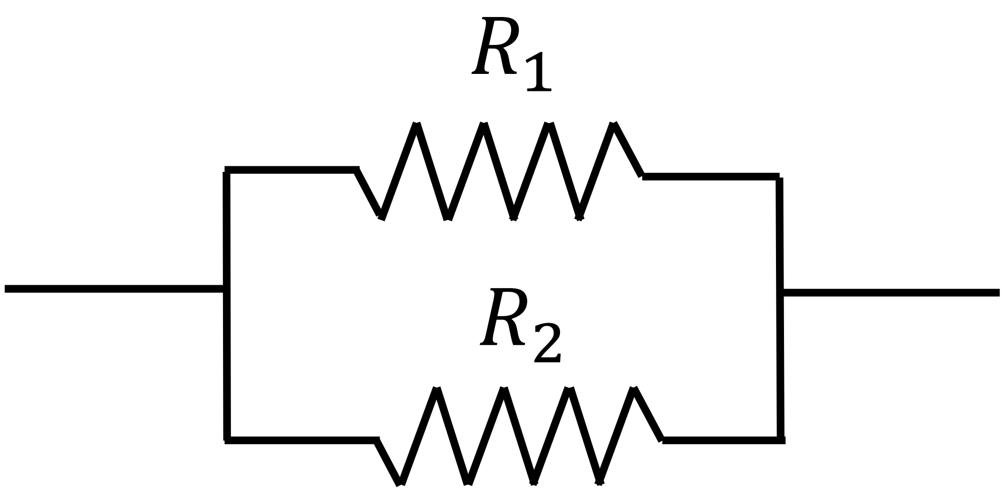
Electricity key facts (6/9)

- Resistances may be combined in series or parallel



$$R_{total} = R_1 + R_2$$

[R increases]

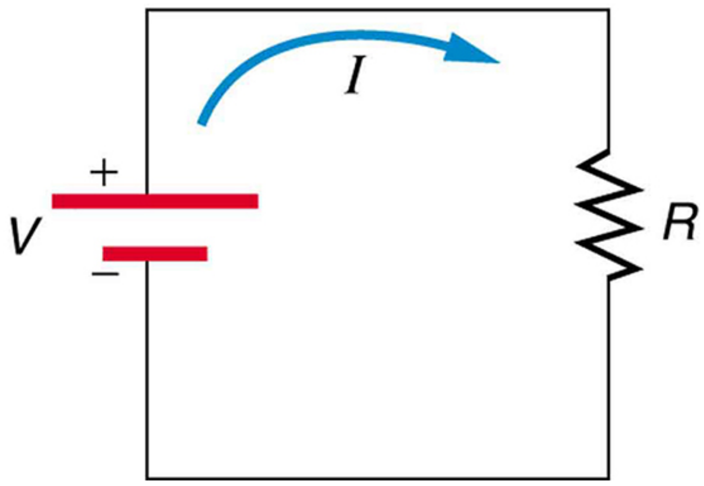


$$\frac{1}{R_{total}} = \frac{1}{R_1} + \frac{1}{R_2}$$

[R decreases]

Electricity key facts (7/9)

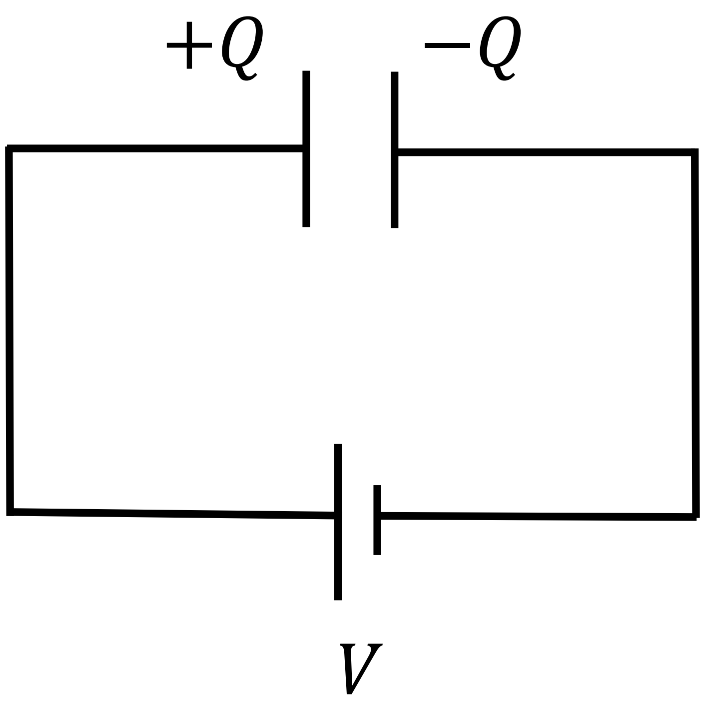
- Electrical energy is dissipated as heat by a resistor



- Electrical Power $P = I\,V = I^2 R = \frac{V^2}{R}$ [unit is W]

Electricity key facts (8/9)

- A capacitor is a device to store charge. Its capacitance C measures the amount of charge Q that can be stored for given potential difference V



$$C = \frac{Q}{V}$$

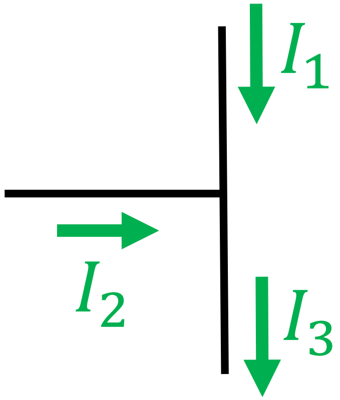
$$Q = C\,V$$

- Capacitance is measured in Farads (F)
- Capacitors may be combined in series or parallel [see lectures]

Electricity key facts (9/9)

- General circuits may be analysed using Kirchoff's rules

Kirchoff's junction rule : the sum of currents at any junction is zero



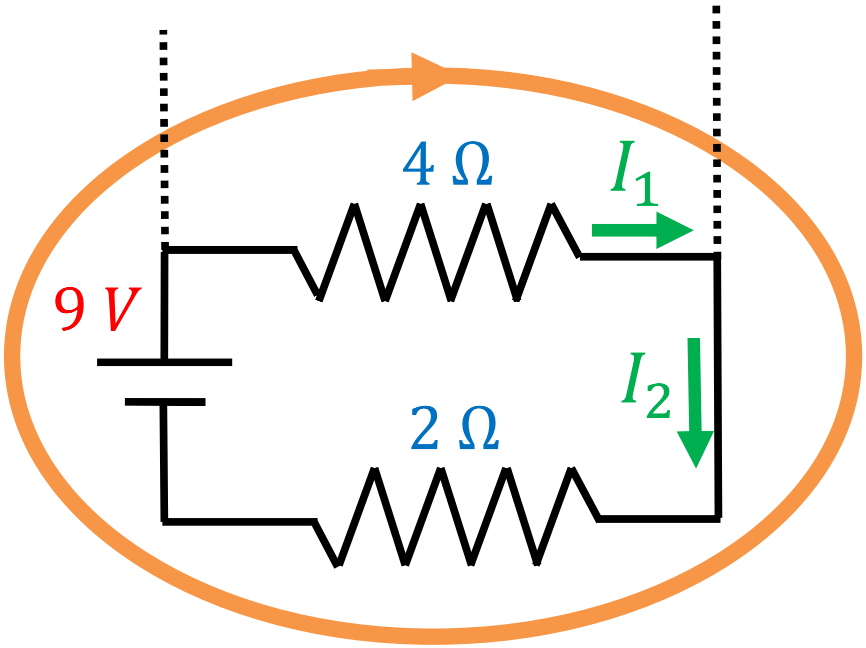
$$I_1 + I_2 - I_3 = 0$$

- Signs are different for inward/outward current
- This rule arises from conservation of charge

Electricity key facts (9/9)

- General circuits may be analysed using Kirchoff's rules

Kirchoff's loop rule : the sum of voltage changes around a closed loop is zero



$$9 - 4\,I_1 - 2\,I_2 = 0$$

- Battery adds potential V, resistors subtract potential IR
- This rule arises from conservation of energy

Practice exam questions: Section A

A18. Two charged particles experience an electric force F from each other. If the charges are now moved so they are twice as far apart, what is the magnitude of the electric force they experience?

A. $0.25F$

B. $0.5F$

C. $2F$

D. $4F$

Coulomb's Law: $F = \frac{k\, Q_1\, Q_2}{r^2}$

Double $r \rightarrow F$ decreases by $\frac{1}{4}$ – option A

A19. In an electrical circuit a 3 kΩ and a 15 kΩ resistor are connected in series with a battery. How do the voltages across each of the resistors compare?

A. They both have the same voltage across them

B. The voltage across the 3 kΩ resistor is less than that across the 15 kΩ resistor

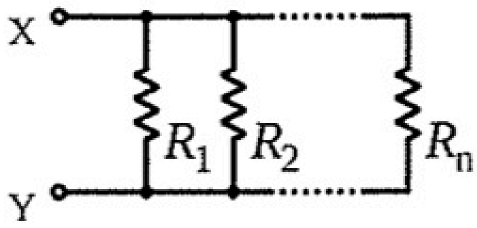
C. The voltage across the 3 kΩ resistor is more than that across the 15 kΩ resistor

D. Impossible to determine without information about the current

Current is the same → $V = I\,R$ → smaller voltage across smaller R → option B

Practice exam questions: Section A

A20. You have an infinite supply of identical resistors. You start to connect them in parallel, one resistor per parallel branch, as shown in the diagram. As the number of connected resistors increases, the resistance between X and Y



A. remains constant

B. decreases

C. increases with no limit

D. increases towards a finite maximum

Decreases – option B

Practice exam questions: Section B

B14. It takes 45 J to move a 15 mC charge from point A to point B. Calculate the potential difference ΔV_{AB}

$$W = q\,\Delta V_{AB}$$

$$\Delta V_{AB} = \frac{W}{q} = \frac{45}{15 \times 10^{-3}} = 3000\ V$$

1

Practice exam questions: Section B

B15. Calculate the current in a 47 kΩ resistor with 110 V across it.

Ohm's Law: $I = \frac{V}{R} = \frac{110}{47 \times 10^3} = 2.3 \times 10^{-3}\ A$

1

Practice exam questions: Section B

B16. Calculate what resistance you should place in parallel with a 56 kΩ resistor to make an equivalent resistance of 45 kΩ.

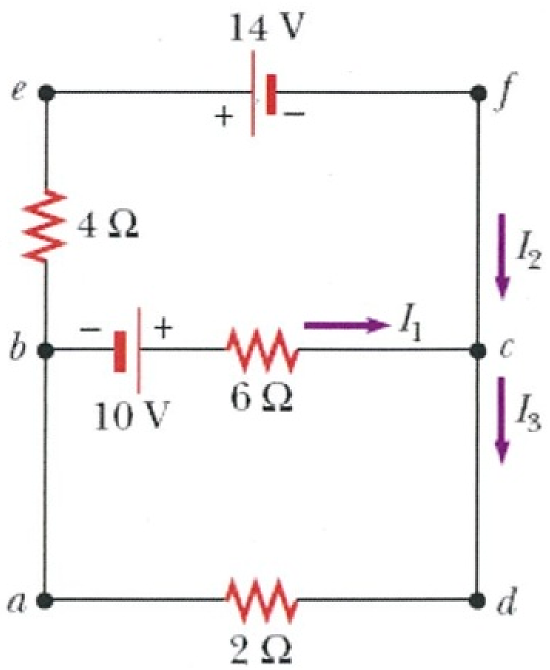
$$\frac{1}{R_{total}} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$\frac{1}{45} = \frac{1}{56} + \frac{1}{R_2}$$

$$R_2 = 230\ k\Omega$$

2

Practice exam questions: Section C



(a) Using Kirchhoff's junction rule, write an equation that relates I_1, I_2 and I_3.

$$I_1 + I_2 - I_3 = 0$$

1

(b) Using Kirchhoff's loop rule, write an equation in its simplest form that relates the potential differences around the loop *abcda*.

$$10 - 6I_1 - 2I_3 = 0 \qquad 5 - 3I_1 - I_3 = 0$$

1

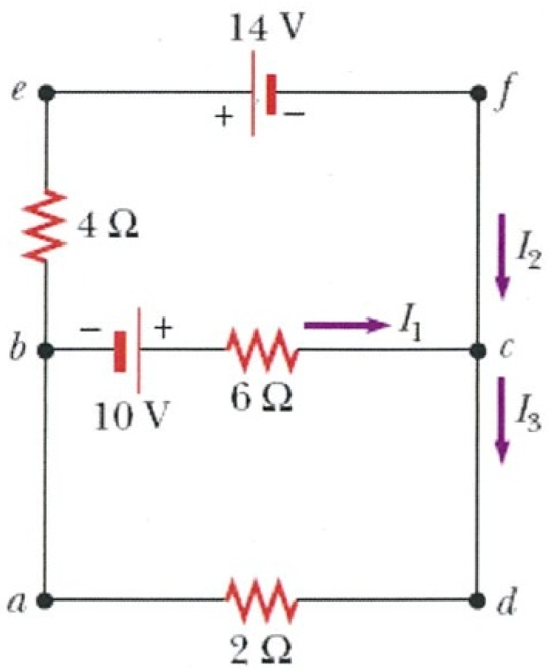
(c) Using Kirchhoff's loop rule, write an equation in its simplest form that relates the potential differences around the loop *befcb*.

$$-4I_2 - 14 + 6I_1 - 10 = 0$$

$$-2I_2 - 12 + 3I_1 = 0$$

1

Practice exam questions: Section C



The potential difference between b and c was measured as 2 V with b at the higher potential.
Calculate
(d) the potential difference across the 6 Ω resistor.

$$V_{bc} = -10 + V_{6\Omega} = 2\ V \quad \rightarrow \quad V_{6\Omega} = 12\ V$$

1

(e) I_1

$$I_1 = \frac{V}{R} = \frac{12}{6} = 2\ A$$

1

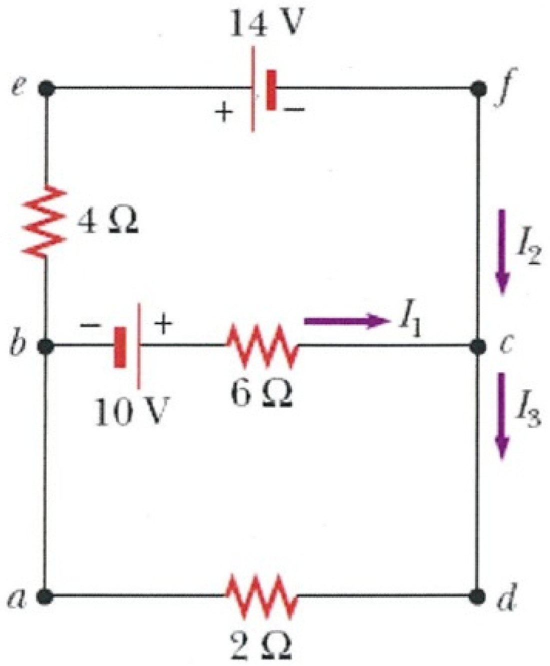
(f) I_3

From before: $5 - 3I_1 - I_3 = 0$

$$I_3 = 5 - 3I_1 = 5 - (3 \times 2) = -1\ A$$

1

Practice exam questions: Section C



(g) I_2 From before: $-2I_2 - 12 + 3I_1 = 0$

$$I_2 = \frac{3I_1 - 12}{2} = \frac{-6}{2} = -3\ A$$

1

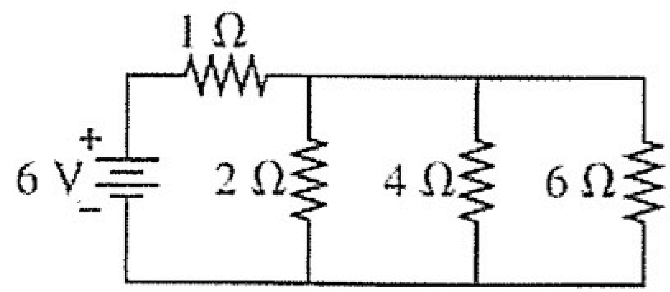
(h) the power delivered to the 2 Ω resistor.

$$P = {I_3}^2 R = (-1)^2 \times 2 = 2\ W$$

1

Practice exam questions: Section C

C5. Consider the following circuit:



(a) Calculate the current supplied by the battery.

Combine the 2Ω, 4Ω, 6Ω resistors in parallel

$$\frac{1}{R_{parallel}} = \frac{1}{2} + \frac{1}{4} + \frac{1}{6} \rightarrow R_{parallel} = 1.1\ \Omega$$

Combine the 1Ω, 1.1Ω resistors in series $R_{total} = 2.1\ \Omega$

Ohm's Law: $I = \frac{V}{R_{total}} = \frac{6}{2.1} = 2.9\ A$

Practice exam questions: Section C

(b) Calculate the current through the 6Ω resistor.

Voltage across parallel combination $= \frac{1.1}{2.1} \times 6\ V = 3.1\ V$

$$I = \frac{V}{R} = \frac{3.1}{6} = 0.52\ A$$

1

Final words

- Thanks to all students for their efforts in the Introduction to Physics course
- Please fill in feedback surveys!
- Good luck in the upcoming exams!