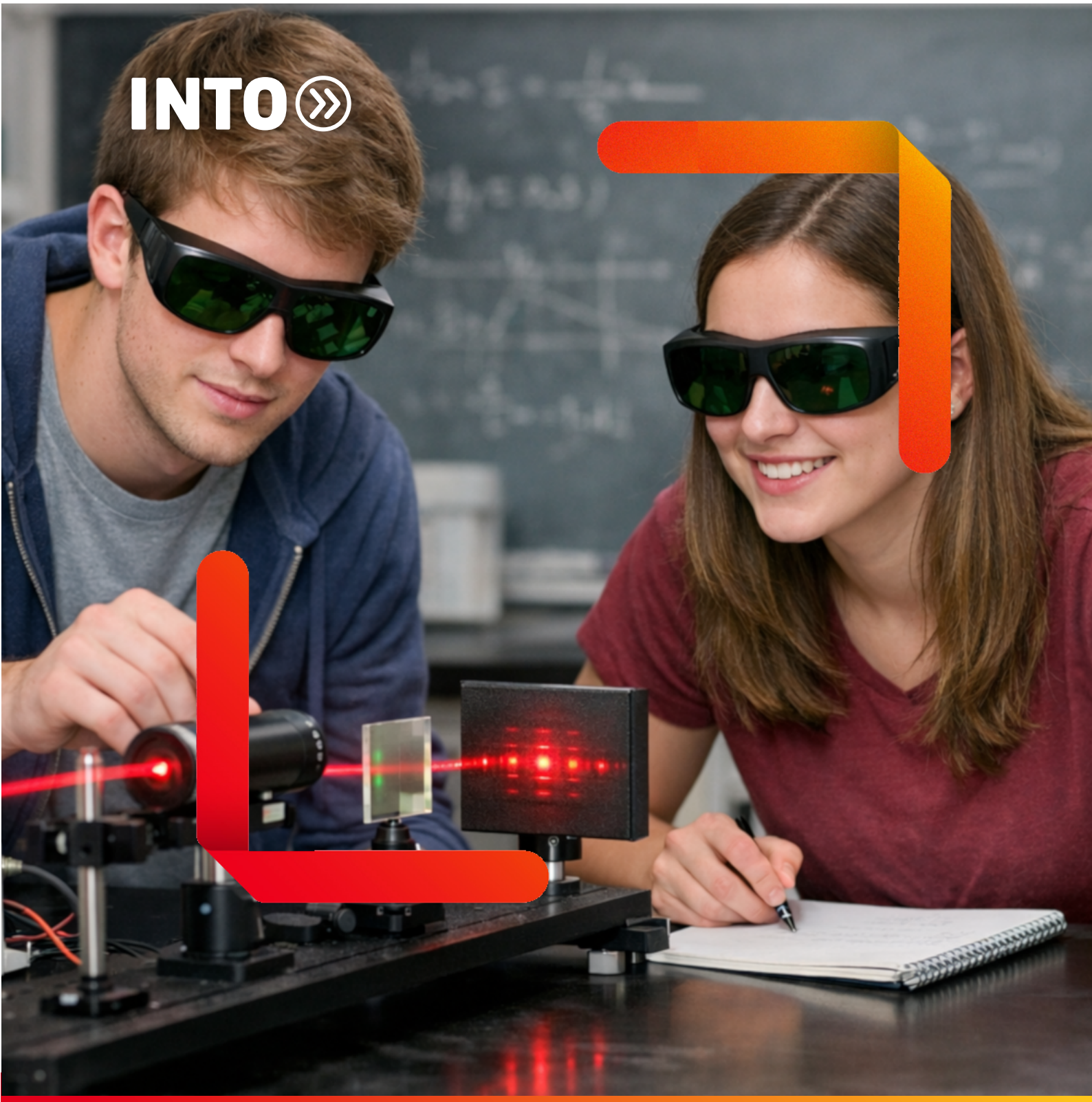


PHYSICS
SCHEME OF WORK

Extended Materials
Version: August 2026

Module Title:	Physics			
Description:	This module develops • understanding of core physics principles across mechanics, waves, electricity, thermal physics, and atomic theory • ability to apply mathematical, investigative and problem-solving techniques to theoretical and practical problems • skills in analysis and interpretation of experimental data • the capacity to assess scientific methods and relate finding to real-world contexts • ethical, environmental and social awareness of physics in modern society			
Programme:	INTO Level 3 Diploma in International Foundation Studies		Mnemonic	13 IFY PHY
Credits points:	30		Year / Version	August 2026
Total hours:	300 learning hours / 120 contact time			
Assessment type	1	Paper 1 Written examination (Physics): End of term, unseen, closed book AOs 1, 2 & 3		2 hours 10 credits
	2	Paper 2 Written examination (Physics): End of term, unseen, closed book AOs 1, 2 & 3		2 hours 10 credits
	3	Reflective 1 Laboratory Log A portfolio showing a student's completion of various class and laboratory exercises during the course AOs 2,3		2000 words (notional – there are data elements, practical teacher assessment elements and experiment outcomes included) 10 credits

#	Topic	Learning Outcomes	Resources	Link to assessment
Subject 1: The Particle Nature of Matter				
4	Ideal Gas Calculations	Module guide LO7 • List assumptions for ideal gases • Derive and/or state kinetic theory equation $pV = \frac{1}{3}Nm\overline{c^2}$ • Practice calculations using all formulas	PowerPoint Lesson Plan Formative quiz	Assessment 1
Subject 5: Fields				
24	Moving Charges in Magnetic Fields	Module guide LO35 LO36 • Force on a moving charge F=BQv • Magnetic flux and magnetic flux linkage • Electric motors and generators • $N\phi = BANcos\ \theta$	PowerPoint Lesson Plan Formative quiz	Assessment 2

Topics not covered

	Distance time graphs	Module guide LO10 • Interpreting distance time graphs		Assessment 1

Ideal Gas Calculations - Lesson plan

Lesson number	4
Subject:	Physics
Topic:	Ideal Gas Calculations
Resources:	Online: • PowerPoint slides • Post session quiz & extension activities In Classroom: • PowerPoint slides • Whiteboard &markers • Student notebooks
Session objectives:	By the end of the session: • Students will be able to apply the ideal gas law to solve practical calculation problems involving pressure, volume, temperature, and number of molecules. • Students will understand the key assumptions and limitations of the ideal gas model and recognise scenarios where real gas behaviour deviates from ideal predictions. • Students will relate the kinetic energy of gas molecules to temperature using mathematical derivations and perform calculations using the Boltzmann constant. • Students will demonstrate their understanding through practice questions, stepwise calculations, and peer discussion, using accurate unit conversions and scientific reasoning.
Learning outcomes:	Learning outcomes from the IQ Module Specification covered in this session: LO7
Total time:	Flexible: 60 to 90 minutes + Post-lesson extension suggestions

Prior Learning:	Students will need to complete the previous sessions on pressure and density, thermal equilibrium and kinetic theory of gases, these topics covered LO1 – LO6	
Part 1 **Review** **10 minutes**	Interaction: S < > S	**Rationale – Sets up lesson** • Recall calculations from previous lesson attempt calculation using pV=nKT • Review answers focussing on common areas of difficulty (not converting temperature to Kelvin. Checking and converting to SI units where necessary)
Part 2 **15 minutes**	Interaction T > Ss	**Recognising Limitations and Real Gas Behaviour** • Examine the limitations of the ideal gas law, focusing on conditions such as high pressure, low temperature, and high density, where intermolecular forces and particle volume become significant. • Present scenarios where the ideal gas law produces anomalous results, such as liquefaction at low temperatures or increased volume at high pressures, and discuss the physical reasons behind these deviations. • Encourage students to identify the assumptions most likely to break down in each scenario, using guided questioning and peer discussion to reinforce conceptual understanding. • Introduce correction factors and briefly mention the van der Waals equation as an example of addressing real gas behaviour, but focus on the importance of recognising when ideal gas calculations may not be accurate.
Part 3 **15 minutes**		**Connecting Temperature to Kinetic Energy of Gas Molecules** • Derive the relationship between temperature and kinetic energy using the equations pV = NkT and pV = (1/3)Nmc^2, where m is particle mass and c is mean square speed. • Explain and calculate root mean square (rms) speed and mean square speed, demonstrating how these relate to molecular motion and energy.

		• Show how kinetic energy per molecule, KE = (1/2)mc^2, is proportional to absolute temperature, and use the Boltzmann constant to perform example calculations. • Use a detailed example, such as calculating the total kinetic energy for 128 g of oxygen at 330K, to illustrate the stepwise approach and highlight the importance of Avogadro's number and unit conversions.
Part 4 **15 minutes**	Interaction T > Ss S < > S	**Applying Ideal Gas Calculations to Real-Life Scenarios** • Provide students with practice questions involving ideal gas calculations, such as determining the number of molecules removed from a cylinder or calculating the rms speed of gas particles at a specific temperature. • Guide students through stepwise solutions, emphasising careful unit conversions, accurate use of constants (e.g. Boltzmann constant), and interpretation of results. • Encourage students to work collaboratively in pairs or small groups, discussing their approaches and comparing answers to reinforce learning and address misconceptions. • Use a scenario involving the number of air molecules expelled from lungs and the calculation of total kinetic energy, illustrating the practical application of ideal gas laws and linking macroscopic and microscopic perspectives.
Part 5 **5 minutes**	Ss < > Ss & S > T	**Assessment and Reflection on Ideal Gas Calculations** • Administer a short formative quiz or worksheet covering key concepts, assumptions, and calculation steps to evaluate student understanding and identify areas for improvement. • Facilitate a reflective discussion where students share challenges faced during calculations and clarify common errors, such as incorrect unit conversions or misapplication of formulas. • Invite students to summarise the main takeaways from the lesson, focusing on the importance of recognising limitations and the practical relevance of ideal gas calculations. • Conclude with suggestions for further reading or online simulations, encouraging students to explore real gas

		behaviour and advanced applications in future lessons.
Extension activities		EA1: Seminar: Read the document Derivation of idea gas equation and discuss different aspects of the derivation EA2: Research the assumptions for an ideal gas and why they are made. EA3: Writing Work out the rms speeds of various gases (oxygen O_2, ozone O_3, carbon dioxide CO_2, hydrogen H_2, neon Ne) at standard temperature (298K) EA4: Presentation

Legend for Student Interactions	
S > T	Student to teacher feedback / comments / ideas
T > S	Teacher to individual student input, instruction etc.
T > Ss	Teacher to the group – input, instruction etc.
Ss < > Ss	Group work – discussion among students
S < > S	Pair work - Individual student to student interaction
S > Ss	Student to peers, e.g. presenting

Ideal Gases

Particles and States of Matter

INTO

Starter question

- A gas cylinder of volume 0.052 m^3 contains oxygen gas at a temperature of 22°C and a pressure of 2.0 x 10^5 Pa. Some of the oxygen in the cylinder is used and the pressure falls to 1.6 x 10^5 Pa. The temperature remains constant.

- Calculate the number of molecules **removed** from the cylinder. $pV = NkT$ and the Boltzmann constant, $k = 1.38 \times 10^{-23}$ J K^{-1}

- Work in pairs. You have 5 minutes

Answer

- Number of molecules in this case would be N
- Rearrange the formula:
- $pV = NkT \Longrightarrow N = \frac{pV}{kT}$
- **Convert T to Kelvin** $T = 273 + 22 = 295$
- Initial number of molecules $\mathrm{N_i} = \frac{2.0\times10^5\times0.052}{1.38\times10^{-23}\times295} = 2.5547\times10^{24}$
- Final number of molecules $\mathrm{N_f} = \frac{1.6\times10^5\times0.052}{1.38\times10^{-23}\times295} = 2.0437\times10^{24}$
- Molecules removed $= 2.5547\times10^{24} - 2.0437\times10^{24} = 5.11\times10^{23}$

The problem with the gas laws

- When the particles in a gas are forced close together or slow down, the gas law $pV = nRT$ or $pV = NkT$ begins to break down.

- At **high pressure**, the gas molecules are packed close together, so the volume of the molecules themselves become significant, causing the gas to occupy more space than predicted.

- At **low temperatures**, the kinetic energy of the molecules decreases until the intermolecular foces between them becomes significant, pulling the molecules closer together and causing the gas to occupy a smaller volume than predicted. Eventually these forces become stron enough that the gas liquifies.

- When the gas is of **high density** the intermolecular forces dominate over independent movement, reducing the volume from the predicted value

Assumptions for ideal gases

- Several assumptions for ideal gases are made in order for the formulae to work. It is important to be aware of them since any conditions that deviate from these may result in anomalous results.
- They are, in an ideal gas:
  - No intermolecular forces act between molecules. This means that the potential energy involved in change of state can be ignored
  - The duration of any collision isnegligible compared to the time between collisions
  - Motion of molecules is random
  - Collisions involving molecules are considered to be perfectly elastic, meaning no kinetic energy is lost so the magnitude of the velocity remains the same
  - Newton’s laws of motion hold, meaning molecules move in straight lines between collisions

Relating temperature to kinetic energy in a gas

- It can be shown from first principles that:
  - $pV = \frac{1}{3}Nm\overline{c^2}$
- Where p and V arepressure and volume, N is the number of molecules present, m is the mass of a molecule and c^2 is the mean square speed of the molecules, defined as the mean of the square speeds of the gas molecules. Another term, root mean square, is the square root of this value so $c_{rms} = \sqrt{\overline{c^2}}$ so the formula may also be written as:
  - $pV = \frac{1}{3}Nm(c_{rms})^2$
- Since kinetic energy is defined as $K_E = \frac{1}{2}mv^2$, the kinetic energy of all the particles in a gas can be shown to be $K_E = \frac{1}{2}Nm\overline{c^2}$ which is $\frac{3}{2}$ times the right-hand side above.
- We already know that $pV = NkT$, so combining these gives $\frac{1}{2}Nm\overline{c^2} = \frac{3}{2}NkT$. Cancelling the N and considering the kinetic energy of a single gas molecule gives:
  - $\frac{1}{2}m\overline{c^2} = \frac{3}{2}kT$
- So the kinetic energy of a molecule $\left(\frac{1}{2}m\overline{c^2}\right)$ is proportional (constant of proportionality $\frac{3}{2}k$) to the **absolute** temperature T

Example

- A bottle contains 128 g of oxygen at a temperature of 330K. Find the sum of the kinetic energies of all the oxygen molecules given that the relative atomic mass of oxygen is 32 g mol^{-1}

- 1 mole of oxygen has a mass of 32g, so 128 g of oxygen is $\frac{128}{32} = 4$ moles
- Avogadros number tells us how many molecules there are in a mole $\mathrm{N_A} = 6.02\times10^{23}$ so the number of molecules in 4 moles would be $6.02\times10^{23}\times4 = 2.408\times10^{24}$

The kinetic energy of one molecule will be $\frac{3}{2}kT = \frac{3}{2}\times1.38\times10^{-23}\times330 = 6.831\times10^{-21}$J

So the sum of all energies would be $2.408\times10^{24}\times6.831\times10^{-21} = 16450\text{J} \approx 16500\text{J}$

Incidentally, linking $pV = nRT$ and $pV = NkT$, we can see that $nR = Nk$ and since N is the number of molecules in n moles of a substance, $N = N_A n$ where $N_A = 6.02\times10^{23}$, we can also see that

$$k = \frac{R}{N_A} = \frac{8.314}{6.02\times10^{23}} = 1.38\times10^{-23}$$

Practice question 1

- The velocities of four gas particles at 290K are given below in ms^{-1}
- 310, 370, 440, 550
- Show that the root mean square (rms) speed of the sample is about 430 ms^{-1}
- Remember that $\overline{c^2}$ is the mean of the squares of the all the speeds and c_{rms} is the square root of this.

- Calculate the molar mass of the gas, assuming an absolute temperature of 290K and and rms speed of 430ms^{-1}. The Boltzmann constant is $\mathrm{k} = 1.38\times10^{-23}$ J K^{-1} and Avogadro's number $N_A = 6.02\times10^{23}$

- You have 5 minutes

Answer

- $\overline{c^2} = \frac{310^2+370^2+440^2+550^2}{4} = 182275$
- $c_{rms} = \sqrt{182275} = 426.9 \approx 430 ms^{-1}$

- $\frac{1}{2}m\overline{c^2} = \frac{3}{2}kT, m = \frac{3kT}{\overline{c^2}} = \frac{3\times1.38\times10^{-23}\times290}{430^2} = 6.493\times10^{-26}kg = 6.493\times10^{-23}g$
- Mass of one mole $mN_A = 6.493\times10^{-23}\times6.02\times10^{23} = 39.089 \approx 39.1$ g mol^{-1}

Practice question 2

- In a medical test, the volume of air in a patient's lungs is measured to be a maximum of 5.9 x 10^{-3} m^3 and a minimum of 1.9 x 10^{-3} m^3. Whilst in the lungs, the air temperature was 37.0°C and the pressure 1.02 x 10^5 Pa
- Show that the number of air molecules expelled from the lungs between maximum and minimum was 1.1 x 10^{23} Boltzmann's constant $k = 1.38\times10^{-23}$ J $K^{-1.}$

- Calculate the total kinetic energy of the air molecules expelled from the lungs between maximum and minimum (use your exact value for the previous answer before rounding)

- You have 5 minutes

Answer

- $pV = NkT, N = \frac{pV}{kT}$
- Convert T to Kelvin. $273 + 37 = 310$
- $N = \frac{1.02\times10^{5}\times\left(5.9\times10^{-3}-1.3\times1^{-3}\right)}{1.38\times10^{-23}\times310} = 1.096\times10^{23} \approx 1.1\times10^{23}$

- $K_E = \frac{3}{2}kT$ for one molecule so multiply by number of molecules for total
- $K_E = \frac{3}{2}\times1.38\times10^{-23}\times310\times1.096\times10^{23} = 703.3 \approx 700\text{J}$

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Formative Assessment

Sample question type: Multiple choice

Subject:	Physics
Topic:	Particle nature of matter

Question 1:

Which of the following is NOT an assumption made for an ideal gas?

1. Collisions are perfectly elastic
2. *Intermolecular forces are significant
3. Molecules move in straight lines between collisions
4. Motion of molecules is random

Answer: The correct answer is 2. Intermolecular forces are significant

Incorrect. The correct answer is intermolecular forces are significant. Ideal gases have no intermolecular forces, elastic collisions, random motion, and straight-line movement.

Question 2:

At high pressure, why does the ideal gas law begin to break down?

1. Temperature increases
2. Collisions become inelastic
3. Molecules move faster
4. *Molecular volume becomes significant

Answer: The correct answer is 4. Molecular volume becomes significant

Incorrect. The correct answer is molecular volume becomes significant. At high pressure, molecules are close together and their own volume matters.

Question 3:

State the formula linking pressure, volume, number of molecules, Boltzmann constant, and temperature for an ideal gas.

1. $pV = nRT$

2. pV = nKT
3. pV = NRT
4. *pV = NkT

Answer: The correct answer is 4. pV = NkT

Incorrect. The correct answer is pV = NkT k is the Boltzmann constant and N is the number of molecules

Question 4:

A bottle contains 128 g of oxygen at 330 K. Calculate the total kinetic energy of all oxygen molecules. (Relative atomic mass of oxygen = 32 g mol^{-1}) k = 1.38 x 10^{-23}, NA=6.02 x 10^{23}

1. 6.831 x 10^{-21} J
2. 4100 J
3. *16400 J
4. 11000J

Answer: The correct answer is 3. 16400 J

Incorrect. The correct answer is 16400 J 128 g oxygen = 4 moles, N = 2.408×10^{24} molecules, KE per molecule = (3/2)kT.
Calculate KE per molecule: $(3/2) \times 1.38\times10^{-23} \times 330 = 6.831\times10^{-21}$ J.
Multiply by number of molecules: $2.408\times10^{24} \times 6.831\times10^{-21} = 16449 = 16400$ J.

Question 5:

Which statement best describes the motion of molecules in an ideal gas?

1. *Random and straight-line between collisions
2. Circular and predictable
3. Always at constant speed
4. Oscillating around fixed points

Answer: The correct answer is 1. Random and straight-line between collisions

Incorrect. The correct answer is random and straight-line between collisions

Question 6:

Calculate the root mean square (rms) speed of gas particles with velocities 310, 370, 440, and 550 ms^{-1}.

1. 417.5 ms^{-1}
2. 835 ms^{-1}

3. *430 ms^{-1}
4. 860 ms^{-1}

Answer: The correct answer is 3. 430 ms^{-1}

Incorrect. The correct answer is 430 m^{-1}. rms speed = sqrt(mean of squares).
Square each speed: 310^2, 370^2, 440^2, 550^2.
Find mean: ($310^2 + 370^2 + 440^2 + 550^2$) / 4 = 182275.
Take square root: sqrt(182275) ≈ 430 ms^{-1}.

Question 7:

Which formula links the number of moles, universal gas constant, and number of molecules?

1. *nR = Nk
2. NR = nk
3. nRk = N
4. NRk = n

Answer: The correct answer is 1. nR = Nk

Incorrect. The correct answer is nR = Nk. pV = nRT = NkT

Question 8:

Which of the following conditions causes a real gas to deviate most from ideal behaviour?

1. Low temperature low pressure
2. *Low temperature high pressure
3. High temperature low pressure
4. High temperature high pressure

Answer: The correct answer is 2. Low temperature high pressure

Incorrect. The correct answer is low temperature high pressure

Question 9:

If the temperature of a gas is doubled, what happens to the average kinetic energy of its molecules?

1. It quadruples
2. *It doubles
3. It remains the same
4. It halves

Answer: The correct answer is 2. It doubles

Incorrect. The correct answer is it doubles. KE = (3/2)kT, KE is proportional to T

Question 10:

Which of the following is a direct consequence of perfectly elastic collisions in an ideal gas?

1. Molecules stick together after collision
2. Molecules slow down after collision
3. *No kinetic energy is lost during collisions
4. Collisions are rare

Answer: The correct answer is 3. No kinetic energy is lost during collisions

Incorrect. The correct answer is no kinetic energy is lost during collisions. Elastic collisions mean kinetic energy is conserved.

Moving Charges in Magnetic Fields - Lesson plan

Lesson number	24
Subject:	Physics
Topic:	Moving Charges in Magnetic Fields
Resources:	Online: • PowerPoint slides • Post session quiz & extension activities In Classroom: • PowerPoint slides • Whiteboard &markers • Student notebooks • Magnetic field handout
Session objectives:	By the end of the session: • Understand and explain the fundamental interaction between moving charges and magnetic fields, including the concept of Lorentz force. • Apply the right-hand rule to determine the direction of force on a moving charge in a magnetic field. • Analyse real-world examples and applications, such as particle accelerators and everyday devices, where moving charges interact with magnetic fields. • Investigate and interpret the mathematical relationship between force, velocity, charge, and magnetic field strength using relevant equations.
Learning outcomes:	Learning outcomes from the IQ Module Specification covered in this session: LO35, LO36
Total time:	Flexible: 60 to 90 minutes + Post-lesson extension suggestions

Prior Learning:	Students will need to complete the previous session on magnetic field, this topic covers LO34	
Part 1 **Review** **10 minutes**	Interaction: T < > Ss	**Introduction to Moving Charges and Magnetic Fields** • Begin with a recap of electric charges and their properties, highlighting the distinction between static and moving charges. • Introduce the concept of magnetic fields, using visual aids and physical examples such as bar magnets and iron filings to show field lines. • Discuss how moving charges generate magnetic fields and how they experience forces within external magnetic fields, referencing the Lorentz force. • Present a brief overview of historical experiments, such as Oersted's discovery, to contextualise the topic in scientific history. • Engage students with a question about the everyday significance of moving charges in magnetic fields, such as in electric motors or credit card readers.
Part 2 **15 minutes**	T < > Ss	**The Lorentz Force: Theory and Equation** • Define the Lorentz force in detail, specifying the equation F = Bqv, where F is force, q is charge, v is velocity, and B is magnetic field strength. • Explain the vector nature of the equation, emphasising how the direction of force is perpendicular to both velocity and magnetic field. • Demonstrate the right-hand rule with practical examples, allowing students to practise determining force direction using their own hands. • Discuss the units and physical meaning of each variable in the equation, relating them to measurable quantities in laboratory settings. • Provide a short video or animation showing a charged particle moving through a magnetic field and experiencing a Lorentz force.
Part 3 **10 minutes**	T < > Ss & Ss < > Ss	**Hands-On Experiment: Visualising Magnetic Forces** • Guide students through a simple experiment using magnets, wires, and iron filings to observe the effect of current on magnetic field patterns. • Encourage students to predict and then observe how the direction of current affects the movement of iron filings, linking this to the right-hand rule. • Facilitate discussion on the observed phenomena, prompting students to relate their findings to the theoretical Lorentz force.

		• Ask students to sketch diagrams of their experimental setups and annotate the direction of force, current, and magnetic field. • Support students in identifying sources of error and suggesting improvements to the experiment, fostering scientific enquiry.
Part 4 **15 minutes**	T < > Ss & S < > S	**Mathematical Applications and Problem Solving** • Present sample calculation problems involving moving charges in magnetic fields, such as finding the magnitude and direction of the Lorentz force. • Guide students through step-by-step solutions, emphasising the importance of vector analysis and unit consistency. • Challenge students to work in pairs, solving additional problems and comparing their approaches and answers. • Introduce more complex scenarios, such as the motion of charges in circular paths and the concept of cyclotron frequency. • Encourage students to use calculators and rulers to verify their answers, reinforcing practical mathematical skills.
Part 5 **10 minutes**	Ss < > Ss & S > T	**Real-World Applications and Interdisciplinary Connections** • Explore real-world technologies, such as particle accelerators, MRI machines, and electric motors, where moving charges interact with magnetic fields. • Discuss the interdisciplinary nature of the topic, linking physics concepts to engineering, medical imaging, and environmental science. • Invite students to research and present brief findings on a chosen application, fostering independent learning and presentation skills. • Highlight the importance of understanding magnetic forces in designing safe and efficient technological devices. • Use multimedia resources, such as news articles or short documentaries, to illustrate the societal impact of these technologies.
Part 6 **Review, Reflection and Assessment** **10 minutes**	T < > Ss & S < > S	**Assessment and Review (10 minutes)** • Conduct a quick quiz or interactive poll using the projector to assess students' understanding of key concepts and equations. • Encourage students to reflect on what they have learnt and ask questions about any areas of uncertainty.

		• Review the main points covered in the lesson, summarising the relationship between moving charges and magnetic fields. • Provide feedback on students' experimental diagrams and problem-solving exercises, highlighting strengths and areas for improvement. • Assign a short homework task, such as researching a new application of moving charges in magnetic fields or solving additional equations.
Extension activities		EA1: Seminar: Discuss how MRI works EA2: Research Particle accelerators EA3: Writing Complete practice questions on electric motors EA4: Presentation of research findings

Legend for Student Interactions	
S > T	Student to teacher feedback / comments / ideas
T > S	Teacher to individual student input, instruction etc.
T > Ss	Teacher to the group – input, instruction etc.
Ss < > Ss	Group work – discussion among students
S < > S	Pair work - Individual student to student interaction
S > Ss	Student to peers, e.g. presenting

Moving Charges in Magnetic Fields

Fields



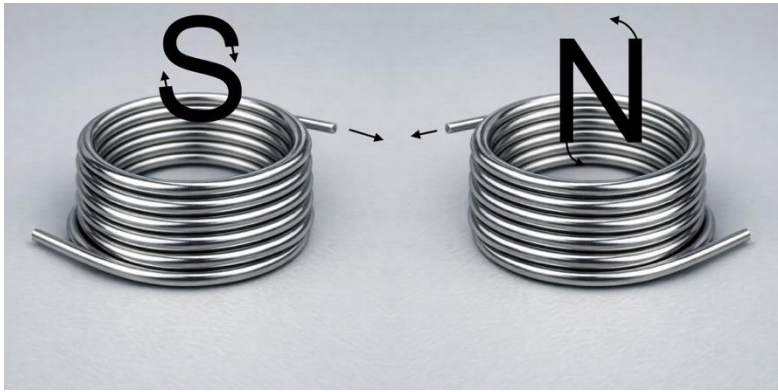
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Force on Charged Particles Moving in a Magnetic Field

- Starting with the Force on a current carrying wire as a whole:
  - $F = BIL$
- Current is defined as the rate of flow of charge $I = \frac{Q}{t}$ and velocity $v = \frac{d}{t}$ or $v = \frac{L}{t}$ given the distance travelled is the length of the wire. This rearranges to $L = vt$ and substitutes into the above equation to give:
  - $F = B \times \frac{Q}{t} \times vt$
  - $F = BQv$

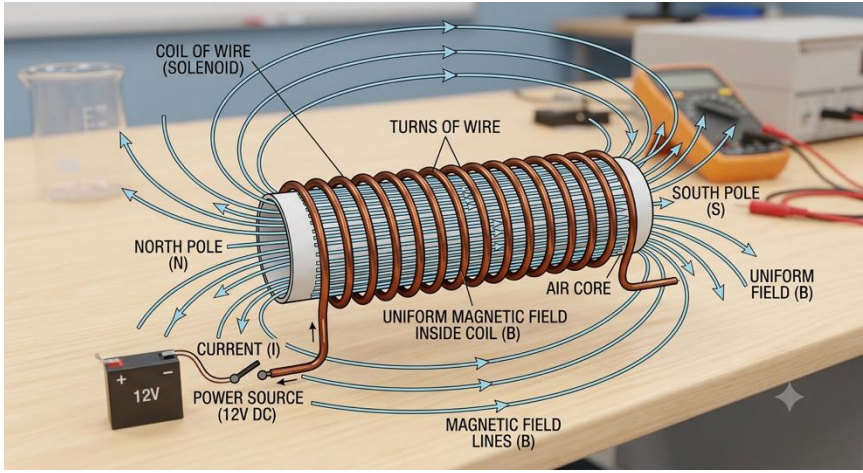
Electromagnets

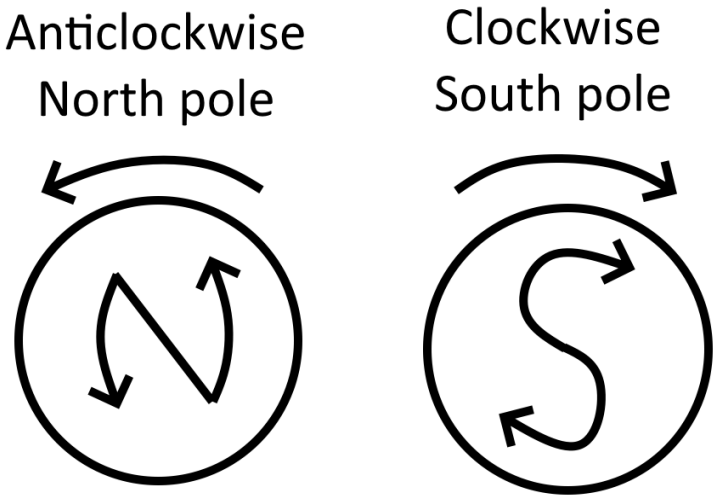
- Electromagnets can be made by taking a current carrying wire and wrapping it into a coil. This has the advantage of combining the magnetic flux from each coil, multiplying it by the number of turns, and by even more if a central core is used to concentrate the magnetic flux (such as iron).
- The poles of the magnet can be determined by considering the direction of flow of conventional current: If, when looking end on at the coil, the conventional current is rotating:
- Clockwise, then the pole closest to you is a south pole
- Anti-clockwise, then the pole closest to you is north
- This can be worked out simply by looking at the direction the ends of the letters appear to be rotating



Magnetic fields in a coil of wire

- When a direct current passes through a coiled wire hitchhiker's rule shows that the magnetic field passes in one direction through the centre of the coil and the other on the outside forming the equivalent of a bar magnet.
- The direction of the current around the coil decides which pole is at which end, and links nicely to the orientation of the letter. North poles are always where the current goes in an anticlockwise (counter-clockwise) direction and south where the current goes clockwise.
- Each turn of the coil creates its own magnetic field, so multiple turns link together forming a stronger field. This is known as **flux linkage.**





Magnetic flux linkage

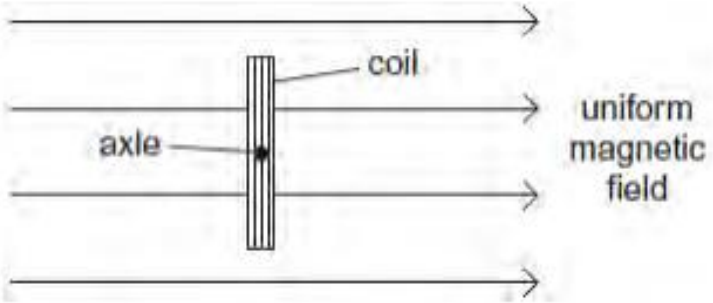
- Magnetic flux density or magnetic field strength of a uniform field, like that found inside a coil, is a measure of the magnetic flux per unit area passing perpendicular to the coil, so the magnetic flux, ϕ, through a coil of area A would be
  - $\phi = BA$
- for a field where the flux lines are perpendicular to the coil or:
  - $\phi = BA\cos\theta$
- Where the lines of magnetic flux are at an angle θ to the normal to the area of the coil

- For a coil with N turns, the **flux linkage** is the magnetic flux of a single turn of the coil multiplied by the number of coils so:

  - $N\phi = BANcos\,\theta$
- Magnetic flux is measured in Weber (Wb) and flux linkage also in Weber since N has no dimensions, although flux linkage is sometimes given the term Weber turns.

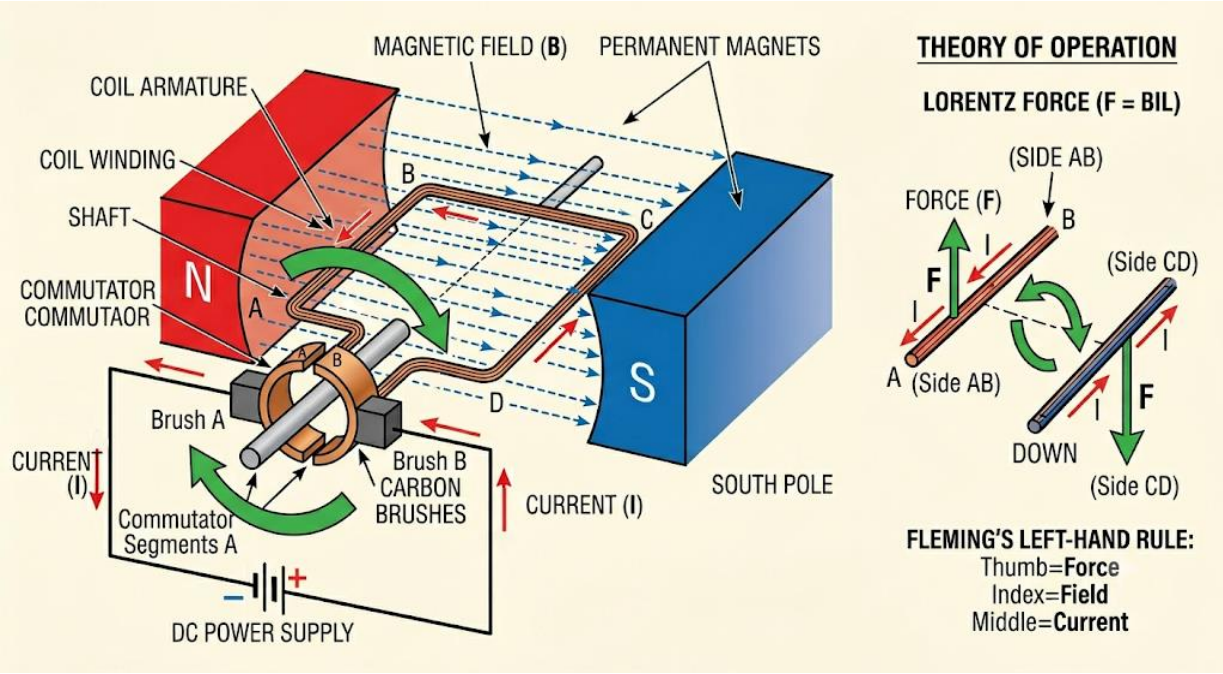
Sample question

- A 40 turn coil of cross sectional area 3.6 x 10^{-3} m^2 has its plane set at right angles to a uniform magnetic field of flux density 0.42T.



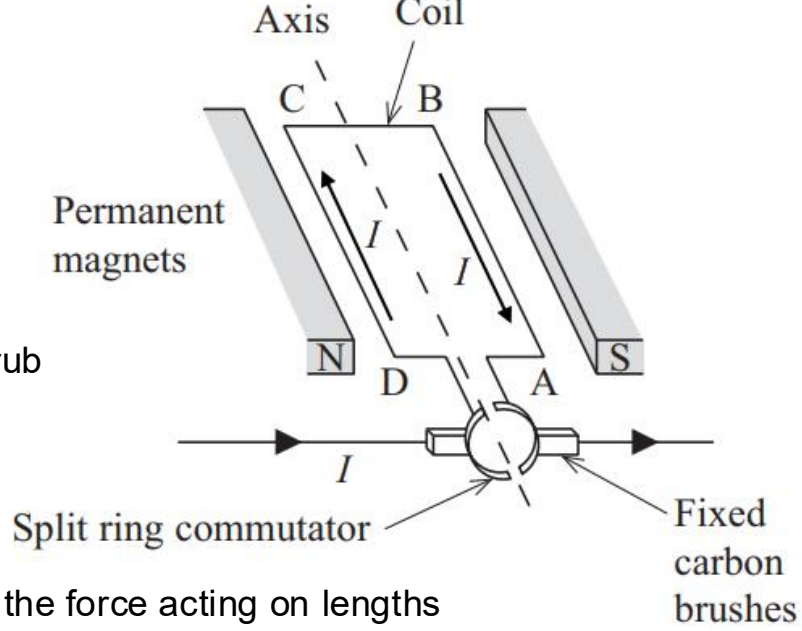
- Calculate the magnetic flux linkage for the coil and state and appropriate unit.
- $\phi = BAN\cos\theta . \theta$ in this case is $90°$ so $\cos\theta = 1.$
- $\phi = 0.42 \times 3.6 \times 10^{-3} \times 40 = 0.06$ Wb (or Wb turns)

Electric motors



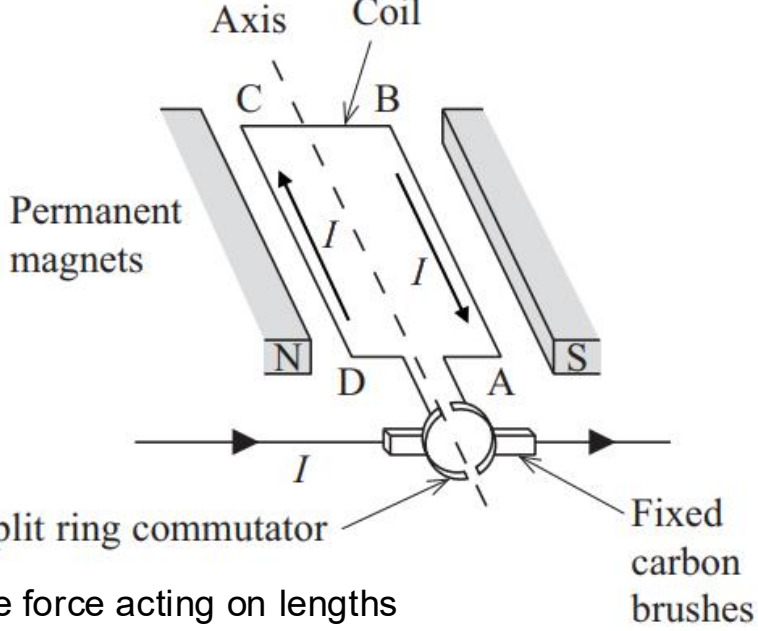
- A simple electric motor with a rectangular coil and a current flowing anticlockwise will, according to Flemings left hand rule experience a force upwards on the left and downwards on the right.
- The resulting torque will cause the coil to rotate until it is vertical, at which point inertia will carry it past the top point.
- The split ring commutator will then switch sides so current flows in the opposite direction and the forces will switch so that the upper length of wire perpendicular to the field is pulled down and the lower is pushed up, maintaining a rotation in the clockwise direction

Practice question



- A simple dc electric motor is shown. The split ring commutator consists of two copper semicircular sections attached to either end of the coil. Fixed carbon brushes rub against them and make electrical connection.
- If the coil consists of a single loop of wire with an 8.0cm length inside a 0.30 T magnetic field and a current of 2.0A, calculate the magnitude and direction of the force acting on lengths AB and CD of the motor.
- Explain why the motor continues to turn beyond the first 90^{o} of rotation.
- You have 5 minutes

Practice question answer



- A simple dc electric motor is shown. The split ring commutator consists of two copper semicircular sections attached to either end of the coil. Fixed carbon brushes rub against them and make electrical connection.
- If the coil consists of a single loop of wire with an 8.0cm length inside a 0.30 T magnetic field and a current of 2.0A, calculate the magnitude and direction of the force acting on lengths AB and CD of the motor.
- $F = BIL = 0.3 \times 2 \times 0.08 = 0.048N$. From Flemming's Left Hand rule, AB goes up and CD goes down
- Explain why the motor continues to turn beyond the first 90° of rotation.
- Once the coil has passed through 90°, inertia caries it through the vertical point, the split ring commutator switches connections with the graphite brushes and the current reverses. This means that AB is now in the same condition as CD had been with the current reversed and the force now pusing it down.

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Formative Assessment

Sample question type: Multiple choice

Subject:	Physics
Topic:	Moving charges in magnetic fields

Question 1:

Which unit is used to measure magnetic flux?

1. *Weber (Wb)
2. Volt (V)
3. Ampere (A)
4. Tesla (T)

Answer: The correct answer is 1. Weber (Wb)

Incorrect. Magnetic flux is calculated as ϕ = BA, and its unit is Weber (Wb).

Question 2:

What is the effect of increasing the number of turns in a coil on magnetic flux linkage?

1. *It increases the flux linkage
2. It has no effect
3. It decreases the flux linkage
4. It reverses the direction of the flux

Answer: The correct answer is 1. It increases the flux linkage

Incorrect. Flux linkage is magnetic flux multiplied by number of turns

Question 3:

If the current in a coil flows anticlockwise when viewed end-on, which pole is closest?

1. *North
2. South
3. East
4. West

Answer: The correct answer is 1. North

Incorrect. Write an upper case letter with arrows on it. N points anti-clockwise, S point clocwise (Or use hitchhikers rule to work out the direction of the field)

Question 4:

What is the formula for magnetic flux through a coil where the normal is at an angle 0° to the field?

1. *ϕ = BA cos θ
2. ϕ = BA sin θ
3. ϕ = BAN
4. ϕ = B/A cos θ

Answer: The correct answer is 1. ϕ = bBA cos θ

Incorrect. cos 0 is 1 so when the angle between the field lines and the normal to the coil is 0, the flux is at its maximum

Question 5:

A coil with 40 turns and area 3.6×10^{-3} m² is at right angles to a 0.42 T field. What is the flux linkage?

1. 0.15Wb
2. 0.042Wb
3. 0.36Wb
4. *0.06Wb

Answer: The correct answer is 4. 0.06Wb

Incorrect. Flux linkage = BAN cos θ = 0.42 × 3.6 × 10?³ × 40 × cos(0) = 0.06 Wb.

Question 6:

What is the direction of force on a wire carrying current perpendicular to a magnetic field?

1. Parallel to the field
2. *Perpendicular to both current and field
3. Parallel to the current
4. Opposite to the current

Answer: The correct answer is 2. Perpendicular to both current and field

Incorrect. Force is perpendicular to both current and field (Flemming's left hand rule)

Question 7:

What is the main advantage of using a core material like iron in an electromagnet?

1. It decreases current
2. It increases resistance
3. It reverses the magnetic field
4. *It concentrates and strengthens the magnetic field

Answer: The correct answer is 4. It concentrates and strengthens the magnetic field

Incorrect. Soft iron increases strength by concentrating flux.

Question 8:

Which component in a motor reverses the current direction every half turn?

1. Carbon brush
2. Rotor
3. *Split ring commutator
4. Stator

Answer: The correct answer is 3. Split ring commutator

Incorrect. Every half turn, commutator reverses current.

Question 9:

In a simple DC motor, why does the coil continue to rotate through the 90° point?

1. Magnetic field disappears
2. Current stops flowing
3. Gravity pulls it down
4. *Inertia of the coil

Answer: The correct answer is 4. Inertia of the coil

Incorrect. When the coil reaches 90° there is no turning moment acting on the coil so its inertia has to carry it until the commutator switches current direction and the force starts act again

Question 10:

What is the term for the combined magnetic field from multiple turns of a coil?

1. Magnetisation

2. *Flux linkage
3. Inductance
4. Flux density

Answer: The correct answer is 2. Flux linkage

Incorrect. Flux linkage is the sum of flux through all turns.