Unit title	Principles and Applications of Physics I
Guided learning hours	60
Number of lessons	30
Duration of lessons	2 Hrs

Links to other units

- Unit 7: Principles and Applications of Physics II
- Unit 18: Astronomy and Space Science
- Unit 23: Materials Science

Key to learning opportunities			
AW	Assignment writing	**V**	Visit
TL	Tutor-led	**GW**	Group work
IS	Independent study		

Lesson	Topic	Lesson type	Suggested activities	Classroom resources
Learning aim A: Understand the main features and practical uses of waves used in communication				
1 (2 hrs)	**A1: Working with waves** • Understand the features common to all waves, using the correct terminology • Graphical representation of wave features • The differences between the two main	TL	• **Lead in and tutor presentation:** Show the general features of longitudinal and transverse waves outlined in the unit specification by using a 'slinky' spring. Use the interactive whiteboard and/or video to support the demonstration. Correct labels (see below) for both wave types will need to be correctly entered into learner workbooks: ○ periodic time ○ speed ○ wavelength ○ frequency ○ amplitude ○ oscillation.	• Slinky spring, whiteboard, laptop and video projector, classroom space • Go to YouTube and search for 'Transverse wave explained' and 'Transverse and longitudinal waves – Fuse School'

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	types of wave		• **Tutor-led discussion:** Lesson discussion on the main differences between the wave types – transverse and longitudinal. This should lead to a list which learners must record. • **Paired activity:** Learners must produce work outlining key features of waves. They should then complete a group presentation so that you can identify key misunderstandings and discuss them within the group. • **Plenary:** Learners must make valid notes from further research sources and ensure that all sources give the same information. They must then make a note of any areas which they remain unsure about and feed back these points to the group.	

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2 (2 hrs)	**A1: Working with waves** • Understand concepts applied to diffraction gratings • Understand concepts of coherence, path difference, phase difference Understand the industrial application of diffraction gratings, including emission spectra and identification of gases	GW, IS	• **Tutor presentation:** Outline the concept of diffraction' and use of diffraction gratings. Give the definitions of displacement, coherence, path difference and phase difference during the presentation for learners to write in notebooks. **Paired practical activity:** Learners should perform an activity using enclosed trays which can support water. Carefully position obstacles, such as blocks of wood, to enable learners to visualise the change in waves when travelling through a 'gap' between two blocks of wood positioned in the middle of the tray. Waves can be generated by vertical movement of a length of wood at one end of the tray. The gap size can be carefully changed for each wave generated to view the change in wave shape (spreading out). Learners link the gap size to wave shape and produce photographs, which can form the basis of discussion later. Learners should then complete research into the applications of diffraction gratings in industry linked to emission spectra and identification of gases. • **Plenary:** What do learners understand by the term diffraction? How are diffraction gratings used in industry? Give an end-of-topic discussion which will address these questions after learners have completed additional research into diffraction gratings and their uses in emission spectra and identification of gases.	• Deep-sided trays • Blocks of wood – one which is the width of the tray and two which can be used to produce a gap • 30cm ruler

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3 (2 hrs)	**A1: Working with waves** • Understand the concept and applications of stationary wave resonance • Musical instruments and speed of a wave on a string • Using the equation for calculation of speed (v = √ T/ μ)	TL, GW	• **Tutor-led practical demonstration:** A model should be set up prior to the start of the lesson and tested. This is to ensure that an appropriate wave is produced from which measurements can be taken. The wave generator will produce a standing wave (appears stationary) when the correct conditions are met. Explain the key terms: node, antinode, resonance. • **Tutor-led discussion:** Establish what is already known about waves. Have learners watch the video on standing waves. Introduce an equation which can be used to find the speed of the wave on the string: v = √ T/ μ (T = tension in the string, μ = mass of string in kg m-1). Give additional example calculations during the lesson; set these as a test of understanding of the principles and practice in calculating unknown factors. Ask learners to identify other factors which can be changed to alter the pitch of the note produced by the string – this should yield answers including change in mass per unit of length of a string and also the length of the vibrating part of the string. • **Individual activity:** Set learners a research task to give an explanation of the use of standing waves in other musical instruments. Ask learners to form groups of three and share their findings. A spokesperson for each group will give their explanations of how standing waves are used in other instruments. • **Recap:** a) Wave features b) Diffraction c) Standing waves and equation. • **Assignment writing:** Development internal assignment on above topics.	• Wave generator, bench and pulley attachment, string or guitar wire, up to 10 weights x 1N • Video projector • Go to YouTube and search for 'Standing Waves Part I: Demonstration'

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4 (2 hrs)	**A3: Use of electromagnetic waves in communication** • Identify key sections of the electromagnetic spectrum • Understand that all electromagnetic waves travel with the same speed in a vacuum • Understand how regions of the electromagnetic spectrum are grouped according to frequency Understand how the applications of electromagnetic waves in communications are related to frequency, including satellite communication, mobile phones, Bluetooth®, infrared, Wi-Fi.	TL, GW, IS	• **Tutor presentation:** Introduce the electromagnetic spectrum, using a complete and detailed diagram which must include: ○ all sections of the spectrum from radio waves to gamma rays ○ frequency ranges of each wave type ○ wavelength ranges of each wave type figures in standard form. NOTE: Figures presented in standard form will need further explanation, using examples from low numbers to higher numbers. Learners will need to perform individual research in pairs, to identify examples of the uses for each section of the e/m spectrum. • **Plenary:** Set learners the task of discussing the uses of each part of the e/m spectrum. This can develop to enhance the work undertaken and to confirm the information gathered by research. Each pair of learners will give a brief (possibly three minutes) presentation of their findings to the class. Collate the main aspects of the e/m spectrum and have all learners take notes.	• Video projector, availability of laptops for research or text books for learners’

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5 (2 hrs)	**A3: Use of electromagnetic waves in communication** • Be able to use the wave equation, V = f λ in context	TL, IS	• **Tutor presentation:** Introduction to the wave equation: V = f **λ (**velocity = frequency x wavelength). Give a short recap of definitions for each aspect of the equation, followed by the correct units. Introduce the speed of electromagnetic waves in a vacuum as 3.0 x 10^8m/s and emphasise that the speed of e/m waves through different mediums, such as air, water, glass etc., is slightly different and is related to the density of the material. • **Individual activity:** Learners should complete a series of example calculations using v = f λ which also include rearrangement of the equation. A sufficient number of calculations will be needed to ensure that learners are confident in the rearrangement process. • **Plenary:** Learners present their results of calculation to the class. Identify common errors made and give further supporting examples to reinforce the correct use of the equation and eliminate common errors.	• Prepared worksheet or power-point slide with example questions. Availability of laptops/white board for learners to present examples of calculations.
6 (2 hrs)	**A2: Waves in communication** • Understand the principle of fibre optics • Refractive index	TL, IS	• **Tutor presentation:** Emphasise that the speed of electromagnetic waves through different mediums such as air, water and glass is slightly different and is related to the density of the material. Introduce the principle of refraction as the bending of light waves when passing from one medium to another. Set the task as follows: ○ Light waves travel in a straight line. ○ When light travels from one medium through another of different density, it bends or is 'refracted'. ○ Watch the video. ○ Carry out a similar activity to determine the refractive index of	• Light ray boxes and access to electrical sockets • Protractors • Large white paper sheets • Rectangular glass and Perspex blocks • Video projector • Go to YouTube and search for

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			both a glass block and a Perspex block. ○ Calculate the RI of each block using 'sine of the angle of incidence / sine of the angle of refraction'. [n = c / v = sin. i / sin. r] Compare values achieved between each group for each material and account for possible differences (e.g. linked to experimental error or possible imperfections of the blocks). • **Plenary:** Learners should carry out independent research on the practical uses of refraction in society and then collaborate with other learners to share website choices. You will chair a discussion which will help to answer key questions, e.g. What is refraction? What were the differences between group measurements and why were they different? Are there any other examples of refraction in the real world that the class can identify?	'Refraction Experiment – IGCSE Physics'
7 - 8 (4 hrs)	**A2: Waves in communication** • Understand the principle of total internal reflection used in fibre optic cables • Calculation of critical angles at glass-air interface (Sin c = 1 / n) • Understand the	TL, IS	• **Tutor presentation:** Continue the bending of light principle for refraction by demonstrating a sample of fibre optic cable and how light passes through the cable even when bent. Introduce a glass semi-circle for the practical investigation: ○ Learners watch the video presentation. ○ Practical determination by learners of the angle at which light is totally internally reflected (TIR) through a semi-circular glass block. ○ Learners slowly move the light ray up the curved side of the semi-circular glass block, observing the increased angle of refraction which occurs. ○ Take care to ensure that learners do not work through the	• Video projector • Visit YouTube and search for 'light refraction in a glass air surface, varying incidence angle' • Semi-circular glass blocks • Protractor • Light ray boxes

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	applications of fibre optics in medicine, including endoscopes • Understand the applications of fibre optics in communication, including analogue and digital signals, analogue-to-digital conversion, and broadband		angle changes too quickly and miss the point at which the light ray disappears. ○ Learners continue to increase the angle of incidence to the 'critical angle' and observe the light ray being totally internally reflected. ○ Introduce the calculation of critical angles (Sin c = 1 / n) to learners, with a number of example calculations for them to complete. • **Plenary:** Learners should work in pairs to research the uses of fibre optics in medicine (specifically endoscopes) and communication (specifically analogue and digital signals, analogue-to-digital conversion and broadband). Learners individually produce a brief report of their findings and share it with the class. Reinforce the conditions which give rise to TIR and practical uses of optical fibres. **Recap:** Learners read through their notes on the principles of both refraction and total internal reflection independently. Then in pairs they can test their understanding by asking each other to explain what they understand about refraction and total internal reflection. You can then discuss any key points which may be confused. Each learner summarises the uses of fibre optic cables and learners compare notes.	

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9 -10 (4 hrs)	Consolidate understanding of learning aim A	TL, IS	• **Individual learning activity:** Ask learners to make valid summary notes on the subject material already covered in previous lessons: ○ wave characteristics and wave types ○ the wave equation ○ production of standing waves for musical instruments ○ principles of refraction ○ principles and uses of fibre optics, i.e. total internal reflection. Arrange a visit to a local hospital, a visiting speaker or a virtual meeting, with a focus on the use of endoscopic methods for diagnosis and treatment of medical conditions. Learners should also recap notes from the electromagnetic spectrum related to the speed of e/m waves in a vacuum, and the grouping of frequencies. This activity will be best carried out as either a brief quiz of knowledge or assessment preparation activity. Learners will need to include descriptions of each section with frequency ranges. Further examples of calculations using $v = f\lambda$ should be performed to establish confidence in formula rearrangement. • **Tutor presentation:** Introduction of wave intensity. Give learners the equation for wave intensity, $I = k/r^2$. An explanation of the inverse square relationship for wave intensity needs further discussion to reinforce the principle (as the distance from the transmission source is doubled, the intensity of the wave is reduced to $1/2^2$ i.e. ¼). Then introduce examples of calculations. Use the link to help explain the change in intensity with distance, and give further example calculations to reinforce learning. Introduce a task for learners to research the frequency ranges of the following communication waves: satellite, mobile phones, Bluetooth®, infrared, Wi-Fi. Learners draw a diagram of their positions on the e/m spectrum and a table of particular characteristics of each, in terms of:	• Go to Wikipedia for a definition of inverse-square law • Access to laptops for research

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Learning aim B: Explore the fundamental principles and applications of forces in transportation				
11 (2 hrs)	**B1: Measurement and representation of motion** • Identify and use the appropriate units of measurement for motion • Calculation of speed • Calculation of average or mean speed • Velocity as a vector quantity • Distance/time graphs and velocity/time graphs	TL	• **Tutor presentation:** Introduce the correct units of speed and distance used for different situations. Ask learners to identify units used for distance (e.g. miles, kilometres, metres, feet) and units for speed (e.g. miles per hour, kilometres per hour, feet per second). They should clearly identify all relevant base units. • **Class discussion:** Ask learners to suggest the most appropriate use of each measurement in a given situation. • **Tutor presentation:** Introduce the formula for calculation of speed: = *distance / time.* Give example calculations to learners with formula rearrangement, i.e. finding distance when given time and velocity, and finding the time taken when given distance and velocity. Explain the fundamental aspect of velocity having direction, and so being a vector quantity, unlike speed, which is a scalar quantity. • **Group activity:** Give learners a sufficient number of calculations to determine the mean speed based on a suitable scenario of a car travelling over a given distance, for example. Introduce subsequent examples from relevant input from learners based on their experiences, so that they have suitable practice; this could include animals and vehicles. Discuss the most suitable units for a given situation (see videos). • **Group recap:** Recap on fundamentals of velocity-time graphs: a) velocity is the gradient of the graph, b) a horizontal straight line is constant velocity. **Plenary:** Confirm the formula: *velocity = distance / time*. Give further consolidation of representing a journey on a distance/time graph, where velocity is the gradient of the graph	• Whiteboard for initial introduction of units and calculations • Projection of video footage of objects travelling at various speeds, such as animals and vehicles footage • Go to YouTube and search for the following three videos: 'Giant tortoise on the move at the Galapagos Islands' • 'Cheetah full speed' 'High quality – Apollo 8 Saturn V rocket launch'

Lesson	Topic	Lesson type	Suggested activities	Classroom resources
			and constant velocity is a straight line. Learners, in pairs, will need to give individual example graphs and describe what the graph represents to the class.	
12 (2 hrs)	**B1: Measurement and representation of motion** • Understand the use of appropriate distance/time and velocity/time graphs	TL	• **Tutor-led discussion:** 'How is motion best represented so that the journey undertaken can be easily seen?' Show and discuss forms of graphical representation of distance/time graphs. These examples will illustrate the passage of movement by lines clearly so that learners can identify the following: a) constant velocity, b) no movement, c) increase in constant velocity. Include further examples which are more relevant to learners, e.g. recent travel to the school or college, a recent bicycle or motorcycle trip, a sports day race. Give further written examples to consolidate understanding of distance / time graphs. Discuss graphical representation of velocity/time graphs to introduce acceleration. Suitable graphs would include: velocity/time axes, labels, units, and clear lines so that total distance travelled can be calculated from the area of the graph. **Tutor presentation:** Introduce variations to the graphs to show non-uniform acceleration, i.e. increase or decrease in acceleration. **Plenary:** Set learners the task of researching examples of distance-time graphs and allow them to give one example to the class. Have learners undertake a similar activity for velocity-time graphs for both uniform and non-uniform acceleration (where the total distance is the area under the graph). Make corrections where necessary and reinforce the main aspects of each type of graph.	• Projection of suitable images for distance/time and velocity/time graphs

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13 - 14 (4 hrs)	**B1: Measurement and representation of motion** • Understand how to use the equations of motion • Principle of accelerometers	TL	• **Tutor presentation:** Introduce the equations of motion with suitable example calculations of each. Allow time for learners to identify which one applies, practise using each equation and check answers. Give definitions for each of the letters making up the equations. Example questions: a) A car starts from rest and accelerates at 2.2m/s^2 for 10 seconds. What is its final velocity and how far has it travelled? (Learners to use equation 1 first, then equation 4.) b) A ball is thrown upwards vertically at 18m/s. How high does it travel and how long does it take to get to this point? (Learners to use equation 3 first, then equation 1.) **Accelerometer:** Learners are to produce a basic explanation of the operation of the accelerometer in groups. There is likely to be debate among learners for this. 'Principles will include: mechanical - using a suspended mass, electronic – using a capacitor and piezoelectric – using the principle of pressure on a quartz crystal' **Paired activity:** Give learners further examples to practise their identification of correct equations of motion, and to ensure that calculations are undertaken with clarity so that there is structure to the work. Remaining in pairs, learners are to research the operation of an accelerometer and present a short explanation of the basic 'principles of operation' to the group. • **Plenary:** Reinforce learning of the basic definitions of letters used in the equations of motion, i.e. **v** is velocity, **u** is initial velocity, **t** is time, **a** is acceleration, **s** is distance. Then introduce a number of questions, to be solved using variations of the listed formulae to determine the characteristics of motion of a number of objects. A	• Equations of motion: 1. [v = u + at] 2. [s = ut + ½ at^2] 3. [v^2 = u^2 + 2as] 4. [s = (u+v) t / 2]

Lesson	Topic	Lesson type	Suggested activities	Classroom resources
			group discussion on correct rearrangement of formulae with examples will result in useful notes taken by learners. • **Recap:** Fundamentals of representing a journey using graphs, calculation of velocity, distance and time, calculations using the motion equations. Have learners produce short notes in preparation for the set assignment. • **Coaching:** Example formative assessment, which focusses on correct definitions, graphical representation of a journey and using the equations of motion. Use a tutor-led activity with examples of two or more journeys to be correctly represented by learners, with discussion of each part of the journey in groups when completed.	
15 (2 hrs)	**B2: Laws of motion** • Understand Newton's First Law of Motion • Inertia, mass and weight definitions	TL, GW	• **Tutor-led practical demonstration:** Introduction to Newton's First Law of Motion. Describe key aspects which relate to understanding the difference between mass and weight. Explain this using an example of a textbook of approximately 1 kg of mass (its atoms) and 10 Newtons in a gravitational field, i.e. on Earth. Demonstrate inertia, using a coin placed on a piece of card which is then put onto a glass beaker, open end up. Flick the card away quickly and the coin falls into the beaker. Explain that the coin has resisted movement. • Introduce the concept of inertia: *If a mass has no resultant force on it a) if it is at rest, it remains at rest, b) if it is moving, it continues to move at a constant speed in a straight line.* • **Small group activity:** Learners should apply the concept of inertia to situations involving transport. In groups, allow learners a short time to give a clear explanation of the reason that passengers are injured when a vehicle in which they travel is in a	• Go to YouTube and search for 'Athletics hammer throw women –final'

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			collision. Each group voices their explanation and discusses key points identified by you. • **Video:** Learners should watch the video footage of women's hammer throwing. The circular motion of the athlete ends in the hammer being released, but it flies straight when released. This is because Newton's First Law implies that the hammer will continue to move in a straight line unless a force is applied. The athlete applies this force, which is acting towards the centre of the circle of rotation (centripetal force). • **Paired activity:** Have learners explain how a car remains on a bend in the road, and what happens to the size of the centripetal force when a) the car travels faster, b) the car has a greater mass, c) the curve of the bend is sharper. • **Plenary:** Give learners the opportunity to 'rewrite' Newton's First Law of Motion in their own words. These can be shared with the class and you can then confirm correct interpretations. Learners should then research examples of inertia, giving brief explanations of each one, and hand these to you for checking to produce a class montage.	
16 (2 hrs)	**B2: Laws of motion** • Measuring the speed of road vehicles and calculating frictional forces	TL, GW	• **Tutor-led discussion:** Discuss the operation of the Gatso speed camera, following a Q&A session to determine how the speed of a moving vehicle can be found as it passes. • **Paired activity:** Have learners simulate the operation of the Gatso speed camera in general terms, using the following apparatus: 2m ramp, trolley representing the car, timer, metre ruler, means of raising one end of the ramp. Have learners repeat the measurements of the speed of the trolley passing the 1m mark and then the 2m mark to produce an average. The	• Go to YouTube and search for 'Car causes collision on rainy day / viral hog' • 2m ramp • Trolley • Timer • Metre ruler • Means of raising

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			acceleration (m/s^2) of the trolley can be found using *change in velocity / time taken for the change.* Ask learners to compare results from the paired activity and discuss the basic principle of calculating the trolley acceleration, and link these to some aspect of operation of the speed camera. • **Tutor-led discussion:** Calculating frictional forces and introduction of $-F = \mu \times N$ *Scenario*: A small car of mass 1000kg is travelling on a dry road surface, but a sudden downpour of rain changes the surface from very dry to very wet. This means that the coefficient of friction (μ) changes from 0.9 to 0.1 if the driver needs to slam on the breaks in an emergency. Find the friction force A (dry) and Friction force B (wet). The normal force of the car is found by multiplying its mass by gravitational field strength, i.e. 9.8N/kg = 1000kg x 9.8N/kg = 9800N: A (dry): 0.9 x 9800 = 8820N B (wet): 0.1 x 9800 = 980N • **Group discussion:** A discussion on this example should then include the difference of frictional forces when the road conditions are different – for example, when it rains. Give further examples of this calculation to reinforce learners' understanding (the coefficient of friction element can be given as any value between 0.1 and 0.9 for example calculations). Additional calculations using a variety of vehicle sizes (masses)	one end of the ramp

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			would indicate the range of frictional forces involved, and the significance of the drop in frictional forces in wet road conditions. **Plenary:** Learners must research and explain the principles of the Gatso speed camera to determine the acceleration of a vehicle between two points. The work will be displayed in a PowerPoint presentation with footnotes. Learners, in groups of three, must also give a 'public information film' on PowerPoint to explain to the class how frictional forces are changed significantly on different road surfaces. You should then judge this activity for accuracy in detail.	
17 (2 hrs)	**B2: Laws of motion** • Understand Newton's Second and Third Laws of Motion	TL, GW	• **Tutor presentation:** Introduce Newton's Second Law to learners by giving the definition 'One newton (1N) is the amount of force which accelerates a mass of 1kg by 1 m/s^2'. Define Newton's Second Law in the formula: *F* = *m x a* (force = mass x acceleration). Explain that the force, F, is the resultant or unbalanced force on the mass. Give a selection of practice calculations. This example calculation could begin the process: 'A Saturn V Rocket has a mass of 3.0 x 10^6kg at lift-off and a thrust from its engines of 3.3 x 10^7N. What is its acceleration at lift-off?' **Tutor-led practical demonstration:** Set up a light gate and trolley for measuring the acceleration for different resultant forces (1 to 5N). Use two trolleys (1kg and 2kg). From the results, learners are to produce a graph of resultant force against acceleration and plot the results for both trolleys. Learners must then answer: 1. What happens to the acceleration of an object if the applied	Go to the NASA website and search for 'STEMonstrations – Newton's Second Law of Motion' (2.4 minutes) Go to YouTube and search for 'Newton's Second Law of Motion' (4.3 minutes)

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			resultant force is increased? 2. What happens to the acceleration of an object if its mass is increased? • **Tutor-led discussion:** Lead the following demonstration: using two spring balances attached by their hooks to each other, ask one learner from the class to gently pull on one spring balance; the readings on both the scales will be the same. Encourage learners to identify that the forces are equal in size and opposite in direction. This forms the basis of Newton's Third Law, and can also be stated as 'To every action, there is an equal and opposite reaction'. • **Group discussions:** Ask learners to work in small groups to discuss any pairs of forces which act in this way and put the answers onto a whole class poster. Examples could be: a rocket during launch, an inflated balloon which is released, the force of a book on the table and the opposite force of the table on the book, the force of a sprinter on the ground and the force of the ground on the sprinter, the recoil of a gun after firing. • **Formative assessment:** Ask learners to produce a research presentation for both Newton's Second and Third Laws of Motion. The work should include a general definition of each, based on more than one source and explanation of each, using relevant examples in a real-world context. This work will then need to be handed in to you for checking. • **Recap:** Newton's Laws (First, Second and Third), calculation of frictional force and operation of the speed camera.	

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18 (2 hrs)	**B2: Laws of motion** Understand the factors needed to achieve flight: • Generating lift • Considering air as 'fluid' • Lift acting perpendicular to motion of aircraft • Geometry of wings • Velocity of air and angle of aircraft to air flow • Mass of air • Principles of lift, drag, thrust and weight	GW, IS	• **Class discussion:** Set a task with sheets of A4 paper placed on tables, for learners in small groups to make a mind map of the factors which allow an aircraft to become airborne. Collate and summarise the main ideas from a whole class discussion. Ask learners: 'In what direction will the paper move if you blow over the paper?' Learners should discuss this briefly. Then instructs learners to blow either over the top of the paper, or at either side of the paper held vertically. This activity gives an introduction to the principle of flight and change of air pressure underneath and over an aircraft wing. Introduce the video. Instruct learners to take a series of notes when watching the video in readiness for discussion later. • **Pair work:** In pairs, learners should produce notes for a brief presentation on the main principles which allow flight. The presentations will occur during lesson time, following a sufficient period of time for learners to produce their notes and images. Presentations should last a maximum of five minutes. You should take notes to address possible misunderstandings and commend correct understanding after the presentations. • **Individual activity:** Give a homework activity which needs to be handed in next lesson. The work will focus on the question: 'What other vehicles use the principle of wing design and how does it work?' • **Plenary:** Discuss the air pressure differences above and below an aircraft wing, which help to give its lift. Explain that the passage of air over the wing top meets with that below the wing.	• Go to YouTube and search for 'How Wings ACTUALLY Create Lift!'

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19 (2 hrs)	**B2: Laws of motion** Understand the principles of ship design: Archimedes' Principle; reducing the density of materials, e.g. iron, to less than water by changing the shape; increasing volume; thrust given by propellers	GW	• **Paired activity:** Give learners a simple task and basic materials (one sheet of greaseproof paper, an enclosed plastic tray, sets of equal numbers of marbles). Present a basic task in the form of a competition: 'Form a shape with your paper to see which design holds the most marbles'. • **Class discussion:** Learners should have 15 minutes to make a mind map, within pairs, of what shapes may be best to hold marbles. General ideas will probably be 'boat-shape', but learners should be encouraged to change the general shape, use low level sides as opposed to high level, add more than one 'hull' together, etc. • **Individual activity:** Introduce the video clip and instruct learners to take notes in preparation for a class discussion following the video. • **Group discussion:** Show a number of photographs of seagoing vessels used for different purposes. A tutor-led discussion will form the basis of questions about the different designs of the ships, related to their purpose. • **Paired activity:** Learners should produce a paragraph which outlines the main aspects of Archimedes' Principle, for inclusion on a whole-class wall poster. This activity will help to explain the following aspects of buoyancy: ○ volume of container ○ density of liquids ○ up-thrust ○ pressure of liquids.	• Go to YouTube and search for 'Archimedes' Principle: Made EASY / Physics' (11 minutes)

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			• **Plenary:** Learners should use research notes to explain how a ship/boat is able to float on water. General aspects which need to be considered must be included and used in a poster, designed to be displayed on a classroom wall. The important principle and aspects to achieve buoyancy should be explained with the aid of diagrams, where relevant. **Recap:** Principles of flight and ship design, focussed on the shape of an aircraft wing and Archimedes' Principle for ships.	
20 (2 hrs)	**B2: Laws of motion** • GPS • Factors needed to achieve orbit, thrust from burning propellants, sufficient speed, standard earth orbit (17,000 mph/27,360 kph) and geostationary orbit • Newton's Third Law of Motion	TL, GW	• **Tutor-led practical demonstration:** Release an inflated balloon which flies around the room. Relate the principle of rocket launches to Newton's Third Law of Motion and draw a simplified diagram on the whiteboard. • **Video:** Show the video of the Apollo launch to the Moon (Apollo 11) as an iconic moment in history. • **Group activity:** Learners are to produce a video presentation of approximately five minutes, related to GPS, to be performed in groups of three learners. The task will include research material. Allow suitable research time on the internet. Learners must demonstrate a robust confirmation process, linked to their research. Each group must present an appraisal of the development and function of the Global Positioning Satellite system for navigation. The work will include details on achieving satellite orbits (both standard and geostationary), triangulation of signal to give accurate location on the Earth's surface, Earth-based monitoring, level of precision of location, means of power supply for the satellite systems, and responsibility of operation and maintenance.	• Go to YouTube and search for 'Apollo 11 Launch Countdown – moon landing live – BBC America'

Lesson	Topic	Lesson type	Suggested activities	Classroom resources
			The presentations will be no longer than 15 minutes per group, and each group member must have input. • **Plenary:** Learners should take notes for the research aspect of the group activity. These notes will need to be written out in full by all learners and any additional information added if applicable. Learners will also include an explanation of Newton's Third Law of Motion. They should include details of the network of Global Positioning Satellites (GPS) used to give accurate positioning of an object on the Earth's surface.	
21 (2 hrs)	**B3: Driving safely** • Identify physical factors relating to road transport	TL, GW	• **Tutor presentation:** Introduce learners to the subject of motor vehicle transport and collisions by using a number of video clips which show the effects of vehicle collisions in all weather conditions. Learners are to give suitable explanations for vehicle crashes related to driving conditions and road surfaces. The class can discuss the science of reduced friction while the videos are watched and make a strong link to Lesson 13 (frictional forces), with a possible recap on calculation of frictional force. Encourage learners to identify individually the factors which affect stopping distance; this can lead to a discussion relating the factors to their effect on the stopping distance, and how it can be reduced. This will also include poor vehicle maintenance for specific parts of the vehicle. • **Tutor presentation:** Introduce learners to tabulated information for stopping distances under normal road conditions and wet road conditions. Learners will present the information in graphs of 'total stopping distance against speed' for both road	Go to YouTube and search for 'WORST car pile-up crash snow – crazy chain crash' and 'Video shows moments that caused 30-car pile-up on Green Bay's Leo Frigo Bridge'

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			conditions. • **Paired activity:** Learners should produce results of the effects of road conditions on friction of the road surface by a simple practical activity. This will involve a wooden ramp with a choice of three interchangeable surfaces (plastic sheet, coarse sandpaper and fabric). A 1 kg mass will be placed on the ramp at one end, which is raised until it moves. The height of the ramp and the time taken for each mass to reach the bottom of the ramp will be repeated and recorded. • **Extension activity:** An addition to this practical activity could involve using the same surface (e.g. plastic sheet) and performing the activity when the sheet is both dry and wet. • **Plenary:** Learners must use research notes and class practical investigation to produce a clearly worded document which details the changes of friction on different road conditions, and changes to driver reaction times as a consequence of alcohol. This could be presented as a group PowerPoint activity for delivery during lesson time.	
22 (2 hrs)	**B3: Driving safely** • Understand the use and effects of impact force controls in road vehicles	TL, IS, GW	• **Tutor-led discussion:** Introduce the principle of motor vehicle design, in view of the changes made to the design aspects of the vehicle to protect the passengers. Introduce the three video clips, which give an overview of the way that forces are transferred by designing certain areas of the vehicle to crumple on impact and help to protect the passengers. • **Independent learning activity:** Learners should research up to 11 areas on a motor vehicle where safety measures have been introduced into the design. From notes taken, learners must then complete a table which identifies the safety measures and	• Go to YouTube and search for the following 3 videos: 'Forces and motion - the physics of car crashes (preview)' 'Cars are designed to crumple' 'These crashes show the

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			explains how they result in less damage to the passengers and the vehicle. This work will include crumple zones, seat belts, airbags, bumpers, headrests, bonnet, suspension, gearbox, bulkhead and passenger cage. Collate the information given from learners by question and answer. Where some factors have not been identified, you must give details. • **Paired practical activity:** Introduce an activity aimed at consolidating learners' understanding of impact force control through practical development. The activity will include a competition to drop an egg from a safe height of approximately 5m (external to the laboratory) without it being damaged. Give each pair of learners 15 plastic straws, 0.5m of Sellotape and one fresh medium-size egg. The best designs are likely to incorporate the egg supported in the centre of a star-like shape, with the straws not cut down to size. Learners write a brief appraisal of the result of the drop and the outcome for the whole group, with explanation of where the forces of impact may have been transferred. • **Plenary:** Modern-day road vehicles have special sections designed to crumple and redistribute forces in a collision. Passenger safety is reinforced in a cage design within motor vehicles. • **Recap:** Principles of GPS, vehicle collisions and crumple zones; importance of reaction times. • **Assignment writing:** Example assignment covering the main topics of learning aim B.	difference 20 years has made to car safety / WIRED' • Plastic straws • Sellotape • Medium-size eggs

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23–30	• Assessment using Pearson Set Assignment	AW	• 16 hours under controlled conditions are required for assessment.	

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