Physics

ON Wednesday, May 16, the SQA physics exams at all levels take place. When you enter the examination room or hall you need to be prepared technically with the correct tools and mentally with confidence in your ability to competently answer the problems in the paper. This article is designed to help you prepare to pass.

Make sure your revision plan is realistic by setting up a calendar showing when your exams are and working out when you can give up time to studying physics. Often important examinations are very close together, especially at Intermediate 2 level.

Once you have your plan, assemble your materials like recent past papers and a clock to pace yourself – and get stuck in!

STANDARD GRADE

TELECOMMUNICATIONS

In this section, the exam tests knowledge of speed and wave theory so you have to be able to use the equations:

- Wave speed = frequency x wavelength
- Speed = distance/time.

Most problems arise when people look for equations for frequency and wavelength in the data booklet, because they are not there. You often have to work out frequency and wavelength from their definition then use them in the equations above.

Remember, wavelength is distance/number of waves and frequency is number of waves/time.

Make sure you can recognise and draw angles of incidence, reflection and refraction for ray diagrams.

Other key topics for a checklist are CRO wave shapes, radio, TV, modulation, fibre optics and satellites

HEALTH PHYSICS

The same equations as in telecommunications are important here but so are:

- Power = 1/focal length in metres for lenses.

You have to be able to write about or draw various imaging methods using parts of the electro magnetic spectrum e.g. CAT scans using X-rays for 3D imaging.

Many questions centre on eye defects and how to correct them with lenses, or on medical applications of radioactivity e.g. the use of gamma wave sources with reasonably short half-lives as tracers, types of radiation and how ionising they are.

Your ruler, protractor and an eraser for correcting drawings can be vital in this section (remember correcting fluid takes too long in exams!). You need to be able to find the half-life of a radioactive source from graphs or tables. Half-life is the time it takes for the activity of the source to halve its value.

Other key topics for a checklist are: temperature measurement, sound levels, frequencies of sound and ultrasound, alpha, beta, gamma, activity in bequerels and the structure of an atom including the nucleus. Also look at Sieverts.

USING ELECTRICITY

The most important formulae are:

- Ohms law, PD in Volts = Current x Resistance (V= I x R)
- The power equations, Power = Voltage x Current (P = V x I); $P = I^2 \times R$; $P = V^2 / R$
- Energy = power x time (E =P x t)
- Charge = current x time (Q = I x t)

You need to know the basic differences between series and parallel circuits and some applications of these circuits, e.g. the parallel ring main in your home, how an earth circuit works, the plug colour code, the cost of power and energy in household circuits, AC theory and mains voltages.

Electric motors are important, especially differences between commercial and simple motors.

Other key topics for a checklist are the kilowatt hour, double insulation, fuses, positioning of fuses, mains voltage, fault finding with an ohmmeter, magnetic field lines, brushes in motors and commutator rotating coils.

ELECTRONICS

Electronics splits into: input and output devices, electronic processing circuits, digital logic and analogue systems.

With Input and Output, you have to recognise different input and output devices and their symbols. You should be able to describe the energy changes in them and practical uses for them in circuits. A useful memory trick is LURD: light up, resistance down for an LDR; and HURD: hotness up, resistance down for a thermistor.

You should be able to explain how signals from input devices are altered in the process section to switch on output devices. For example, be able to explain the operation of an automatic system using a transistor switch to turn on security lights when it gets dark. This type of question requires a systematic breakdown of the problem into half-mark answers.

Another favourite type of question is when you are asked to calculate the voltage outputs from potential divider circuits or to calculate the size of protective resistors for Light Emitting Diodes (LEDs).

The digital logic section requires knowledge of the three digital gates AND, OR and NOT, and their truth tables, as well as the explanation for the operation of a clock pulse generator.

The analogue section is linked to a simple amplifier and equations for power gain and voltage gain.

Other key topics for a checklist are the seven-segment display, charging time for a capacitor, time constant, binary numbers up to decimal 16 and practical uses for electronics.

TRANSPORT

This section develops from the simple ideas of speed and acceleration to forces, work done and energy and how they affect the world around us.

You should know the difference between instantaneous and average speed and ways to measure these.

Acceleration is the rate of change of speed and a = (v-u) / t measured in m/s^2. In problems, speed-time graphs are important for several reasons: firstly the slope of a v-t graph is the acceleration of the object and the area under the line of the graph is the distance gone. This can be useful in problems involving braking distance.

You can only find distance gone using speed x time if you have constant speed or average speed.

In forces you need to know the meaning of Newton's three laws of motion. Simply put, these are:

- An object moves at constant speed in one direction unless an unbalanced force acts on it.
- Force = mass x acceleration
- Every force has an equal and opposite "reaction force" (see Space section).

You should be able to work out problems from practical examples affected by these laws. For example, how seat belts protect you from moving forward in a car crash by applying a restraining force to decelerate you. Or how a rocket moves forward because the thrust on the rocket pushing it forward has an equal reaction force pushing out the exhaust gases from the rocket.

Work and energy are the same thing in physics. For example, work done to lift something is force x distance moved ($E_w = F \times d$), which is just the same as E_p = mgh because mg is weight force and vertical distance is height.

It is important to remember that g is both the acceleration caused by gravity and the gravitational field strength; so on Earth g is 10 m/s^2 or 10 N/kg. On any planet, if you know the acceleration due to gravity, you also know the force per unit mass.

Lots of problems assume you know that energy is conserved. If you know a fairground car has 10,000 joules of potential energy at the top of a slope it will have 10,000 joules of energy at the bottom but some of it may appear as heat wasted and some may be kinetic energy.

Power is energy/time or work done/time.

You may be asked about efficiency in transport questions (See Energy section).

Other key topics for a checklist are: friction forces always act opposite to motion, constant speed means no unbalanced force and power is measured in watts.

ENERGY

This section splits into energy in the environment, generation of electricity, transmission of electricity and heat in the home.

The first section on environmental physics requires you to be able to describe how to conserve fuel and to know the advantages of renewable and non–renewable fuel sources.

In the generation of electricity you should be able to draw a diagram showing the main parts of electrical generating stations. You should be able to do this for nuclear or fossil fuel (both are types of thermal power stations) and for hydroelectric, wave or wind powered stations. You have to understand what a fission chain reaction is and be able to solve problems using power and energy equations. You should be able to explain why every system which wastes or loses energy must be less than 100% efficient.

You need to know how generators work and be able to describe their operation.

Important ideas to remember are: induced voltage is increased when magnetic field strength is increased, or when coils/wires cut through the field faster or when the number of coils or length of wire cutting the magnetic field is increased.

To transmit electricity, the National Grid is used to move electrical energy from place to place. This is done at high voltage to reduce energy losses and improve efficiency. To get the high voltages for transmission, step up transformers are used to raise voltage and step down transformers are used to reduce voltage. You need to be able to use the transformer equations:

- $N_s/N_p = V_s/V_p$
- $I_p \times V_p = I_s \times V_s$
- % Efficiency = (energy out / energy in) x 100 or (power out / power in) x 100

In the heat section you need to use equations on:

- $E_h = cm\Delta T$ and $E_h = mL$

You should revise how heat travels by conduction, convection and radiation, and be able to describe how to conserve heat in different situations. Remember, in a change of state there is no temperature change!

Learning off by heart what specific heat capacity and latent heat mean makes it much easier to understand and should help you to explain practical based problems on heat.

Other key topics for a checklist are: fossil fuels are finite, pumped hydroelectric power stations, rotor coils, stator coils, energy losses in transformers, evaporation, solar cells and how fridges work.

Turn to page 18

A girl has a hair-raising moment with a Van De Graf generator at Glasgow's Science Centre Photograph: Martin Shields

ABOUT THE AUTHOR

JOHN O'Brien is principal teacher of Physics in Eastwood High School in East Renfrewshire and is currently a member of the SQA Physics Subject Advisory Group.

PHYSICS

From page 17

SPACE PHYSICS

This section draws together and develops information learned in previous units so that questions will not always be based on work from just one unit.

The space section starts with the structure of the solar system and distances in space. To receive information from space we need to understand telescopes and ray diagrams, the electromagnetic spectrum and line spectra emitted by stars.

Forces and Newton's third law are important to explain how rockets might travel in space. The variation in the value of g on planets of different mass is used to explain why mass stays the same but weight changes from planet to planet. At large distances from the earth's surface, the value of g decreases.

Projectile theory for objects launched into the air is important. Remember, horizontal speed is constant if there is no friction, but vertically, objects accelerate at 10 m/s^2 on Earth or at the g value for a planet. You need to be able to explain why objects can appear weightless in free fall and why objects can orbit the earth while in free fall if their horizontal speed is high enough.

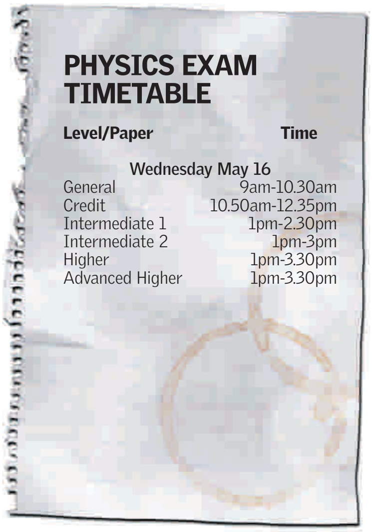
Objects from space lose potential and kinetic energy as they re-enter the atmosphere, which produces heat as work done against friction.

Other key topics for a checklist are: light year = $3x10^8$ x60x60x24x365 metres, magnifying glass, stars, visible spectrum (roygbiv), whole E-M spectrum, Newton's thought experiment (Newton's cannon).

PRACTICAL WORK

Your practical mark makes up 20% of your total grade but does not affect your written exam very much. However, you may be given questions based on your practical techniques. For example:

- Describe how to measure instantaneous speed.
- Describe how you measure focal length for a convex lens.
- Describe how you could use a circuit tester to find an open circuit.
- Complete a circuit diagram showing positions of a voltmeter and an ammeter, used properly.



PHYSICS EXAM TIMETABLE

Level/Paper	Time
Wednesday May 16	
General	9am-10.30am
Credit	10.50am-12.35pm
Intermediate 1	1pm-2.30pm
Intermediate 2	1pm-3pm
Higher	1pm-3.30pm
Advanced Higher	1pm-3.30pm

EXAM TIPS FOR STANDARD GRADE STUDENTS

You will be competing with about 17,000 other students doing SG Physics, so it is important that you make as few mistakes as possible.

One important thing to remember is that the data book containing equations for physics does not really have everything you need. Often you have to use the data book equations in combination, or one after another, to work something out. For example frequency and wavelength calculations were mentioned already and they are often used with the wave equation v = f x λ.

Another example might be when you use a = $\Delta v / t = F / m$. You have to realise that you need to use both equations; it does not tell you to do that in the booklet.

Here are some other tips that can help:

- Use past papers and a watch to pace yourself with SQA standard questions and use the answers to check your work. If you cannot understand an answer do a check with software, summaries, friends or teachers until you solve the problem. Do not give up!
- Look at the marks for each part of a question and at the space given in the exam booklet when judging the length of a descriptive answer. If there are two marks and you only make one point in your answer you have not done enough. Most questions have half marks available in physics exams so sometimes two marks means four parts to the answer.
- Watch for the standard two-marker! In this type of question the first half mark is for choosing an equation properly. The next half mark is for substituting in the information from the question. The last mark is for the correct answer with a unit if required. If you forget the unit you lose half a mark.
- In some problems you have to rearrange an equation to find the answer. If you do have this type then SQA suggest that you substitute the numbers into the equation before you rearrange the equation. If you make a mistake rearranging you still get the substitution mark doing it this way.
- Answers to most questions use basic units such as kilograms, seconds, etc. Every time you forget a unit you lose half a mark. Another mistake to watch for is when you forget to convert units to the basic ones. Examples include forgetting to change minutes to seconds by multiplying by 60 and mistaking M, which means Mega (a million), for k which means kilo (a thousand), or for m, which means milli (one thousandth).
- If you make a mistake, write the correct answer before you rub out the wrong one. I would suggest you circle the wrong answer and write "ignore this", because if you change your mind twice you can simply write "don't ignore this answer" and score the wrong one out. If you have scored it all out you waste even more time rewriting again.

The Ariane-5 rocket lifts off from the Kourou space base in French Guiana

Photograph: AP

Never, ever leave two different answers to the same question; the marker will give you zero marks even if one is correct. The principal assessor's advice is that you must eventually score out the wrong answer.

- Remember you have about 1 minute per mark, so pace yourself.

EXAM TIPS FOR INTERMEDIATE 2 STUDENTS

Your tips are really similar to Standard Grade but remember:

- You may need a protractor for vector problems.
- You have to learn the prefixes such as milli, mega, etc, since they will not be part of the data sheet at the start of your exam paper.
- Remember the 3, 4, 5 triangle shape in case it appears in a vector problem.
- In multiple choice questions, work out the answer and then look to see which response is the same as yours.
- In multiple choice, try to eliminate impossible answers quickly. Often there are really only two sensible responses so it becomes a true/false question.
- Know what is meant by the principle of conservation of momentum and write out fully, in sentences, in answers.
- In projectile problems, separate your working for vertical motion and horizontal motion, and label your data carefully so you and the marker knows which is which.
- Remember you have about six minutes for every five marks so pace yourself.

EXAM TIPS FOR INTERMEDIATE 1 STUDENTS

Your exam lasts one-and-a-half hours, so make sure you work fast enough to finish the paper.

- Read every question fully before you answer it
- Don't get stuck on a question. If you can't do it, move on; you might get a chance to come back and finish it later.
- Use a pencil for drawings and graphs so you can sort mistakes with a rubber.
- Remember to use your data book to check equations are written the right way round.
- Usually your answers to calculations will be straightforward whole numbers; if your answer looks weird, double check it.
- Remember, your answers should always make sense. If you calculate a car's speed to be faster than sound, it is probably wrong. Double check!!

HIGHER GRADE

THE Course splits into three units of equal weighting in the examination. The problem solving part is about 60% and knowledge and understanding is normally about 40%.

The exam has 20 multiple-choice marks and 70 marks comprising written materials, together totalling 90 marks. Last year's lowest pass mark out of 90 was 65 marks for an A, 53 marks for a B, 42 marks for a C and 36 marks for a D.

When the total marks available are as low as 90, it is absolutely essential to avoid silly mistakes like forgetting to put units in answers or getting scientific notation wrong. A few minor mistakes can make a massive difference.

MECHANICS

The three main sections of this unit are closely connected. The kinematics section involves vectors, equations and graphs of motion and projectiles, but these link so closely with the forces in the dynamics section that it is difficult to separate them. Similarly, the ideas of unbalanced force, impulse, conservation of energy and conservation of momentum are required to fully understand the gas laws in the properties of matter section.

Calculators are a must for most people when calculating densities and upthrust or when using the gas equations. Uncertainties are part of this unit, for example systematic uncertainty in temperature readings caused by heat loss.

EXAM TIPS FOR HIGHER MECHANICS

- To avoid wasting time and losing marks you need to take great care in reading questions thoroughly and ensuring that the instructions in questions are followed precisely. If it asks you to state something, then state it: you do not need to explain it. If a question says "with the aid of a diagram", assume you must draw a diagram. Key words to look for are: describe, state, show, explain, draw and "find the relationship".
- Remember you may need to use, state or derive expressions that are not listed in the data booklet, eg the component of weight of an object down a slope (mg sinθ), where θ is the angle of the slope to the horizontal.
- The acceleration down a slope is independent of the mass and is g sinθ.
- Make sure you can resolve a vector into two components at right angles, eg for a ball launched at 30 ms^{-1} at 40° from horizontal, the horizontal component of velocity of the ball is 30 cos 40 and the vertical component is 30 sin 40.
- Always label your data and write your answers clearly. This makes it easier for the marker to find your marks, makes it easier for you to check the logic of your answers and improves the marker's mood, hopefully making it more likely you will get the benefit of doubt when professional judgement is needed.
- If you are asked to show something is true you need to write down any suitable equation followed by appropriate substitutions and calculations in well laid out logical manner.
- In the gas laws you may be asked to write out descriptions or explanations. These need to be clear. The principal assessor gave an example in this year's report: "*a candidate saying that an increase in temperature causes 'molecules to collide more', means very little. A more precise description would be 'molecules collide with the container walls harder and more frequently.*"
- Always put a direction in vector problems. Students seem to be poor at putting in the correct sign in impulse and velocity questions. You don't just lose half a mark for getting this wrong; markers are told it is wrong physics so they stop marking the question.
- Graphs require some thought – many students do not label the origin and axes on sketch graphs
- When a graph is a straight line through the origin you can state that the quantity on the vertical axis is directly proportional to the quantity on the horizontal axis. This is why we switch temperatures scales from Celsius to Kelvin in gas laws graphs of P vs T and V vs T.
- The area under the line of a graph is important. For example, under a velocity-time graph the area is the displacement and the area under a force-time graph is the impulse or change of momentum during a collision.
- The gradients of graphs are also important sources of information, for example the gradient of a displacement-time graph is the velocity, the gradient of a velocity-time graph is the acceleration.
- Make sure you know the prefixes needed for the course. Unlike Standard Grade, your data sheet will not include these and you will lose marks every time one is wrong. Similarly, practice using an appropriate number of significant figures in problems and do not round up during a question. Do so at the end of a question if it is appropriate.
- Watch for integrative questions where theory from other units is part of what looks like a mechanics question, for example equating electrical energy Q x V to kinetic energy, $1/2\ mv^2$ -
- Main questions to look out for: addition of vectors, projectiles, momentum and impulse, gas laws experiments and kinetic theory, density of substances and buoyancy in fluids.
- Do as many past paper questions as you can manage.

ELECTRICITY UNIT

This unit splits into resistors in circuits, ac theory, capacitance and analogue electronics.

Resistors in circuits have derivations of formulae using conservation of charge and energy. Usually circuit analysis is followed by potential dividers and both the balanced Wheatstone bridge and the slightly out of balance bridge.

In ac theory you will need to be able to calculate frequency and voltage from settings on oscilloscopes, and in capacitance you need to be able to describe the charge and discharge of capacitors for dc and the effects of changing ac frequency on them. In analogue electronics you need to distinguish between the inverting and differential mode of an op amp. Uncertainties are part of this unit, for example absolute uncertainties equal to ± the last digit of a digital meter reading.

EXAM TIPS FOR HIGHER ELECTRICITY UNIT

- You should study the content statements for the Physics course so that you can give definitions of terms, for example the definition of potential difference.
- Make sure that your calculator is set to scientific notation and not radians.
- Learn rules for circuit behaviour, for example all branches of a circuit in parallel have the same voltage; adding branches in parallel reduces total resistance of a circuit; the total resistance of a parallel circuit is less than the resistance of one branch of the circuit; and if all branches of a parallel circuit are the same then total resistance is found by dividing the resistance of one branch by the number of branches.
- Internal resistance causes lost volts in power supplies; do expect different and unusual power supplies to be used as EMF sources in an effort to confuse you.
- Learn the shapes of three graphs related to internal resistance; lost volts vs current; voltage vs current ; resistance vs 1/current.
- For Wheatstone bridges remember the out of balance voltage varies directly with small changes in resistance.
- Learn the shapes of charge and discharge graphs for large/small capacitances and resistances.

Turn to page 20

PHYSICS

From page 19

- Remember that in AC current, as frequency increases the current through a capacitor increases but current through a resistor is not affected by changes in frequency.
- Voltage gain for an inverting mode op amp is R_f / R_1 and equals V_{out} / $V_{in.}$
- Make sure you change the sign of the output voltage compared with the input for an inverting op amp. For a gain set at 1, the output voltage would be -4 volts if the input was +4 volts.
- The maximum output voltage is limited by the operational amplifier saturation voltage which is determined by the power supply voltage to the op amp.
- In some integrative problems you have to describe whether an NPN or PNP transistor is switched on by the output from an op amp.
- Likely questions: basic circuit analysis, internal resistance, out-of-balance Wheatstone bridges, applications of capacitors for charge and discharge and applications of analogue electronics.

RADIATION AND MATTER

The radiation and matter unit splits into sections involving wave effects like interference and refraction, spectra and atomic structure. The opto - electronics section covers the inverse square law, photo-electric effect, lasers, semiconductor theory, and semiconductor components. Radioactivity covers half-life theory, half-thickness, dosimetry, decay, fission chain reactions and mass difference calculations, and fusion. Uncertainties are part of this unit, for example random uncertainty in repeated readings and protractor readings inaccurate by ± half a degree (± half of one scale division).

EXAM TIPS FOR HIGHER RADIATION AND MATTER UNIT

- Do remember the data sheet at the start of the exam paper has important information on physical quantities like Planck's constant.
- When comparing incident and refracted angles remember light always travels faster in the medium with the bigger angle between ray and normal.
- Learn the electromagnetic spectrum off by heart and know the order of increasing wavelength.
- Learn a value for the wavelength of blue and red light.
- In topics such as the photo-electric effect and atomic theory, you need to give extensive descriptive answers. Use the marks allocation as a guide to how many points are needed in the answer.
- Remember the inverse square law applies to point sources so you don't use it in laser questions.
- The principal assessor reported that students wrongly used the term electron-hole pairs in LED questions last year so double-check answers!!!
- You should study the content statements for the Physics course so that you can give definitions of terms, for example the definition of irradiance
- In problems where you need to show a relationship using all the data, you must use all the data, don't stop when its obvious what the answer is.
- Learn the difference between mass number and atomic number.
- In fission calculations do not round the figures before calculating the loss in mass.

And remember the most important tip of all: practice as many exam type questions as possible.

OFFICIAL SQA PAST PAPERS

The questions have been chosen to illustrate the breadth of topics in Physics.

STANDARD GRADE

2006 Credit paper, Question 9

A table from the Highway Code giving overall stopping distances for vehicles is shown.

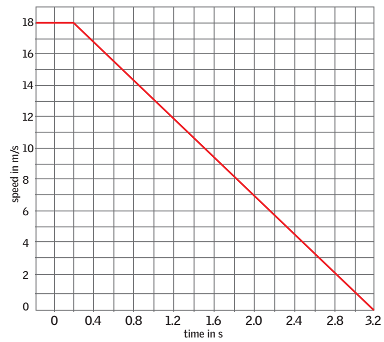
The overall stopping distance is made up of: The thinking distance – the distance travelled while the driver "thinks" about braking (this distance depends on the driver's reaction time) PLUS the braking distance – the distance travelled while braking.

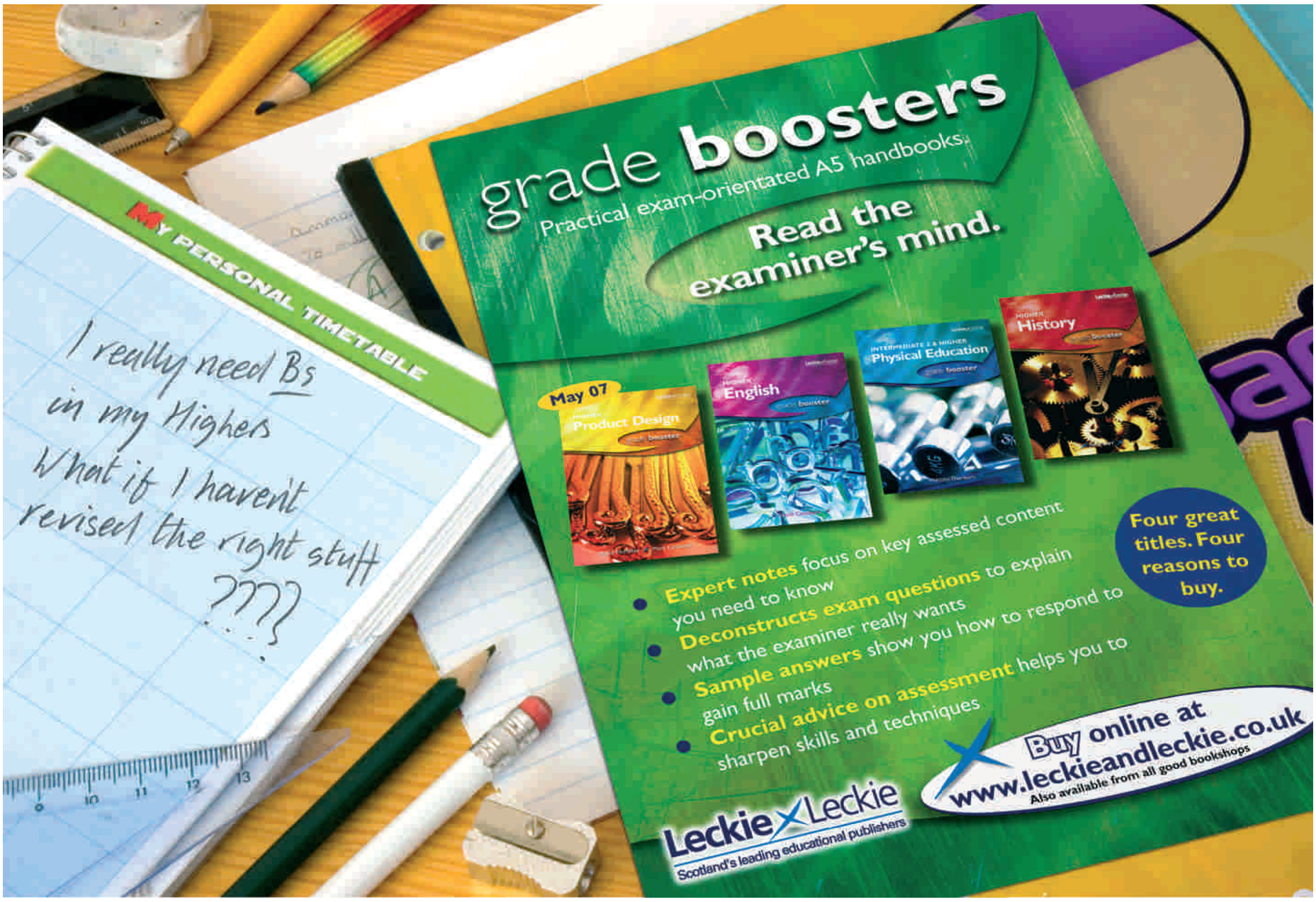
Speed of vehicle (m/s)	Overall stopping distance (m)
8.9	6 6
13.4	9 14
17.8	12 24
26.7	18 55
thinking distance	braking distance

(a) (i) How far does a vehicle travelling at 13.4 m/s travel while the driver things about braking?

(ii) Use information from the table to calculate the reaction time.

(b) A car travels along a road. The driver sees traffic lights ahead change from green and starts to brake as soon as possible. A graph of the car's motion, from the moment the driver sees the traffic lights change, is shown.





(i) What is this driver's reaction time?
(ii) Calculate the overall stopping distance.
(iii) Calculate the acceleration of the car from the time the driver applies the brakes.

Answer

(a) (i) 9m

(ii) $t = \frac{d}{v}$

$= \frac{6}{8.9}$

$= 0.67$ s

(b) (i) 0.4 s

(ii) distance = area between graph and time axis
$= (18 \times 0.4) + (1/2 \times 18 \times 2.8)$
$= 32.4$m

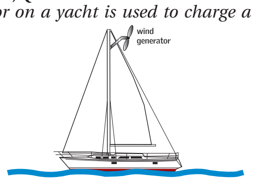
(iii) $a = \frac{v - u}{t}$
$= \frac{0 - 18}{2.8}$
$= -6.4$ m/s^2

Comments

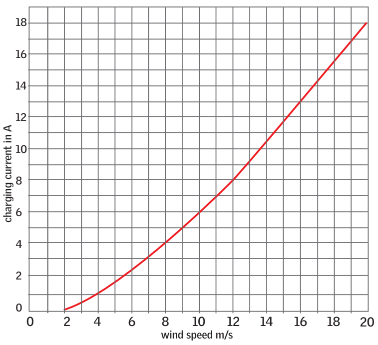
This question shows how an application of physics can support the developing citizen. Most candidates will soon be driving real cars and braking and thinking distances will help them as drivers. All the material is taken from the Transport Unit.

2006 Credit paper, Question 11

A wind generator on a yacht is used to charge a battery at 12V.



The graph shows the charging current at different wind speeds.



(a) The wind blows at a speed of 10 m/s.
(i) What is the charging current at this wind speed?
(ii) Calculate the electrical power produced by the generator at this wind speed.
(iii) The wind speed does not change.
Calculate the energy supplied to the battery in 3.5 hours.

(b) The yacht has a stand-by petrol powered generator to charge the battery. Why is the petrol generator necessary, in addition to the wind generator?

Answer

(a) (i) 6A
(ii) P = IV
$= 6 \times 12$
$= 72$ W
(iii) E = Pt
$= 72 \times 3.5 \times 60 \times 60$
$= 907\,200$ J
(b) Wind does not always blow OR wind speed may be less than 2 m/s.

Comments

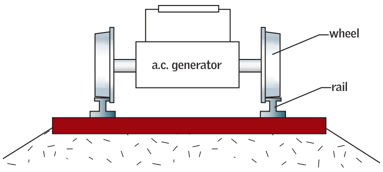
In this unfamiliar situation, pupils are questioned on a particular application of alternative power generation using wind power on a sailing boat. This question is based on the Energy section but makes pupils think about some disadvantages of wind power for electrical generation. This is a neat way to make pupils more aware of environmental issues when global warming is a major issue.

HIGHER

2004, Question 22

A train of mass 7.5 × 10^{5}kg is travelling at 60m s^{-1} along a straight horizontal track.
The brakes are applied and the train decelerates uniformly to rest in a time of 40 s.

(a) (i) Calculate the distance the train travels between the brakes being applied and the train coming to rest.
(ii) Calculate the force required to bring the train to rest in this time.
(b) Part of the train's braking system consists of an electrical circuit as shown in the diagram.



While the train is braking, the wheels drive an ac generator which changes kinetic energy into electrical energy. This electrical energy is changed into heat in a resistor. The r.m.s. current in the resistor is 2.5 × 10^3 A and the resistor produces 8.5 MJ of heat each second.

Calculate the peak voltage across the resistor.

Answer

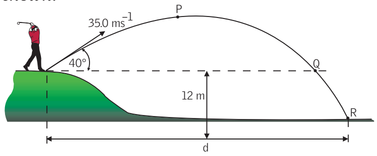
(a) (i) 1200m
(ii) (–)1.13 × 10^6 N
(b) 4808 V

Comments

By choosing an engineering application for a train as the context for the problem, this is a question where work from the Mechanics and Electricity Units are combined in a situation which is not familiar to pupils. This is a good example of an integrative problem.

2003, Question 21

A golfer on an elevated tee hits a golf ball with an initial velocity of 35.0 m s^{-1} at an angle of 40° to the horizontal.
The ball travels through the air and hits the ground at point R.
Point R is 12m below the height of the tee, as shown.



The effects of resistance can be ignored.
(a) Calculate:
(i) the horizontal component of the initial velocity of the ball;
(ii) the vertical component of the initial velocity of the ball;
(iii) the time taken for the ball to reach its maximum height at point P.

(b) From its maximum height at point P, the ball falls to point Q, which is at the same height as the tee.
It then takes a further 0.48s to travel from Q until it hits the ground at R.
Calculate the total horizontal distance d travelled by the ball.

Answer

(a) (i) $v_h = v\cos\theta$
$= 35.0\cos 40°$
$= 26.8$ m s^{-1}

(ii) $v_v = v\sin\theta$
$= 35.0\sin 40°$
$= 22.5$ m s^{-1}

(iii) Vertically ↑ +
$v = u + at$
$0 = 22.5 - 9.8t$
$t = 2.3$ s
(b) time to Q = 2 × time to max height
$= 4.60$ (s)

time of flight = 4.60 + 0.48 = 5.08 s

(horiz) dist = (horiz) speed × time (of flight)

OR $s = \left(\frac{u+v}{2}\right)t$ *OR* $s = ut + 1/2\,at^2$
$= 26.8 \times 5.08$
$= 136$ m

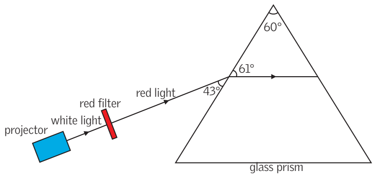
Comments

This is a problem based on the Mechanics Unit. It starts with a vector calculation and requires an understanding of projectile theory in a sporting situation unfamiliar to many candidates.

2005, Question 28

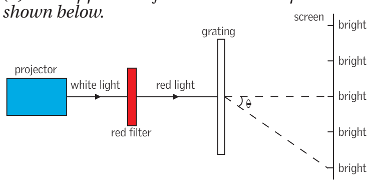
A Physics student investigates what happens when monochromatic light passes through a glass prism or a grating.

(a) The apparatus for the first experiment is shown below.



(i) Calculate the refractive index of the glass for the red light.
(ii) Sketch a diagram which shows the ray of red light before, during and after passing through the prism. Mark on your diagram the values of all relevant angles.

(b) The apparatus for the second experiment is shown below.

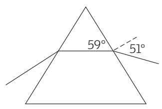


A pattern of bright and dark fringes is observed on the screen.
The grating has 300 lines per millimetre and the wavelength of the red light is 650 nm.
(i) Explain how the bright fringes are produced.
(ii) Calculate the angle θ of the second order maximum.
(iii) The red filter is replaced by a blue filter. Describe the effect of this change on the pattern observed.

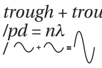
Justify your answer.

Answer

(a) (i) 1.51
(ii)



(b) (i) Bigger crests and troughs
Constructive interference
Bigger amplitude
Waves are meeting /in phase
/in step
/crest + crest and trough + trough
/pd = nλ
/



(ii) 23°
(iii)
- *The fringes are closer together*
- *wavelength of blue light <λ of red light or frequency of blue light > f of red light or λ blue is smaller or f greater*
- *Angle θ smaller as λ blue <λ red*

Comments

This problem is one which should be entirely familiar to all higher pupils as these are standard classroom experiments. Its difficulty lies in the different behaviour of refracted light and diffracted light. Red light is refracted less because it travels faster than blue light in glass but red light is deviated more in the interference pattern because the path difference to the second order maximum for the bigger wavelength red light is greater than for the shorter wavelength blue light. Many candidates will be confused when faced with both diffraction and refraction in the same question.