C

[3220/260] 1991

SCOTTISH CERTIFICATE OF EDUCATION

PHYSICS

Standard Grade—CREDIT LEVEL

Wednesday, 15th May—1.30 p.m. to 3.15 p.m.

1. **All questions should be answered.**
2. **The questions may be answered in any order but all answers must be written clearly and legibly in ink in the answer book provided.**
3. **Any necessary data will be found in the DATA SHEET on page two.**

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DATA SHEET

Speed of light in materials

Material	*Speed in m/s*
Air	$3{\cdot}0 \times 10^8$
Water	$2{\cdot}3 \times 10^8$
Glass	$2{\cdot}0 \times 10^8$

Speed of sound in materials

Material	*Speed in m/s*
Air	340
Water	1 400
Muscle	1 600
Bone	3 000

Gravitational field strengths on the surface of planets

Planet	*Gravitational field strength in N/kg*
Venus	9
Earth	10
Mars	4
Jupiter	26

Specific heat capacity of materials

Material	*Specific heat capacity in J/kg °C*
Water	4 200
Alcohol	2 500
Aluminium	800
Copper	395

SI Prefixes and Multiplication Factors

Prefix	*Symbol*	*Factor*	*Prefix*	*Symbol*	*Factor*
mega	M	$1\,000\,000 = 10^6$	milli	m	$0{\cdot}001 = 10^{-3}$
kilo	k	$1\,000 = 10^3$	micro	μ	$0{\cdot}000\,001 = 10^{-6}$

1 tonne = 1000 kilogram

K&U	PS

1. During the Apollo space programme, an astronaut of mass 80 kg travelled to the Moon. The gravitational field strength did not remain the same throughout the journey.

(*a*) What is meant by *gravitational field strength*? **1**

(*b*) Copy and complete the **last two columns** of the table below to show the astronaut's mass and his weight in different situations. **3**

Situation	*Gravitational field strength*	*Mass*	*Weight*
On the Earth	10 N/kg		
At a point in the journey	negligible		
On the Moon	1·6 N/kg		

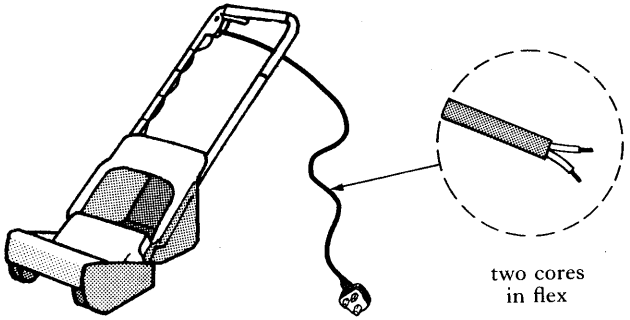
2. The distance from Earth to the nearest star, Proxima Centauri, is 4·3 light years.

Estimate the month and year in which light radiated today (May 15th 1991) from Proxima Centauri will be seen on Earth. **2**

[Turn over

	K&U	PS

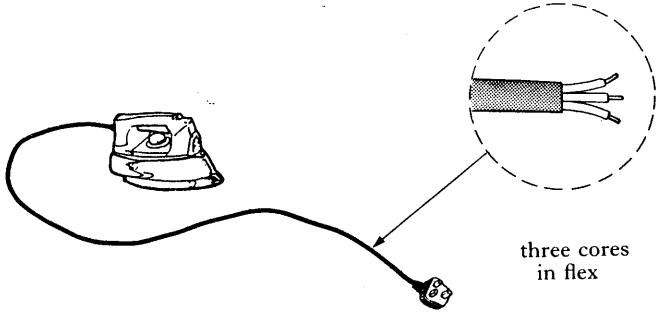
3. (*a*) A lawnmower is connected to the mains supply by a two core flex.



(i) Name the two wires in the flex and give the colours of their insulation. In your answer make it clear which colour applies to each wire. — 2

(ii) In which of these two wires should the switch be connected? Give a reason for your answer. — 2

(*b*) An electric iron is connected to the mains supply by a three core flex.



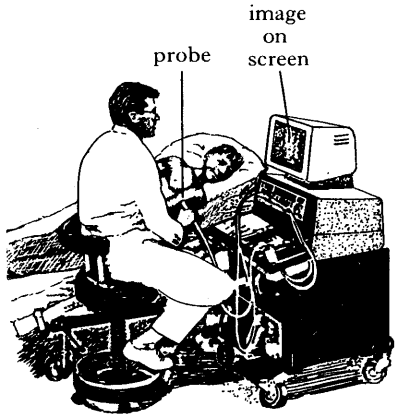
(i) Name the additional wire in this flex. — 1

(ii) Explain how this additional wire acts as a safety device when a fault occurs in the iron. — 2

(iii) The heating element of the iron has a resistance 48 Ω. Calculate the current in the element when the iron is connected to the 240 V mains supply. — 2

	K&U	PS

4. Images which have been produced by ultrasound are sometimes used by doctors.



(*a*) The ultrasound is transmitted through the patient's skin from a probe as shown.

(i) What is meant by ultrasound? — 1

(ii) The ultrasonic waves have a frequency of 8·0 MHz. Calculate the wavelength of the ultrasound in muscle. (Data you require will be found in the Data Sheet on page two.) — 3

(iii) A range of probes with different ultrasonic frequencies may be used. Shorter wavelengths of ultrasound allow sharper images to be produced. Why does a probe of 8·0 MHz frequency give a sharper image than one of 2·25 MHz? — 1

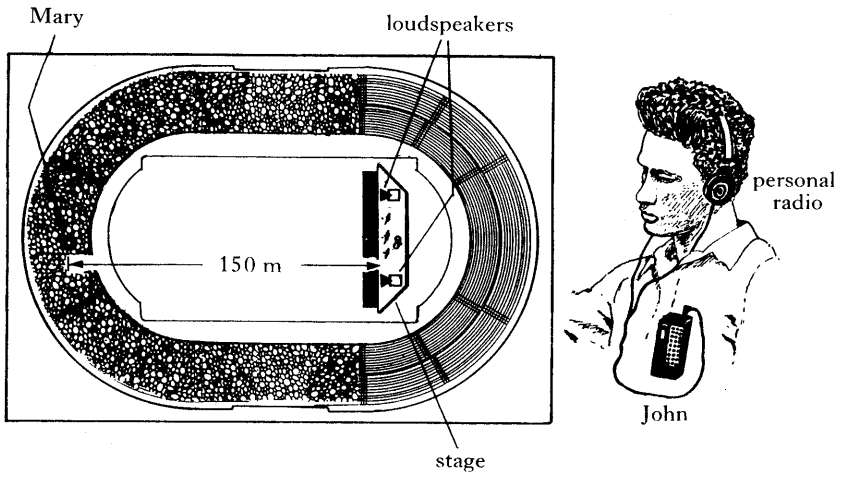
(*b*) Give **one** example of the use of ultrasound in medicine. — 1

(*c*) Why is ultrasound safer than X-rays for some medical investigations? — 1

[Turn over

	K&U	PS

5. Mary is sitting in the crowd at a rock concert being held at Wembley stadium in London. Mary's seat is 150 m from the loudspeakers as shown. Her brother John is listening to a live broadcast of the concert on his personal radio in their Edinburgh home.



(*a*) Explain why John hears the music before Mary. **1**

(*b*) Calculate how far radio waves will travel in the time it takes the sound from the speakers to reach Mary. **4**

(Data you require will be found in the Data Sheet on page two.)

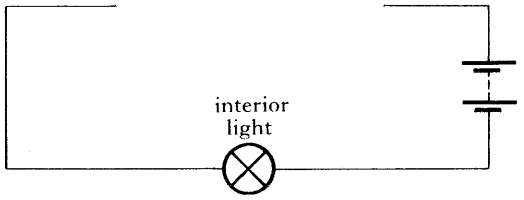
(*c*) The concert is being broadcast on both the medium wave and FM radio wavebands. FM radio waves have higher frequencies than the radio waves used on the medium waveband.

(i) In which of these wavebands do the radio waves have the longer wavelength? **1**

(ii) Explain why people who live in hilly country may have no choice but to listen to the medium wave broadcast of the concert, even if their radios are designed for both medium wave and FM. **2**

	K&U	PS

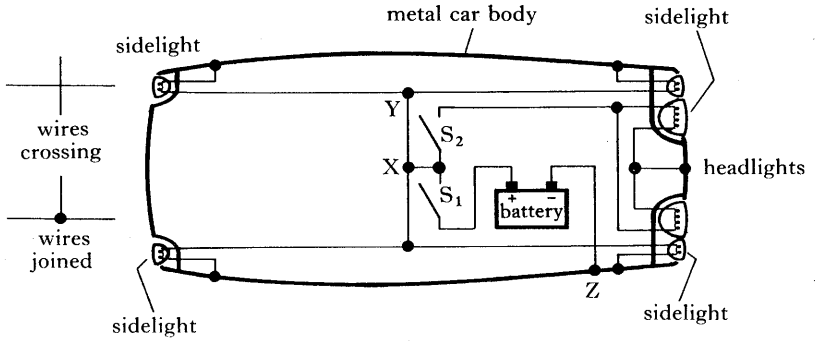
6. (*a*) The interior light in a car comes on when either of the front doors is opened. Each door operates its own switch. An incomplete diagram of the lighting circuit is shown below.



(i) Copy and complete the circuit diagram to show how both of these switches should be connected. **1**

(ii) Explain how your circuit operates. **2**

(*b*) The diagram below shows a simplified version of the wiring used for a car's sidelights and headlights. The negative terminal of the battery is connected to the metal body of the car at Z.



The sidelights of the car are rated at 12 V, 6 W and the headlights at 12 V, 48 W.

(i) Which lights are switched on by closing:

(A) switch S_1 only;

(B) both switches S_1 and S_2? **2**

(ii) There is a current of 0·5 A in each sidelight when switched on.

What is the current in part XY of the circuit when the sidelights are on? **1**

(iii) Calculate the current in one of the headlights when it is switched on. **2**

[Turn over

K&U	PS

7. In the washing machine shown in figure 1, an electric motor is used to turn the drum. Before the clothes are washed, the machine fills with water which is then heated to the correct temperature. Figure 2 shows part of the control circuit for the washing machine.

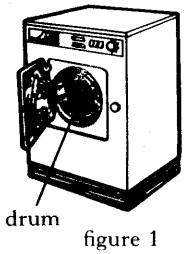


figure 1

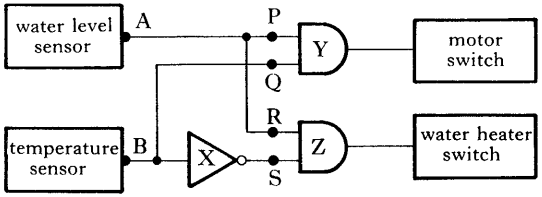


figure 2

When the machine fills to the correct water level, A changes from logic 0 to logic 1.

When the water reaches the correct temperature, B changes from logic 0 to logic 1.

When the output from gate Y is at logic 1, the motor is ON.

When the output from gate Z is at logic 1, the heater is ON.

(*a*) What type of gate is X? | 1 |

(*b*) Give an example of:

(i) an input device which could be used as a temperature sensor;

(ii) an output device which could be used as the motor switch. | 2 |

(*c*) A table may be constructed to show the logic levels at P, Q, R and S and to show whether the heater and motor are switched on or off in a number of cases.

Case 1: just after the machine is switched on and begins to fill with cold water.

Case 2: just after the water reaches the correct level.

Case 3: just after the water reaches the correct temperature.

	P	Q	R	S	*Motor*	*Heater*
Case 1	0	0	0	1	OFF	OFF
Case 2					OFF	ON
Case 3					ON	OFF

Copy and complete the table for case 2 and case 3. | 4 |

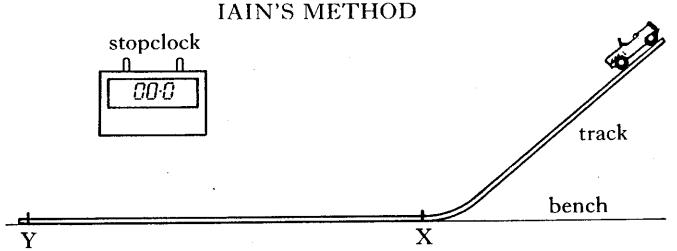
K&U	PS

8. A class has been asked to find the average speed of a toy car as it rolls along the horizontal part XY of a track.

Iain's method and Jill's method are shown below.

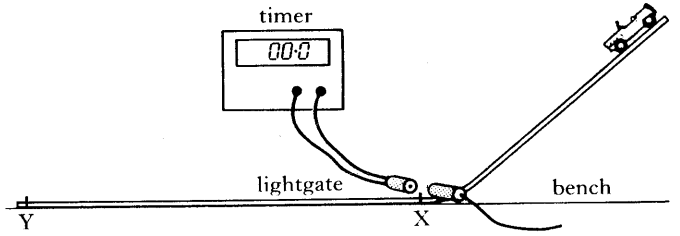
Iain starts his stopclock when the car passes the first mark X and stops the clock when the car passes the second mark Y.

IAIN'S METHOD



Jill uses a light-gate placed at X. This is connected to an electric timer which records the time taken for the car to cut the beam.

JILL'S METHOD



(*a*) How would Iain find the average speed? | 2 |

(*b*) The teacher tells Jill that her method does not measure the average speed of the car over the section XY.

(i) What speed could be found using Jill's timing method? | 1 |

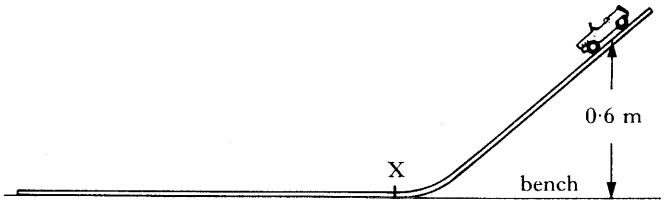
(ii) Jill's method could be changed to allow the measurement of the average speed by adding a second light gate.

How could Jill use the two light gates and the timer to find the average speed? | 3 |

[Turn over

8. (continued)

(*c*) The toy car has a mass of 0·07 kg and is released from a point 0·6 m above the bench.

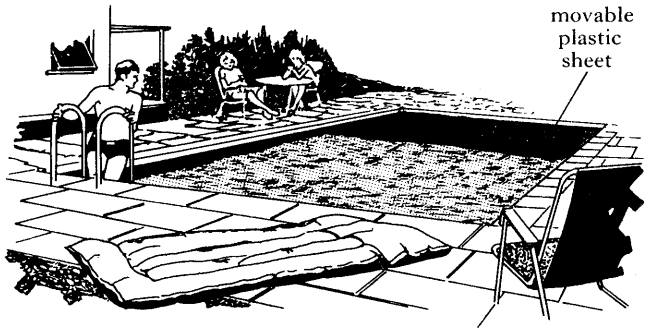


(i) Calculate the change in gravitational potential energy when the car has reached point X. **2**

(ii) Calculate the speed of the car as it passes point X. **3**

(iii) What assumption did you make in part (*c*) (ii)? **1**

9. A hotel swimming pool contains 300 tonnes of water which should be at a temperature of 24 °C. A customer complains to the hotel manager that the water is too cold. The manager measures the temperature and finds that it is 20 °C.



(*a*) How much heat energy is required to bring the water in the pool up to the required temperature? **3**

(Data you require will be found in the Data Sheet on page two.)

(*b*) The pool's electrical heating system has a power of 50 kilowatts.

How many hours will it take to heat the water to the required temperature? **3**

(Data you require will be found in the Data Sheet on page two.)

(*c*) The actual time to heat the water was 32 hours.

Explain why this time is different from your answer to part (*b*). **1**

(*d*) (i) How many kilowatt hours of electrical energy are used by the heating system in the 32 hours? **2**

(ii) Electricity costs 6p per kilowatt hour.

What is the cost of heating the pool from 20 °C to 24 °C? **2**

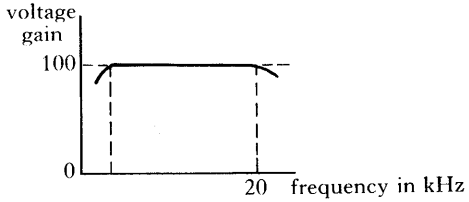
(*e*) Many outdoor pools are covered with a thick plastic sheet at night.

Apart from the fact that it helps to keep the pool clean, suggest a reason for doing this. **1**

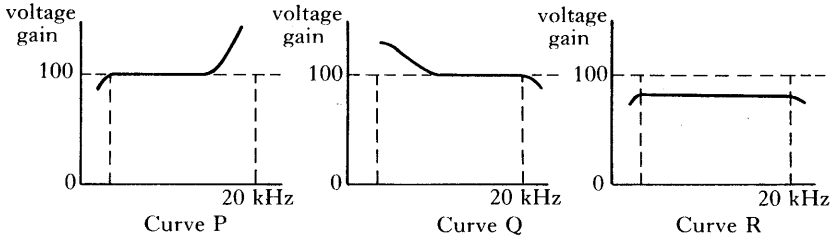
[Turn over

K&U	PS

10. (*a*) An engineer testing an amplifier obtains the frequency response curve shown below.



When he adjusts the bass, treble and volume controls of the amplifier, **one at a time**, he obtains the frequency response curves P, Q and R shown below.



(i) State which control has been altered in each case. 3

(ii) Describe the sound of the music from a tape played through the amplifier with the bass control "turned up". 1

(*b*) The instruction booklet for the amplifier gives the information below.

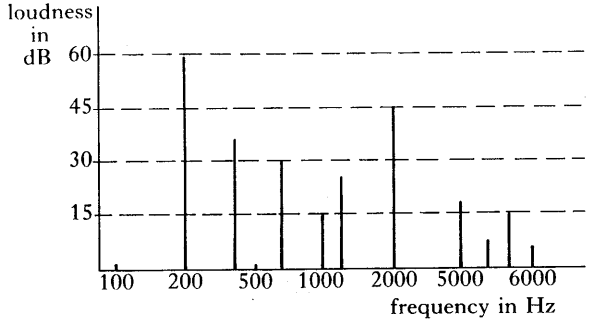
Jack type	phono
Frequency response	15 Hz to 50 kHz
Maximum power output	18 watts
Power gain	45 000

What is the power of the input signal when the amplifier is producing maximum power output? 2

K&U	PS

10. (continued)

(*c*) When a note whose fundamental frequency is 200 Hz is played on a violin, many harmonics are also produced. The diagram below shows the loudness of some of these harmonics.



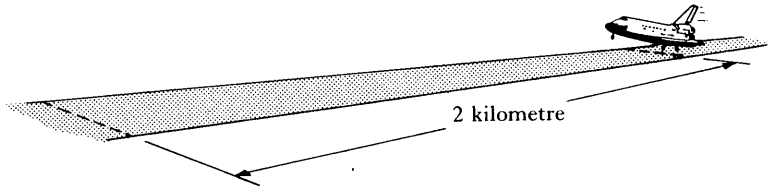
(i) What is the frequency and loudness of the loudest harmonic other than the fundamental? 2

(ii) If a recording of a violin is played through a sound system which can reproduce sounds in the range 150 Hz to 4000 Hz, the recording does not sound very like a violin. Explain. 2

[Turn over

	PS

11. The NASA space shuttle has a mass of 68 500 kg. After re-entry, it has a touchdown speed of 93·0 m/s and travels 2·00 km along the runway before stopping.



(*a*) Calculate the kinetic energy of the shuttle at the instant of touchdown. **2**

(*b*) What is the size of the force necessary to stop the shuttle in the 2·00 kilometre distance? **3**

(*c*) During re-entry, the orbital speed of 7800 m/s is reduced to the touchdown speed of 93 m/s. The shuttle experiences a large reduction in its kinetic energy when this happens.

Explain what happens to this "lost" kinetic energy. **2**

(*d*) The aluminium alloy body of the shuttle is covered with a layer of tiles made from silica.

Suggest one property of the silica tiles which would be of use during the re-entry of the shuttle. Explain your answer. **2**

[END OF QUESTION PAPER]