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# 3220/402

NATIONAL QUALIFICATIONS 2003 MONDAY, 19 MAY 10.50 AM - 12.35 PM PHYSICS STANDARD GRADE Credit Level

Fill in these boxes and read what is printed belo	ow.
Full name of centre	Town
Forename(s)	Surname
Date of birth Day Month Year Scottish candidate number	Number of seat
All questions should be answered.	
2 The questions may be answered in any order b legibly in this book.	out all answers must be written clearly and
3 Write your answer where indicated by the que question.	estion or in the space provided after the
4 If you change your mind about your answer y space provided at the end of the answer book.	ou may score it out and rewrite it in the
5 Before leaving the examination room you must not, you may lose all the marks for this paper.	give this book to the invigilator. If you do
6 Any necessary data will be found in the data she	eet on page two.





#### **DATA SHEET**

### Speed of light in materials

Material	Speed in m/s
Air	$3.0 \times 10^8$
Carbon dioxide	$3.0 \times 10^{8}$
Diamond	$1\cdot2\times10^8$
Glass	$2.0 \times 10^{8}$
Glycerol	$2 \cdot 1 \times 10^8$
Water	$2.3 \times 10^8$

### Speed of sound in materials

Material	Speed in m/s
Aluminium	5200
Air	340
Bone	4100
Carbon dioxide	270
Glycerol	1900
Muscle	1600
Steel	5200
Tissue	1500
Water	1500

#### Gravitational field strengths

	Gravitational field strength on the surface in N/kg
Earth	10
Jupiter	26
Mars	4
Mercury	4
Moon	1.6
Neptune	12
Saturn	11
Sun	270
Venus	9

#### Specific heat capacity of materials

Material	Specific heat capacity in J/kg °C	
Alcohol	2350	
Aluminium	902	
Copper	386	
Diamond	530	
Glass	500	
Glycerol	2400	
Ice	2100	
Lead	128	
Water	4180	

### Specific latent heat of fusion of materials

Material	Specific latent heat of fusion in J/kg		
Alcohol	$0.99\times10^{5}$		
Aluminium	$3.95 \times 10^{5}$		
Carbon dioxide	$1.80 \times 10^5$		
Copper	$2.05 \times 10^5$		
Glycerol	$1.81 \times 10^{5}$		
Lead	$0.25 \times 10^{5}$		
Water	$3.34\times10^{5}$		

### Melting and boiling points of materials

Material	Melting point in °C	Boiling point in °C
Alcohol	-98	65
Aluminium	660	2470
Copper	1077	2567
Glycerol	18	290
Lead	328	1737
Turpentine	<b>-1</b> 0	156

## Specific latent heat of vaporisation of materials

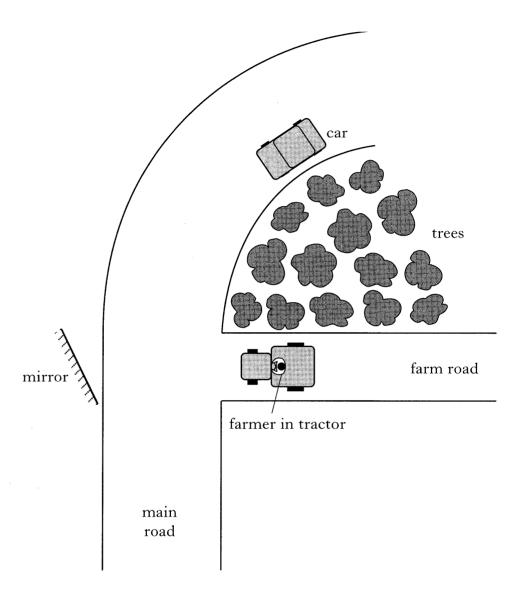
Material	Specific latent heat of vaporisation in J/kg		
Alcohol	$11.2 \times 10^{5}$		
Carbon dioxide	$3.77 \times 10^5$		
Glycerol	$8.30 \times 10^{5}$		
Turpentine	$2.90 \times 10^5$		
Water	$22.6 \times 10^{5}$		

### SI Prefixes and Multiplication Factors

Prefix	Symbol	Factor	
giga	G	$1000000000 = 10^9$	
mega	$\mathbf{M}$	$1000000 = 10^6$	
kilo	k	$1000 = 10^3$	
milli	m	$0.001 = 10^{-3}$	;
micro	μ	$0.000001$ = $10^{-6}$	)
nano	n	0.00000000000000000000000000000000000	)

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A farm road joins a main road at a bend. The farmer has placed a mirror as shown so that he can see when cars are approaching.



(a) On the diagram, draw rays to show how the farmer in the tractor can see the car by using the mirror.

You must label the angle of incidence and the angle of reflection on your completed diagram.

(b) State why the driver of the car can also see the tractor using the mirror.

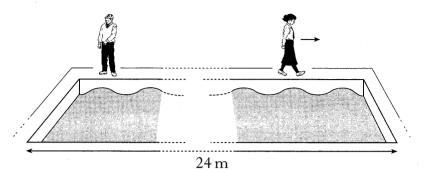
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2. Two students watch the waves produced by a wave machine at a swimming pool.



One student walks beside a wave as it travels along the pool. The wave goes from one end of the pool to the other in 20 s. The length of the pool is 24 m.

(a) Calculate the speed of the waves.

Space for working and answer

(b) In the same time interval, the other student counts 5 waves going past the point where he is standing.

Calculate the frequency of the waves.

Space for working and answer

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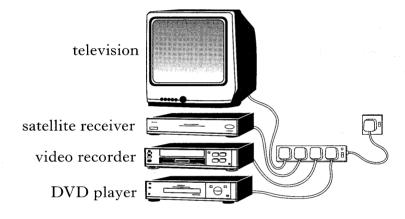
(co	ntinued)		
	The students note that there are 5 complete waves in the pool at any time.		
	Calculate the wavelength of the waves.		
	Space for working and answer		
(d)	Explain why "distance divided by time" and "frequency times wavelength" are equivalent for a wave.	2	
	Space for working and answer		
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3. A home entertainment centre consists of four appliances. The table gives the power rating of each appliance.

Appliance	Power rating (W)
television	110
video recorder	22
satellite receiver	20
DVD player	18

To operate properly, each appliance must be connected to mains voltage. The appliances are connected to the mains using a multiway adaptor.



(a) (i) State the value of the operating voltage of the appliances.

(ii) The connections in the multiway adaptor are arranged to ensure that each appliance is connected to mains voltage.

State how the connections in the multiway adaptor are arranged to achieve this.

(b) Calculate the current from the mains when all four appliances are operating at the power ratings shown in the table.

(You must use an appropriate number of significant figures in your answer to this question.)

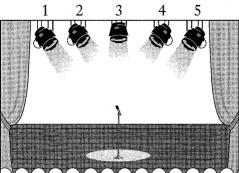
Space for working and answer

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	ate the resistance of the television when it is operating at the rating stated in the table.			
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L		Z		
(d) The pl	ug on the flex of the multiway adaptor contains a fuse.			
What i	s the purpose of this fuse?			
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4. A show uses five spotlights of equal brightness, pointing at the same place on the stage.



The spotlights can be turned on and off individually. The colour of light from each spotlight is shown in the table.

Spotlight	Colour
1	green
2	blue
3	red
4	blue
5	green

(a)	State <b>three</b> spotlights that could be on to produce white light on the stage.		
	1		
( <i>b</i> )	One scene requires yellow light.		
	State <b>two</b> spotlights that could be on to produce yellow light on the stage.		
(c)	Another scene requires <b>pale</b> green light. This needs <b>four</b> of the spotlights to be on.		
	State <b>one</b> spotlight that could be <b>off</b> so that the other four produce pale green light.	:	

5. A textbook has three diagrams showing how an eye lens changes when looking at objects that are different distances away. The diagrams below are copies of these three diagrams, with parts omitted.

Diagrams 1 and 3 are not complete.

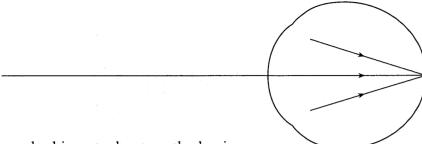


Diagram 1 looking at a boat on the horizon

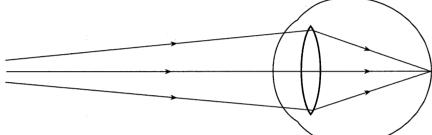


Diagram 2 watching television across a room

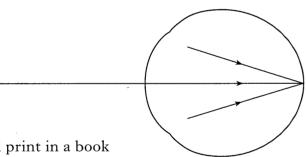
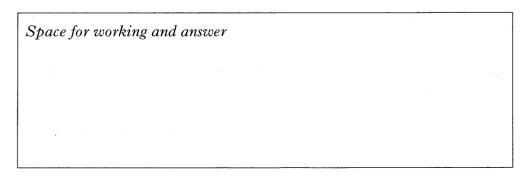


Diagram 3 reading small print in a book

- (a) On diagrams 1 and 3:
  - (i) draw two rays to show light coming from each object to the eye;
  - (ii) draw a lens to show how the shape of the eye lens is different from the shape of the lens in diagram 2.
- (b) The focal length of an eye lens system (the cornea and the eye lens together) is 2.5 cm.

Calculate the power of this eye lens system.

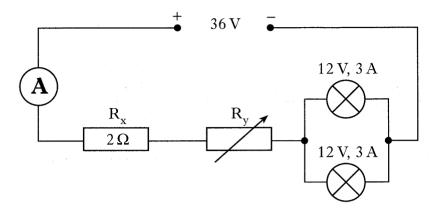


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A student designs the circuit shown to operate a 12 V, 3 A lamp from	<b>a</b> /	
36 V supply.		
+ 36 V −		
30 V		
$(\mathbf{A})$		
$R_x$ $R_y$ 12 V, 3 A		
$\frac{1}{2\Omega}$		
a) What is the reading on the ammeter when the lamp is operating at its	8	
correct power rating?		
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b) The resistance of $R_x$ is $2\Omega$ .		
Calculate the voltage across $R_x$ when the lamp is operating correctly.		
calculate the voltage across $\mathbf{R}_{\mathbf{x}}$ when the lamp is operating correctly.		
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c) Calculate the resistance of $R_y$ when the lamp is operating correctly.		
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#### 6. (continued)

(d) The student connects a second, identical lamp as shown in the diagram below.



Explain why operate corre		ance of R	<sub>y</sub> has to b	e adjusted	for both	lamps to
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(b) The follo	Source P	Half-life 500 years	ailable.  Radiation emitted alpha		1	
(b) The follo	Source P Q	Half-life 500 years 20 hours	ailable.  Radiation emitted alpha beta		1	
	Source P Q R	Half-life 500 years 20 hours 450 years 300 years	ailable.  Radiation emitted alpha beta beta gamma		1	
	Source P Q R	Half-life 500 years 20 hours 450 years 300 years	ailable.  Radiation emitted alpha beta beta		1	
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	Source P Q R	Half-life 500 years 20 hours 450 years 300 years	ailable.  Radiation emitted alpha beta beta gamma		1	
	Source P Q R	Half-life 500 years 20 hours 450 years 300 years	ailable.  Radiation emitted alpha beta beta gamma		1	
	Source P Q R	Half-life 500 years 20 hours 450 years 300 years	ailable.  Radiation emitted alpha beta beta gamma		1	
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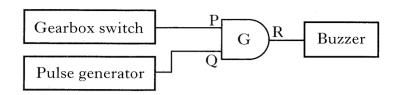
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**8.** A bus is fitted with a buzzer that sounds only when the bus is reversing. Part of the circuit that operates the buzzer is shown.



The output from the gearbox switch is high (logic 1) when the bus is reversing.

(a) Name logic gate G.

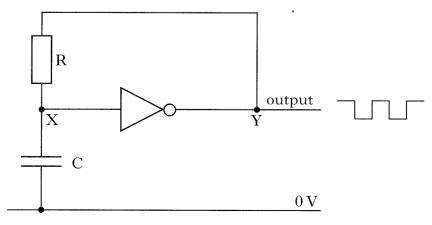
(b) The table shows the different possible combinations of logic levels (0 or 1) for input P and input Q to gate G.

Complete the last column of the table by **drawing** the output R from gate G for each combination of inputs.

Input P	Input Q	Output R
1	1	1
0	0	0
1		1
0		0
1	1	1
0	0	0
1	1	1
0		

(c) The pulse generator part of the circuit is shown below.

The power supply to the NOT gate has been omitted for clarity.



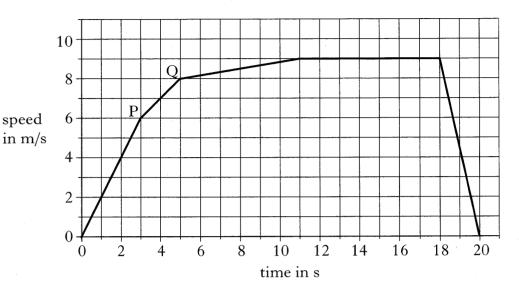
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c)	(con	tinued)			
	(i)	Capacitor C is initially discharged.			
		Explain the operation of the pulse generator circuit, by referring to points X and Y in the circuit.			
		i) Capacitor C is initially discharged.  Explain the operation of the pulse generator circuit, by refet to points X and Y in the circuit.  The pulse generator produces an output with a high frequent State one change that could be made to the circuit to gioutput of lower frequency.  [Turn	2		
	(ii)	The pulse generator produces an output with a high frequency.	nerator circuit, by referring  2  ut with a high frequency. le to the circuit to give an  1  [Turn over		
		State <b>one</b> change that could be made to the circuit to give an output of lower frequency.			
		······································			
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		[Turn over			
	;)	(i)	Explain the operation of the pulse generator circuit, by referring to points X and Y in the circuit.  (ii) The pulse generator produces an output with a high frequency.  State one change that could be made to the circuit to give an output of lower frequency.  [Turn over	(i) Capacitor C is initially discharged.  Explain the operation of the pulse generator circuit, by referring to points X and Y in the circuit.   (ii) The pulse generator produces an output with a high frequency.  State one change that could be made to the circuit to give an output of lower frequency.  [Turn over]	(i) Capacitor C is initially discharged.  Explain the operation of the pulse generator circuit, by referring to points X and Y in the circuit.  (ii) The pulse generator produces an output with a high frequency.  State one change that could be made to the circuit to give an output of lower frequency.  1  [Turn over]

An	electronic circuit is shown below. Component R is a thermistor.	Marks		Р
	P Q		, and the second process of the second proce	
	R			
(a)	Name component P.	1		
(b)	(i) Name component Q.	1		
	(ii) In this circuit, what is the function of component Q?	1		
(c)	Explain how the circuit operates.			
		2		-
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10. A cyclist starts a journey in first gear and uses two other gears during the journey. After a short time the cyclist is forced to brake sharply and comes to a halt. A speed-time graph of the journey is shown.



At point P the cyclist changes from first gear to second gear. At point Q the cyclist changes from second gear to third gear.

(a) (i) Before braking, which gear is the cyclist using when the acceleration is greatest?

.....

(ii) Which gear does the cyclist use for the shortest time?

.....

(b) Calculate how far the cyclist travels in second gear.

Space for working and answer

(c) Calculate the deceleration.

Space for working and answer

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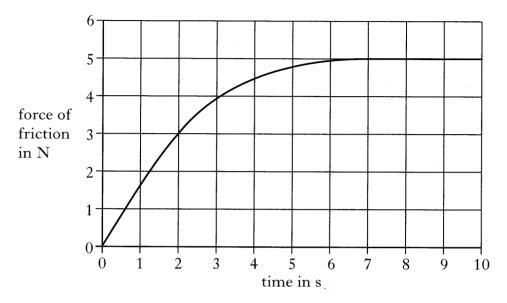
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11. A model motor boat of mass 4 kg is initially at rest on a pond. The boat's motor, which provides a constant force of 5 N, is switched on. As the boat accelerates, the force of friction acting on it increases. A graph of the force of friction acting on the boat against time is shown.



(a) (i) State the force of friction acting on the boat 2s after the motor is switched on.

.....

(ii) Calculate the acceleration of the boat at this time.

Space for working and answer

(b) Describe and explain the movement of the boat after 7 s.

.....

13·8		The	charger contains a transformer that has an output voltage of		
(a)	Wha	t type	e of transformer does the battery charger contain?		
				1	
(b)	The	re are	4000 turns in the primary coil of the transformer.		
` '	Assu	ıming	g the transformer is 100% efficient, calculate the number of he secondary coil.		
	Spa	ice for	r working and answer		
				2	
(c)	(i)	Whe 4.7 A	en charging the battery, the current in the secondary coil is A.  Calculate the power output of the transformer.		
		( )	Space for working and answer		
				2	
		(B)	In practice, the transformer is only 94% efficient. Calculate the current in the primary coil.	2	
			Space for working and answer		
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	(ii)		e and explain <b>one</b> reason why a transformer is not 100% cient.		
		•••••			

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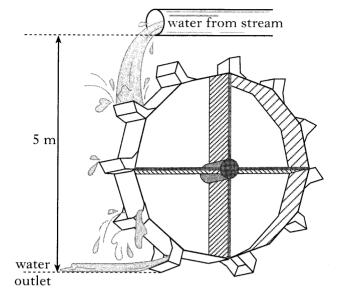
Page nineteen

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13. Water from a stream is used to drive a water wheel. The stream provides 6000 kg of water per minute to the wheel. The water falls a vertical height of 5 m.



(a) Show that the maximum power available to the wheel from the water is 5000 W.

Space for working and answer

(b) The water wheel turns an electrical generator. The generator produces an output of 2990 W.

(i) Calculate the efficiency of the water wheel and generator system.

Space for working and answer

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(ii)	Give <b>two</b> reasons why the efficiency of this system is not 100%.		
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		2	
(iii)	The generator is connected to a heater in a shed. The heater		
	heats the air in the shed. The mass of air in the shed is 161 kg.		
	The specific heat capacity of air is 1000 J/kg °C.		
	Calculate the minimum time to increase the temperature of the air in the shed by 13 °C.		
	an in the shed by 15°C.		
	Space for working and answer		
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(iv)	Give <b>one</b> reason why the actual time taken to increase the		
(iv)	Give <b>one</b> reason why the actual time taken to increase the temperature of the air in the shed is greater than the value		
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(iv)	temperature of the air in the shed is greater than the value		
(iv)	temperature of the air in the shed is greater than the value		
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(iv)	temperature of the air in the shed is greater than the value		
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(iv)	temperature of the air in the shed is greater than the value calculated in (iii).		
(iv)	temperature of the air in the shed is greater than the value calculated in (iii).		

TTO		• .	et and infrared are three	•		
	wes. Every member of this family travels at the speed of light.  What name is given to this family of waves?					
<i>(a)</i>	y waves.					
	•••••	•••••			1	
( <i>b</i> )	Som	ne uses of waves	s in this family are shown	below.		
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		nmunicating nmobile	Linking networked	Treating injuries		
	pho		computers through optical fibres			
	(i)	From the exam	mples above, give a use for	<b>::</b> 		
		gamma rays				
		ultraviolet				
		infrared			3	
	(ii)	Which of the	three waves in (i) has:			
	(11)					
		the longest wa	welength			
		the highest fre	equency?		2	

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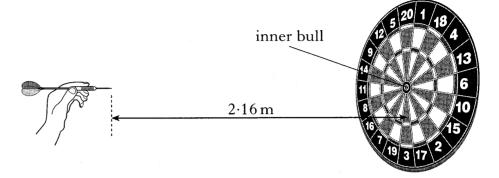
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A darts player throws a dart horizontally at the centre of the inner bull. The dart leaves the player's hand at a distance of 2.16 m from the dartboard and with a horizontal speed of 12.0 m/s.



(a) Calculate the time taken for the dart to travel from the hand to the board.

Space for working and answer

(b) Explain why the dart follows a curved path in its flight to the board.

(c) The average vertical speed of the dart during its flight to the board is  $0.9 \,\mathrm{m/s}$ .

How far below the centre of the inner bull does the dart hit the board?

Space for working and answer

[END OF QUESTION PAPER]

[3220/402]

Page twenty-three

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