X069/301

NATIONAL QUALIFICATIONS 2003

MONDAY, 19 MAY
1.00 PM – 3.30 PM

PHYSICS
HIGHER

Read Carefully

1 All questions should be attempted.

Section A (questions 1 to 20)

2 Check that the answer sheet is for Physics Higher (Section A).

3 Answer the questions numbered 1 to 20 on the answer sheet provided.

4 Fill in the details required on the answer sheet.

5 Rough working, if required, should be done only on this question paper, or on the first two pages of the answer book provided—**not** on the answer sheet.

6 For each of the questions 1 to 20 there is only **one** correct answer and each is worth 1 mark.

7 Instructions as to how to record your answers to questions 1–20 are given on page three.

Section B (questions 21 to 29)

8 Answer questions numbered 21 to 29 in the answer book provided.

9 Fill in the details on the front of the answer book.

10 Enter the question number clearly in the margin of the answer book beside each of your answers to questions 21 to 29.

11 Care should be taken to give an appropriate number of significant figures in the final answers to calculations.

SAB X069/301 6/3/3/16670

DATA SHEET

COMMON PHYSICAL QUANTITIES

Quantity	*Symbol*	*Value*	*Quantity*	*Symbol*	*Value*
Speed of light in vacuum	c	$3{\cdot}00 \times 10^{8}$ m s^{-1}	Mass of electron	m_e	$9{\cdot}11 \times 10^{-31}$ kg
Magnitude of the charge on an electron	e	$1{\cdot}60 \times 10^{-19}$ C	Mass of neutron	m_n	$1{\cdot}675 \times 10^{-27}$ kg
Gravitational acceleration on Earth	g	$9{\cdot}8$ m s^{-2}	Mass of proton	m_p	$1{\cdot}673 \times 10^{-27}$ kg
Planck's constant	h	$6{\cdot}63 \times 10^{-34}$ J s			

REFRACTIVE INDICES

The refractive indices refer to sodium light of wavelength 589 nm and to substances at a temperature of 273 K.

Substance	*Refractive index*	*Substance*	*Refractive index*
Diamond	2·42	Water	1·33
Crown glass	1·50	Air	1·00

SPECTRAL LINES

Element	*Wavelength*/nm	*Colour*
Hydrogen	656	Red
	486	Blue-green
	434	Blue-violet
	410	Violet
	397	Ultraviolet
	389	Ultraviolet
Sodium	589	Yellow

Element	*Wavelength*/nm	*Colour*
Cadmium	644	Red
	509	Green
	480	Blue

Lasers

Element	*Wavelength*/nm	*Colour*
Carbon dioxide	9550 } 10590 }	Infrared
Helium-neon	633	Red

PROPERTIES OF SELECTED MATERIALS

Substance	*Density*/ kg m^{-3}	*Melting Point*/ K	*Boiling Point*/ K
Aluminium	$2{\cdot}70 \times 10^{3}$	933	2623
Copper	$8{\cdot}96 \times 10^{3}$	1357	2853
Ice	$9{\cdot}20 \times 10^{2}$	273	....
Sea Water	$1{\cdot}02 \times 10^{3}$	264	377
Water	$1{\cdot}00 \times 10^{3}$	273	373
Air	1·29	....	....
Hydrogen	$9{\cdot}0 \times 10^{-2}$	14	20

The gas densities refer to a temperature of 273 K and a pressure of $1{\cdot}01 \times 10^{5}$ Pa.

SECTION A

For questions 1 to 20 in this section of the paper, an answer is recorded on the answer sheet by indicating the choice A, B, C, D or E by a stroke made in ink in the appropriate box of the answer sheet—see the example below.

EXAMPLE

The energy unit measured by the electricity meter in your home is the

A ampere

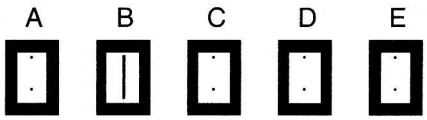
B kilowatt-hour

C watt

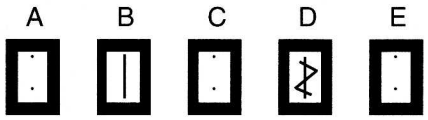
D coulomb

E volt.

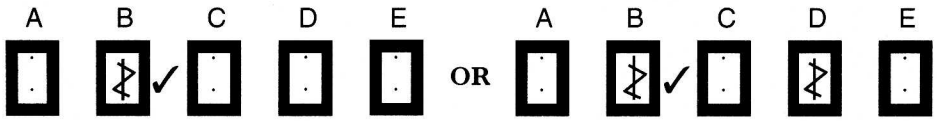
The correct answer to the question is B—kilowatt-hour. Record your answer by drawing a heavy vertical line joining the two dots in the appropriate box on your answer sheet in the column of boxes headed B. The entry on your answer sheet would now look like this:



If after you have recorded your answer you decide that you have made an error and wish to make a change, you should cancel the original answer and put a vertical stroke in the box you now consider to be correct. Thus, if you want to change an answer D to an answer B, your answer sheet would look like this:



If you want to change back to an answer which has already been scored out, you should enter a tick (✓) to the RIGHT of the box of your choice, thus:



SECTION A

Answer questions 1–20 on the answer sheet.

1. Which of the following are **both** vectors?

A Speed and weight

B Kinetic energy and potential energy

C Mass and momentum

D Weight and momentum

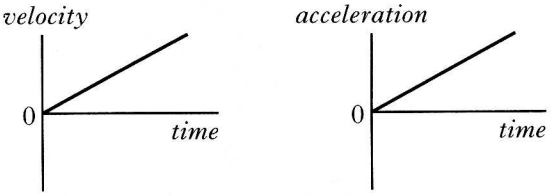
E Force and speed

2. A vehicle is travelling in a straight line.

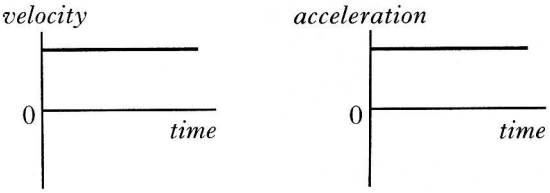
Graphs of velocity and acceleration against time are shown below.

Which pair of graphs could represent the motion of the vehicle?

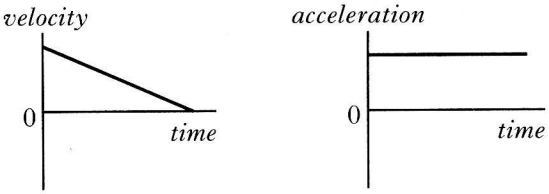
A



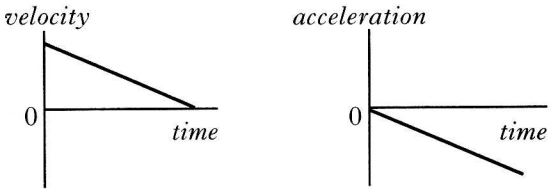
B



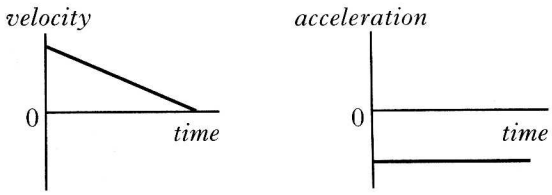
C



D

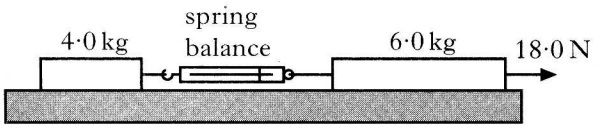


E



3. A block of mass 4·0 kg and a block of mass 6·0 kg are linked by a spring balance of negligible mass.

The blocks are placed on a frictionless horizontal surface. A force of 18·0 N is applied to the 6·0 kg block as shown.



What is the reading on the spring balance?

A 7·2 N

B 9·0 N

C 10·8 N

D 18·0 N

E 40·0 N

4. A car of mass 1000 kg is travelling at a speed of 40 m s^{-1} along a straight road. The brakes are applied and the car decelerates to 10 m s^{-1}.

How much kinetic energy is lost by the car?

A 15 kJ

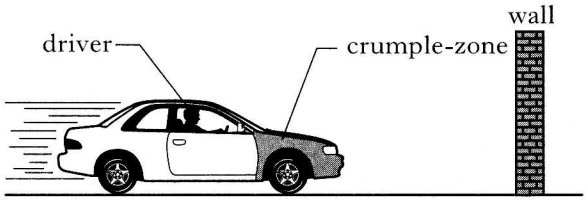
B 50 kJ

C 450 kJ

D 750 kJ

E 800 kJ

5. A car is designed with a "crumple-zone" so that the front of the car collapses during impact.



The purpose of the crumple-zone is to

A decrease the driver's change in momentum per second

B increase the driver's change in momentum per second

C decrease the driver's final velocity

D increase the driver's total change in momentum

E decrease the driver's total change in momentum.

6. A fixed mass of gas condenses at atmospheric pressure to form a liquid.

Which row in the table shows the approximate increase in density and the approximate decrease in spacing between molecules?

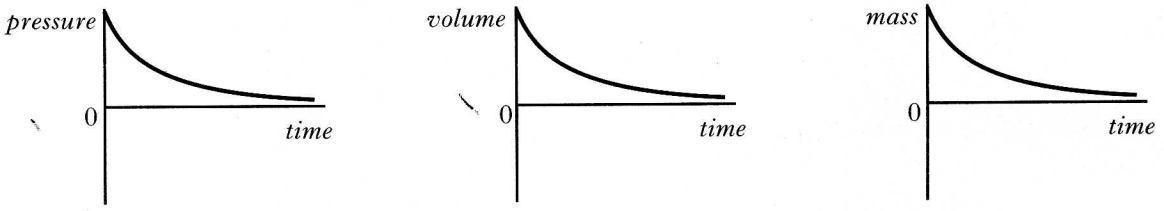
	Approximate increase in density	*Approximate decrease in spacing between molecules*
A	10 times	2 times
B	100 times	10 times
C	1000 times	10 times
D	1 000 000 times	100 times
E	1 000 000 times	1000 times

[Turn over

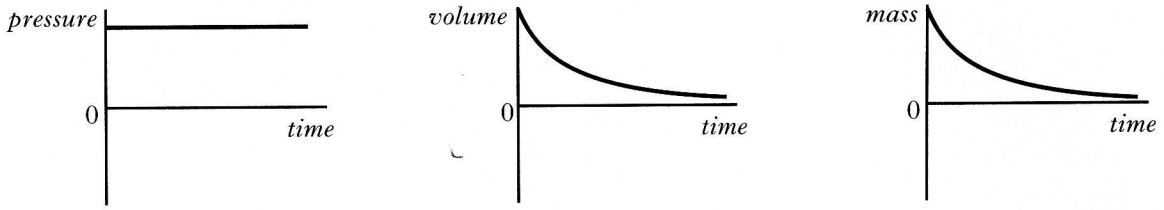
7. A rigid metal cylinder stores compressed gas. Gas is gradually released from the cylinder. The temperature of the gas remains constant.

Which set of graphs shows how the pressure, the volume and the mass of the gas **in the cylinder** change with time?

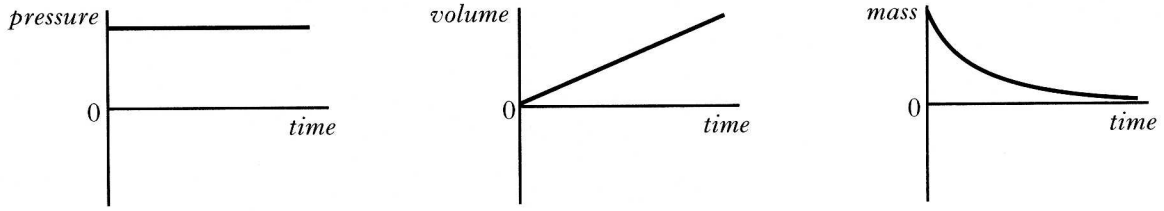
A



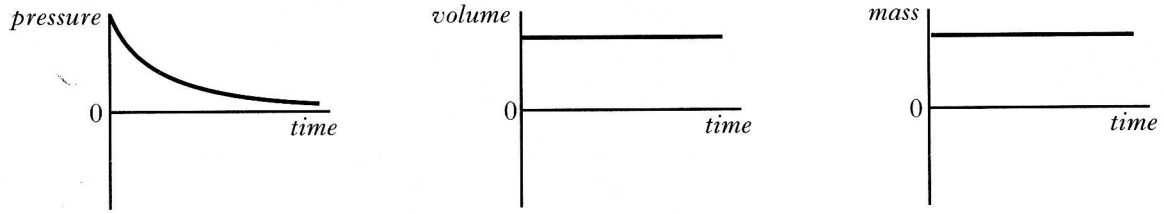
B



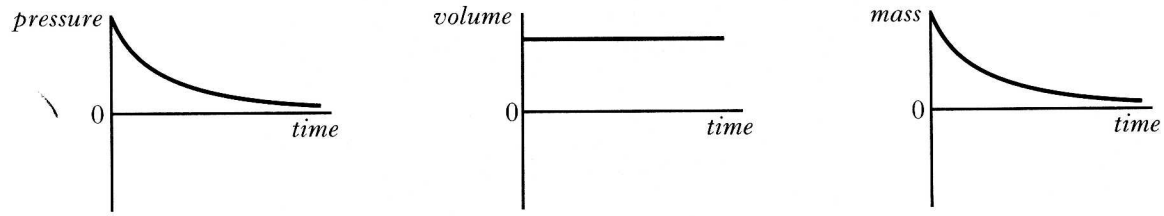
C



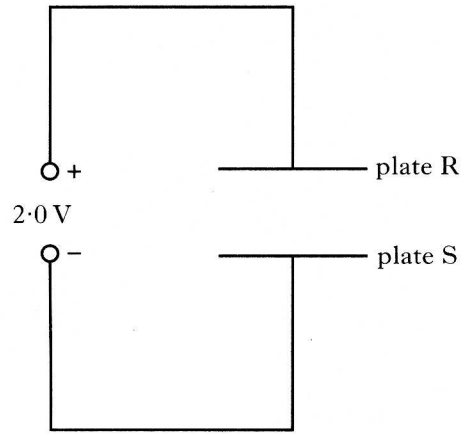
D



E



8. Two parallel metal plates, R and S, are connected to a 2·0 V d.c. supply as shown.



An electron is moved from plate R to plate S.

The gain in electrical potential energy of the electron is

A $8{\cdot}0 \times 10^{-20}$ J

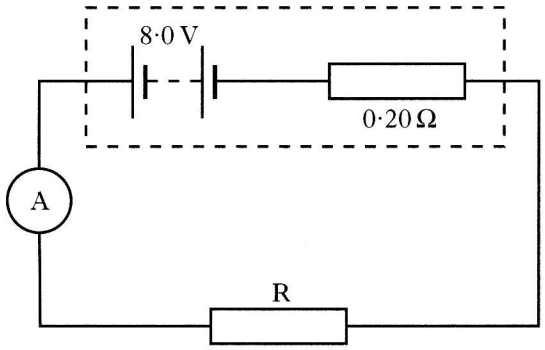
B $1{\cdot}6 \times 10^{-19}$ J

C $3{\cdot}2 \times 10^{-19}$ J

D $6{\cdot}4 \times 10^{-19}$ J

E $1{\cdot}3 \times 10^{-19}$ J.

9. In the following circuit, the battery has an e.m.f. of 8·0 V and an internal resistance of 0·20 Ω.



The reading on the ammeter is 4·0 A.

The resistance of R is

A 0·5 Ω

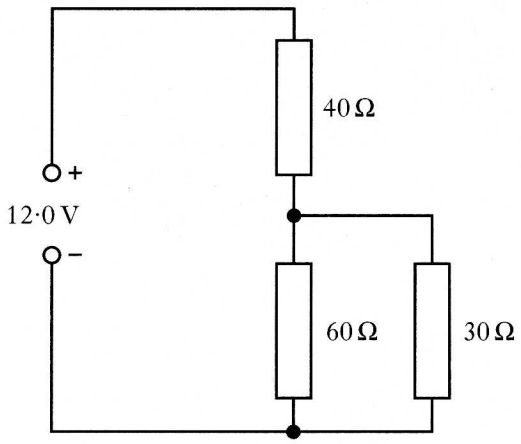
B 1·8 Ω

C 2·0 Ω

D 2·2 Ω

E 6·4 Ω.

10. In the following circuit, the supply has negligible internal resistance.



The p.d. across the 30 Ω resistor is

A 8·0 V

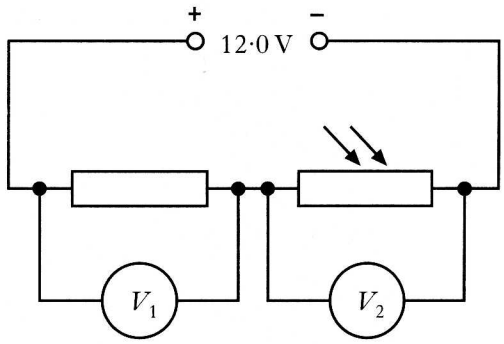
B 7·2 V

C 6·0 V

D 4·8 V

E 4·0 V.

11. A student sets up the following circuit.



The intensity of light incident on the LDR is reduced.

Which row in the table shows the effect on the voltmeter readings V_1 and V_2?

	V_1	V_2
A	increases	increases
B	decreases	decreases
C	increases	decreases
D	decreases	increases
E	no change	increases

12. A student writes the following statements about a capacitor.

I The current in a circuit containing a capacitor decreases when the supply frequency increases.

II A capacitor can store charge.

III A capacitor can block d.c.

Which of these is/are correct?

A I only

B II only

C III only

D I and II only

E II and III only

13. A farad is a

A volt per ampere

B volt per ohm

C coulomb per volt

D coulomb per second

E joule per coulomb.

14. A $10\,\mu F$ capacitor is connected to a 50 V supply. The maximum charge stored by the capacitor is

A $2{\cdot}0 \times 10^{-7}\,C$

B $5{\cdot}0 \times 10^{-4}\,C$

C $5{\cdot}0\,C$

D $5{\cdot}0 \times 10^{2}\,C$

E $5{\cdot}0 \times 10^{6}\,C$.

15. In the following passage three words have been replaced by the letters **X**, **Y** and **Z**.

"Monochromatic light is incident on a grating and the resulting interference pattern is viewed on a screen. The distance between neighbouring areas of constructive interference on the screen:

is ..... **X** ..... *when the screen is moved further away from the grating;*

is ..... **Y** ..... *when light of a greater wavelength is used;*

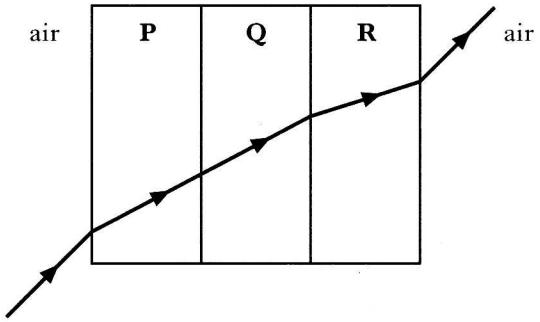
is ..... **Z** ..... *when the distance between the slits is increased."*

Which row of the table shows the missing words?

	X	*Y*	*Z*
A	increased	increased	increased
B	increased	increased	decreased
C	decreased	decreased	increased
D	decreased	decreased	decreased
E	increased	decreased	decreased

16. An engineer creates an experimental window using sheets of transparent plastics **P**, **Q** and **R**.

A ray of light directed at the window follows the path shown.



Which row in the table gives possible values for the refractive indices of the three plastics?

	P	*Q*	*R*
A	1·5	1·9	2·3
B	1·5	1·5	2·3
C	2·3	2·3	1·5
D	2·3	1·9	1·5
E	1·5	1·5	1·2

17. A unit for the intensity of light is

A $\mathrm{J\,m^{-1}}$

B $\mathrm{J\,m^{-2}}$

C $\mathrm{J\,s^{-1}\,m^{-1}}$

D $\mathrm{J\,s^{-1}\,m^{-2}}$

E $\mathrm{J\,s^{-2}m^{-2}}$.

18. When light of frequency f is shone on to a certain metal, photoelectrons are ejected with a maximum velocity v and kinetic energy E_k.

When light of the same frequency and twice the intensity is shone on the same surface then

I twice as many electrons are ejected per second

II the speed of the fastest electrons is now $2v$

III the kinetic energy of the fastest electrons is now $2E_k$.

Which of the statements above is/are correct?

A I only

B II only

C III only

D I and II only

E II and III only

19. A student writes the following statements about n-type semiconductor material.

I Most charge carriers are negative.

II The n-type material has a negative charge.

III Impurity atoms in the material have 5 outer electrons.

Which of these statements is/are true?

A I only

B II only

C III only

D I and II only

E I and III only

20. Which of the following statements describes nuclear fission?

A A nucleus of large mass number splits into two nuclei, releasing several neutrons.

B A nucleus of large mass number splits into two nuclei, releasing several electrons.

C A nucleus of large mass number splits into two nuclei, releasing several protons.

D Two nuclei combine to form one nucleus, releasing several electrons.

E Two nuclei combine to form one nucleus, releasing several neutrons.

[SECTION B begins on *Page eleven*]

SECTION B

Write your answers to questions 21 to 29 in the answer book.

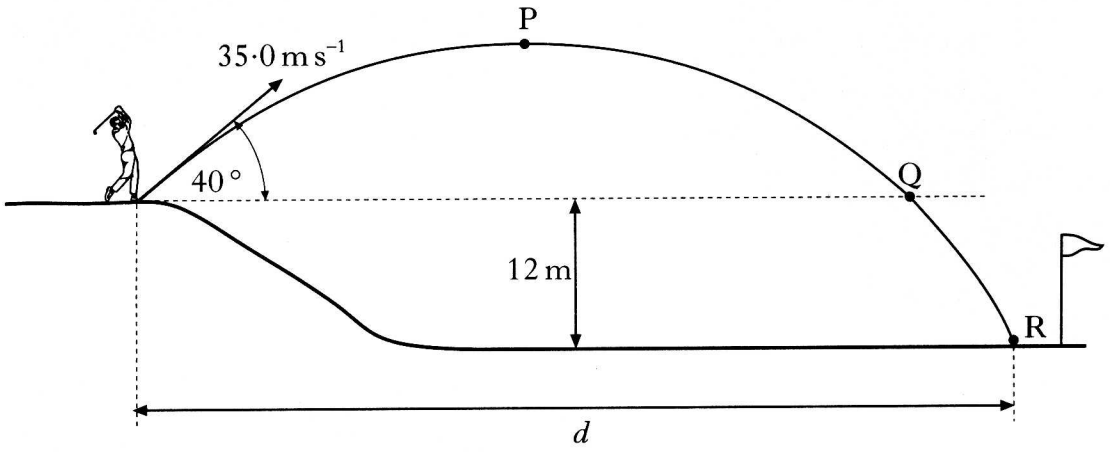
Marks

21. A golfer on an elevated tee hits a golf ball with an initial velocity of $35{\cdot}0\,m\,s^{-1}$ at an angle of 40° to the horizontal.

The ball travels through the air and hits the ground at point R.

Point R is 12 m below the height of the tee, as shown.

diagram not to scale



The effects of air 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. **4**

(*b*) From its maximum height at point P, the ball falls to point Q, which is at the same height as the tee.

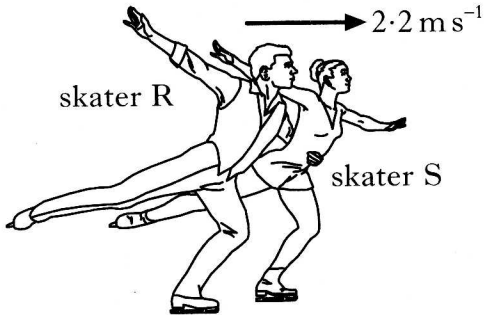
It then takes a further 0·48 s to travel from Q until it hits the ground at R.

Calculate the total horizontal distance *d* travelled by the ball. **3**

(7)

[Turn over

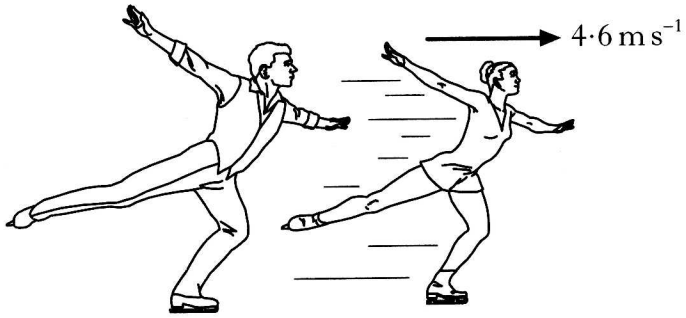
22. Two ice skaters are initially skating together, each with a velocity of $2{\cdot}2\,m\,s^{-1}$ to the right as shown.



The mass of skater R is 54 kg. The mass of skater S is 38 kg.

Skater R now pushes skater S with an average force of 130 N for a short time. This force is in the same direction as their original velocity.

As a result, the velocity of skater S increases to $4{\cdot}6\,m\,s^{-1}$ to the right.



(*a*) Calculate the magnitude of the change in momentum of skater S. **2**

(*b*) How long does skater R exert the force on skater S? **2**

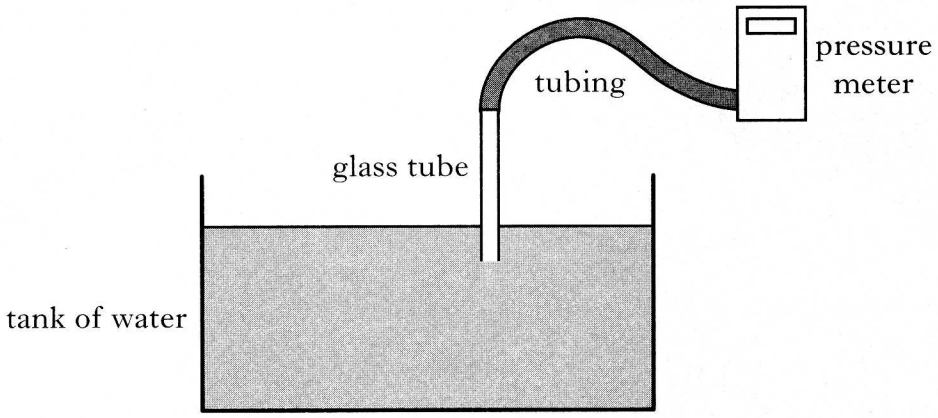
(*c*) Calculate the velocity of skater R immediately after pushing skater S. **2**

(*d*) Is this interaction between the skaters elastic?
You must justify your answer by calculation. **3**

(9)

23. A tank of water rests on a smooth horizontal surface.

(*a*) A student takes measurements of the pressure at various depths below the surface of the water, using the apparatus shown.



The pressure meter is set to zero before the glass tube is lowered into the water.

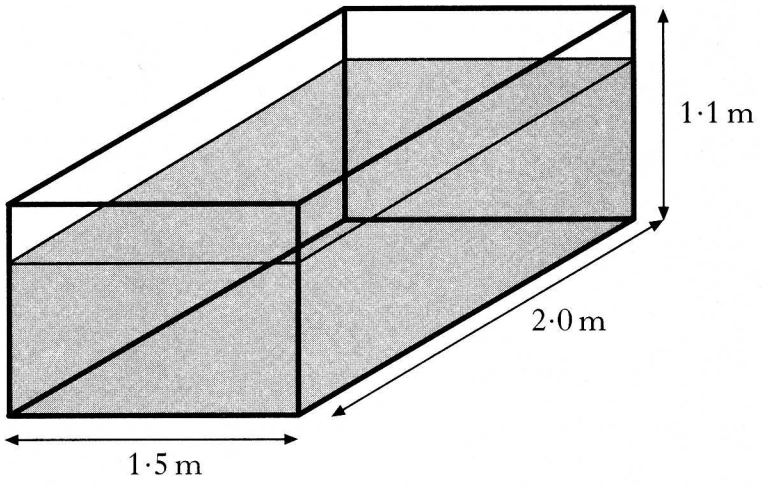
(i) Sketch a graph to show how the pressure due to the water varies with depth below the surface of the water.

(ii) Calculate the pressure due to the water at a depth of 0·25 m below its surface.

(iii) As the glass tube is lowered further into the tank, the student notices that some water rises inside the glass tube. Explain why this happens. **4**

(*b*) The mass of water in the tank is $2{\cdot}7 \times 10^3$ kg. The tank has a mass of 300 kg and a flat rectangular base. The dimensions of the tank are shown in the diagram below.

Atmospheric pressure is $1{\cdot}01 \times 10^5$ Pa.



Calculate the total pressure exerted by the base of the tank on the surface on which it rests. **3**

(7)