

3220/201

SCOTTISH
CERTIFICATE OF
EDUCATION
1998

FRIDAY, 15 MAY
9.30 AM – 11.00 AM

PHYSICS
HIGHER GRADE
Paper I

Read Carefully

- 1 All questions should be attempted.
- 2 The following data should be used when required unless otherwise stated.

Speed of light in vacuum c	$3.00 \times 10^8 \text{ m s}^{-1}$	Planck's constant h	$6.63 \times 10^{-34} \text{ J s}$
Charge on electron e	$-1.60 \times 10^{-19} \text{ C}$	Mass of electron m_e	$9.11 \times 10^{-31} \text{ kg}$
Acceleration due to gravity g	9.8 m s^{-2}	Mass of proton m_p	$1.67 \times 10^{-27} \text{ kg}$

Section A (questions 1 to 30)

- 3 Check that the answer sheet is for Physics Higher I (Section A).
- 4 Answer the questions numbered 1 to 30 on the answer sheet provided.
- 5 Fill in the details required on the answer sheet.
- 6 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.
- 7 For each of the questions 1 to 30 there is only **one** correct answer and each is worth 1 mark.
- 8 Instructions as to how to record your answers to questions 1–30 are given on page two.

Section B (questions 31 to 37)

- 9 Answer questions numbered 31 to 37 in the answer book provided.
- 10 Fill in the details on the front of the answer book.
- 11 Enter the question number clearly in the margin of the answer book beside each of your answers to questions 31 to 37.
- 12 Care should be taken **not** to give an unreasonable number of significant figures in the final answers to calculations.

SECTION A

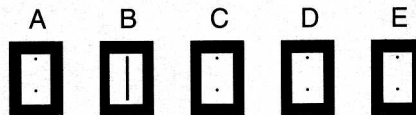
For questions 1 to 30 in this section of the paper, an answer is recorded on the answer sheet by indicating the choice A, B, C, D or E by a stroke made in ink in the appropriate box of the answer sheet—see the example below.

EXAMPLE

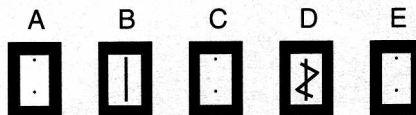
The energy unit measured by the electricity meter in your home is the

- 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 1–30 on the answer sheet.

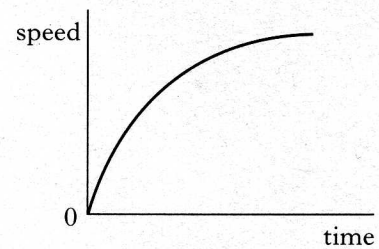
1. Consider the following three statements made by pupils about scalars and vectors.

- I Scalars have direction only.
- II Vectors have both size and direction.
- III Speed is a scalar and velocity is a vector.

Which statement(s) is/are true?

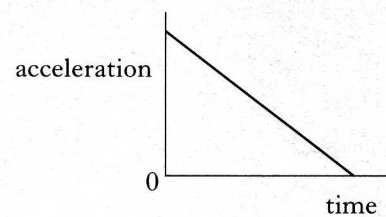
- A I only
- B I and II only
- C I and III only
- D II and III only
- E I, II and III

2. The following is a speed-time graph of the beginning of a cyclist's journey along a straight track.

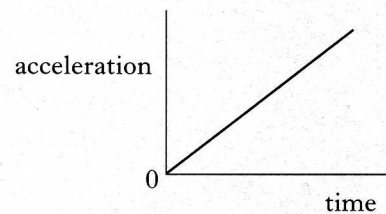


Which of the following could be the corresponding acceleration-time graph for the same period?

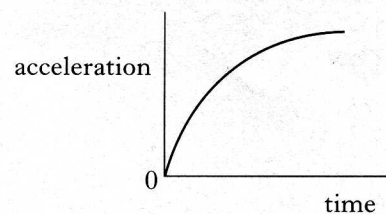
A



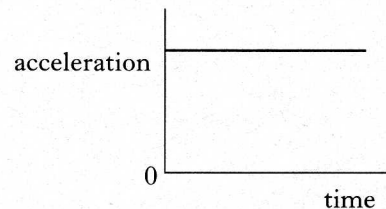
B



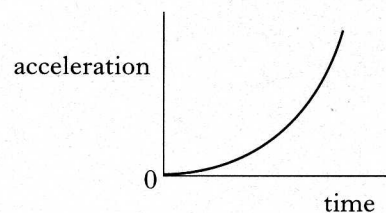
C



D



E

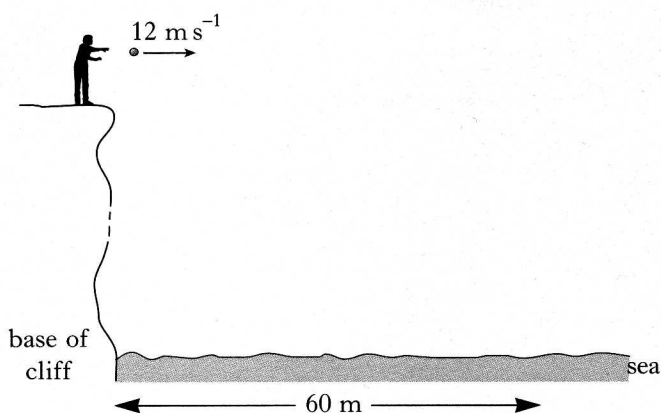


3. A cyclist is travelling along a straight, level road at 10 m s^{-1} . She applies her brakes and comes to rest after travelling a further 20 m.

The braking force is constant. What is her deceleration?

- A 0.25 m s^{-2}
- B 0.50 m s^{-2}
- C 2.0 m s^{-2}
- D 2.5 m s^{-2}
- E 5.0 m s^{-2}

4. A stone is thrown horizontally with a speed of 12 m s^{-1} over the edge of a vertical cliff. It hits the sea at a horizontal distance of 60 m out from the base of the cliff.



Assuming that air resistance is negligible and that the acceleration due to gravity is 10 m s^{-2} , the height from which the stone was projected above the level of the sea is

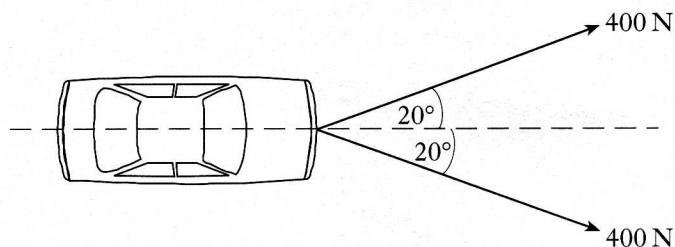
- A 5 m
- B 25 m
- C 50 m
- D 125 m
- E 250 m.

5. A rocket of mass 200 kg accelerates vertically upwards from the surface of a planet at 2 m s^{-2} . The gravitational field strength on the planet is 4 N kg^{-1} .

What is the size of the force being supplied by the rocket's engines?

- A 800 N
- B 1200 N
- C 2000 N
- D 2400 N
- E 4800 N

6. Two boys are pulling a car of mass 800 kg along a level surface with a pair of ropes attached horizontally as shown below.



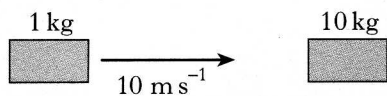
When the pull on each rope is 400 N in the directions indicated, the acceleration of the car is 0.1 m s^{-2} .

What is the size of the frictional force acting on the car in the above situation?

- A 194 N
- B 434 N
- C 533 N
- D 672 N
- E 832 N

7. A block of mass 1 kg slides along a frictionless surface at 10 m s^{-1} and it collides with a stationary block of mass 10 kg . After the collision, the first block rebounds at 5 m s^{-1} and the other one moves off at 1.5 m s^{-1} .

before impact



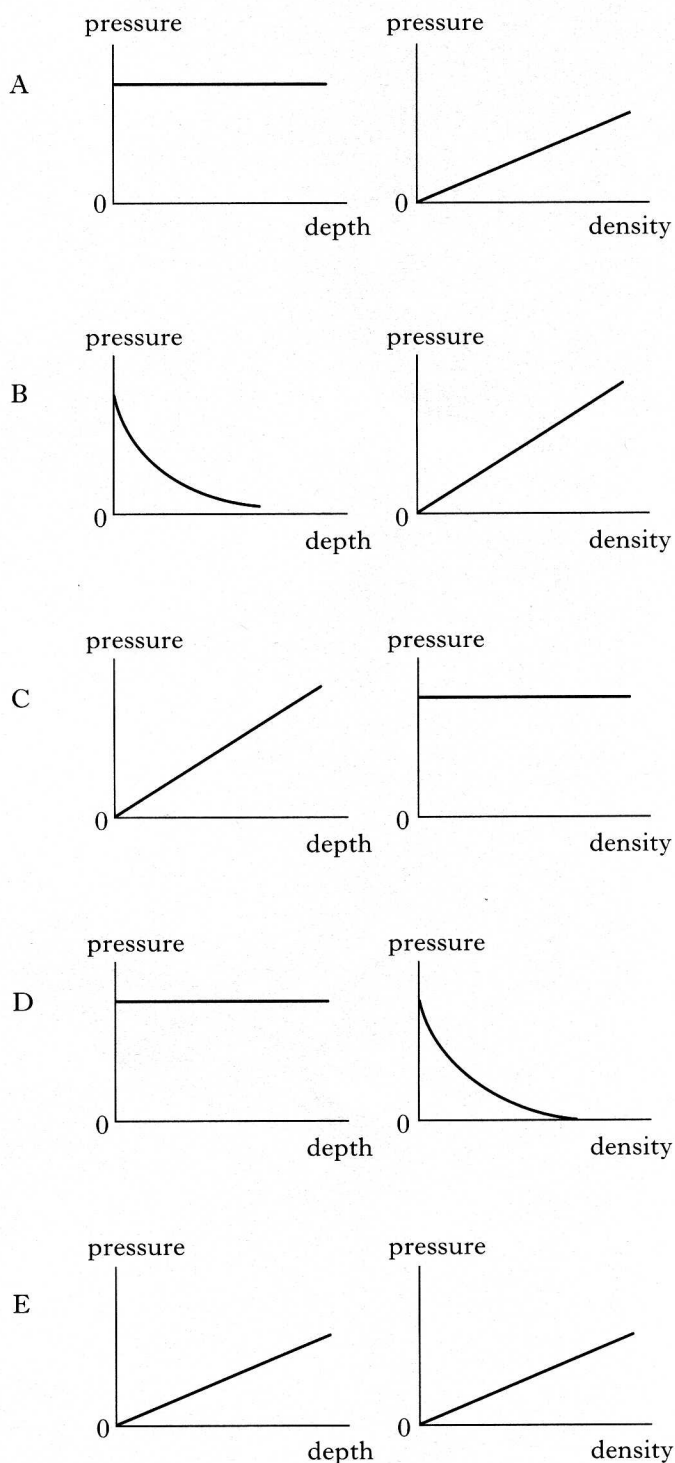
after impact



Which row in the following table is correct?

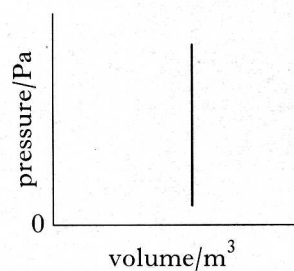
	<i>Momentum of system</i>	<i>Kinetic energy of system</i>	<i>Type of collision</i>
A	conserved	conserved	elastic
B	conserved	not conserved	inelastic
C	conserved	not conserved	elastic
D	not conserved	not conserved	inelastic
E	not conserved	not conserved	elastic

8. Which pair of graphs correctly shows how the pressure produced by a liquid depends on the depth and the density of the liquid?

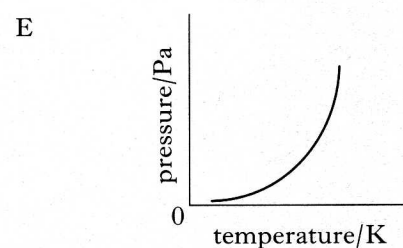
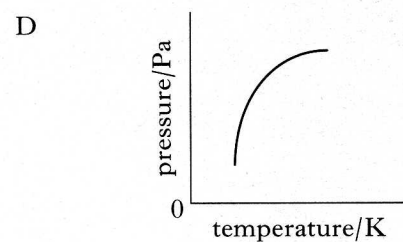
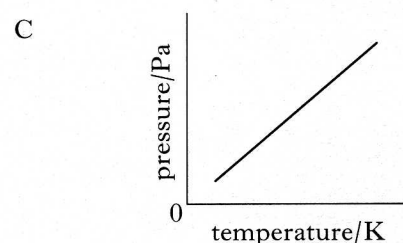
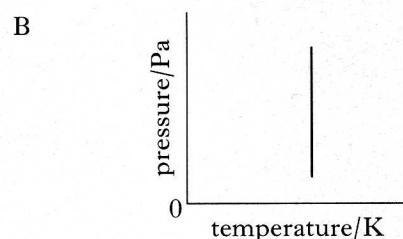
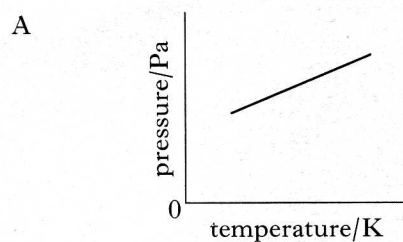


[Turn over

9. The pressure-volume graph below describes the behaviour of a constant mass of gas when it is heated.



Which of the following shows the corresponding pressure-temperature graph?

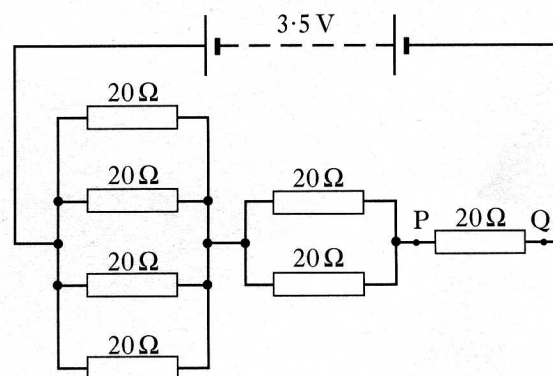


10. A balloon of mass 10 kg accelerates vertically upwards with a constant acceleration of 1 m s^{-2} . The air resistance acting on the balloon is 100 N.

Assuming that the acceleration due to gravity is 10 m s^{-2} , which row in the following table shows the size and direction of the forces acting on the balloon?

	Weight	Air resistance	Upthrust
A	↓ 100 N	↓ 100 N	↑ 200 N
B	↓ 100 N	↓ 100 N	↑ 210 N
C	↓ 100 N	↑ 100 N	↑ 10 N
D	↓ 10 N	↓ 100 N	↑ 120 N
E	↓ 100 N	↑ 100 N	↑ 100 N

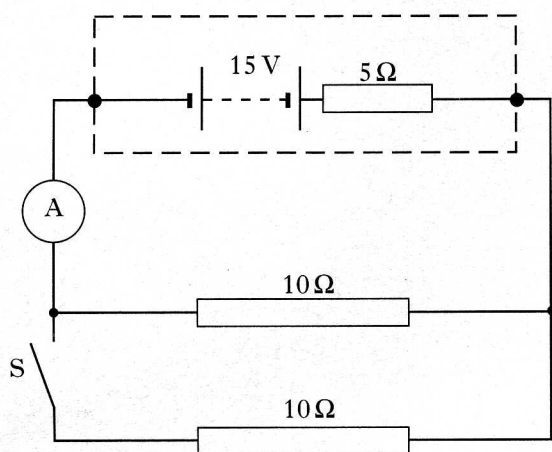
11. In the circuit below, each resistor has a resistance of 20Ω and the battery has negligible internal resistance.



The voltage across PQ is

- A 0.5 V
B 1.0 V
C 1.5 V
D 2.0 V
E 3.5 V.

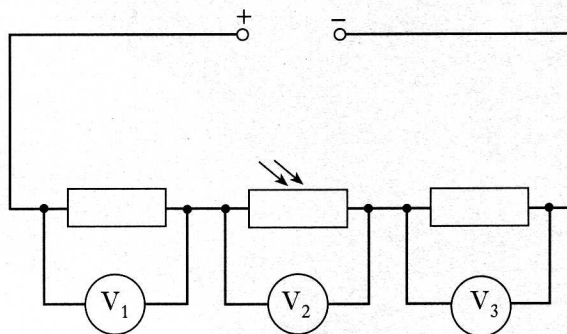
12. A battery, of e.m.f. 15 V and internal resistance $5\ \Omega$, is connected to two $10\ \Omega$ resistors as shown. Switch S is initially open.



When switch S is closed, the reading on the ammeter changes

- A from 1 A to 2 A
- B from 1.5 A to 3 A
- C from 1 A to 1.5 A
- D from 1.5 A to 0.75 A
- E from 1 A to 0.6 A .

13. A student sets up the following potential divider circuit which includes a light-dependent resistor (LDR).

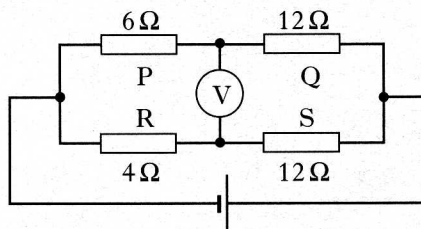


The resistance of the LDR decreases when the light intensity on it increases.

Which row in the table below correctly shows how the voltmeter readings are affected when the student switches off all the lights in the laboratory?

	Reading on voltmeter V_1	Reading on voltmeter V_2	Reading on voltmeter V_3
A	increases	increases	increases
B	decreases	decreases	decreases
C	increases	decreases	increases
D	decreases	increases	decreases
E	no change	increases	no change

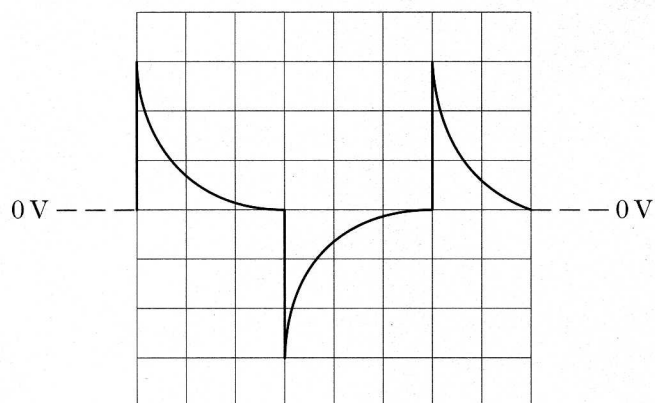
14. In the Wheatstone bridge shown below, there is a small reading on the voltmeter.



What should be done to balance the Wheatstone bridge?

- A Increase the value of resistor P by $6\ \Omega$.
- B Increase the value of resistor Q by $6\ \Omega$.
- C Increase the value of resistor R by $6\ \Omega$.
- D Increase the value of resistor S by $6\ \Omega$.
- E Insert a $6\ \Omega$ resistor in series with the voltmeter.

15. The output from an electrical device produces the following trace on an oscilloscope.



The time-base setting of the oscilloscope is 2 ms per division and the voltage-gain setting is 5 mV per division.

What is the frequency and maximum voltage of the output from this electrical device?

	<i>Frequency of the device/Hz</i>	<i>Maximum voltage output from the device/mV</i>
A	33	15
B	83	15
C	83	30
D	166	30
E	166	15

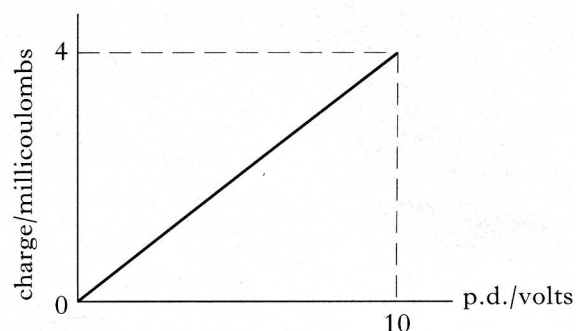
16. What is the relationship between the r.m.s. and peak values for an alternating current?

- A $I_{\text{r.m.s.}} = \frac{I_p}{\sqrt{2}}$
- B $I_{\text{r.m.s.}} = \sqrt{2} I_p$
- C $I_{\text{r.m.s.}} = 2 I_p^2$
- D $I_{\text{r.m.s.}} = \frac{\sqrt{I_p}}{2}$
- E $I_{\text{r.m.s.}} = \frac{I_p^2}{2}$

17. A 25 μF capacitor is charged until the potential difference across it is 500 V. The charge stored in the capacitor is

- A $5.00 \times 10^{-8} \text{ C}$
- B $2.00 \times 10^{-5} \text{ C}$
- C $1.25 \times 10^{-2} \text{ C}$
- D $1.25 \times 10^4 \text{ C}$
- E $2.00 \times 10^7 \text{ C}$

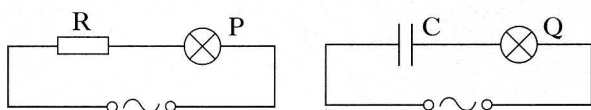
18. The graph shows how the charge stored on a capacitor varies as the p.d. applied across it is increased.



What is the energy stored in the capacitor when the p.d. across it is 10 V?

- A 0.4 mJ
- B 2.5 mJ
- C 10 mJ
- D 20 mJ
- E 40 mJ

19. In the circuits shown below, P and Q are identical lamps and the a.c. supplies have the same r.m.s. voltage output. The lamps glow with equal brightness.

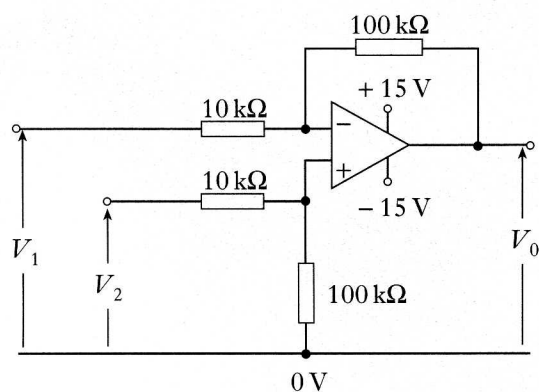


The frequency of each supply voltage is increased without altering the value of the r.m.s. voltage output.

Which row in the following table correctly describes how the brightness of each lamp is affected?

	Lamp P	Lamp Q
A	brighter	unchanged
B	unchanged	brighter
C	dimmer	unchanged
D	unchanged	dimmer
E	dimmer	brighter

20. The amplifier shown below is operating in the differential mode.



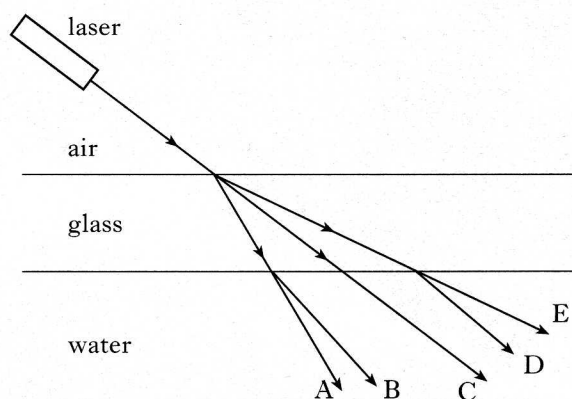
When $V_0 = 0.60 \text{ V}$ and $V_1 = 2.70 \text{ V}$, what is the value of V_2 ?

- A 2.10 V
- B 2.16 V
- C 2.76 V
- D 3.30 V
- E 3.36 V

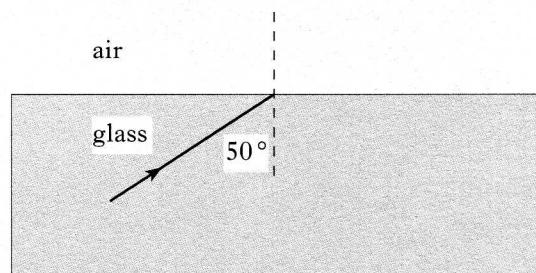
21. The diagram below shows a ray of light from a laser passing from air into glass and then into water.

The refractive index of glass is greater than that of water.

Which is the correct path for the light?

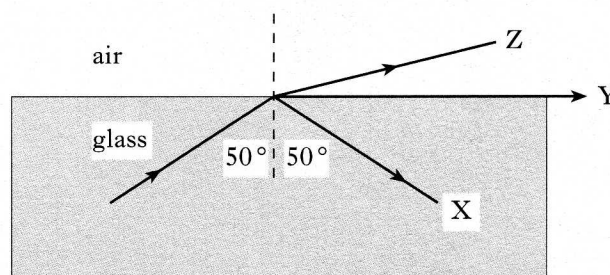


22. A ray of light travelling through glass approaches air, as shown below.



The refractive index of the glass is 1.5.

Which of the following paths will the ray follow?



- A X only
- B Y only
- C Z only
- D X and Z only
- E Y and Z only

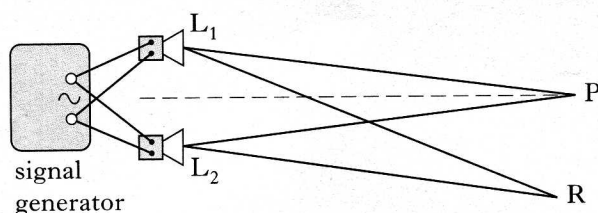
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23. Light travels from air into glass.

Which row in the following table correctly describes what happens to the speed, frequency and wavelength of the light?

	<i>Speed</i>	<i>Frequency</i>	<i>Wavelength</i>
A	increases	decreases	stays constant
B	decreases	stays constant	decreases
C	stays constant	decreases	decreases
D	increases	stays constant	increases
E	decreases	decreases	stays constant

24. Two identical loudspeakers, L_1 and L_2 , are operated at the same frequency and in phase with each other by connecting them in parallel across the output of a signal generator, as shown below. A sound interference pattern is produced.



At position P, which is the same distance from both loudspeakers, a microphone registers a maximum intensity of sound.

The next maximum is registered at position R, where $L_1R = 4.6 \text{ m}$ and $L_2R = 4.3 \text{ m}$.

If the speed of sound is 330 m s^{-1} , then the frequency of the sound emitted by the loudspeakers is given by

- A $\frac{(4.6 - 4.3)}{330} \text{ Hz}$
- B $\frac{330}{(4.6 + 4.3)} \text{ Hz}$
- C $\frac{330}{(4.6 - 4.3)} \text{ Hz}$
- D $330 \times (4.6 - 4.3) \text{ Hz}$
- E $330 \times (4.6 + 4.3) \text{ Hz}$.

25. The intensity of radiation emitted from a point source of light varies

- A directly as the distance from the source
- B directly as the square of the distance from the source
- C directly as the square root of the distance from the source
- D inversely as the distance from the source
- E inversely as the square of the distance from the source.

26. Certain materials can be “doped” to make a semiconductor called an n-type material.

In an n-type material,

- A the majority charge carriers are electrons
- B the majority charge carriers are neutrons
- C the majority charge carriers are protons
- D there are more electrons than protons
- E there are more electrons than neutrons.

27. The symbols for two isotopes of carbon, carbon 14 and carbon 12, are as follows.

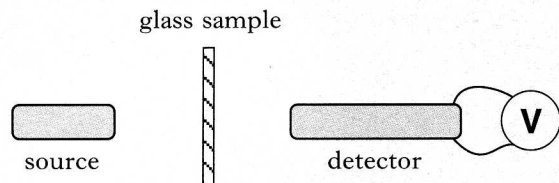


Which of the following statements is true?

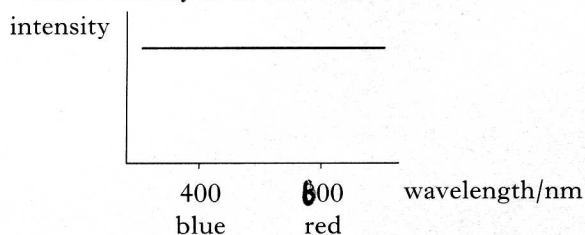
Carbon 14 and carbon 12 are said to be isotopes of carbon because

- A carbon 14 has the same mass number as carbon 12
- B carbon 14 has a different atomic number from carbon 12
- C carbon 14 is radioactive
- D carbon 14 has the same number of neutrons as carbon 12
- E carbon 14 and carbon 12 have different mass numbers but the same atomic number.

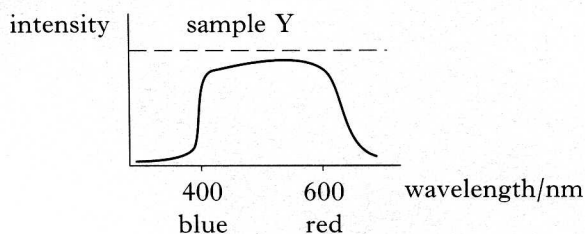
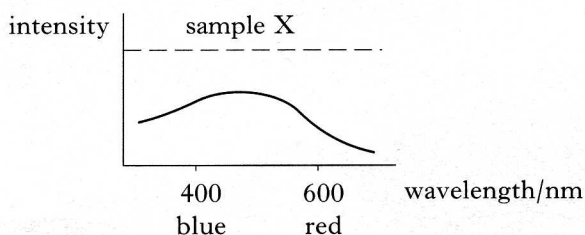
28. Two different types of tinted glass, X and Y, are used to make filters for sunglasses. A sample of each glass is placed in turn between a source and a detector, as shown in the following diagram. Both samples are identical in size and shape.



The source emits electromagnetic radiation with a wide range of wavelengths, all of the same intensity as shown below.



The following graphs show the intensities measured by the detector after the electromagnetic radiation passed through each of the glass samples.



Which of the following statement(s) is/are correct?

- I Sample X is better at absorbing red light than sample Y.
 - II Sample Y is better at protecting the eye from ultraviolet radiation.
 - III The view would appear darker when seen through sample Y than when seen through sample X.
- A I only
 B I and II only
 C I and III only
 D II and III only
 E I, II and III

29. There are a number of equations involving the following quantities.

A , the activity of a radioactive source
 D , the absorbed dose
 H , the dose equivalent
 \dot{H} , the dose equivalent rate
 Q , the quality factor
 N , the number of nuclei decaying
 t , the time

Which row of the following table states **three** of these equations correctly?

A	$A = \frac{N}{t}$	$H = DQ$	$\dot{H} = Ht$
B	$A = Nt$	$H = DQ$	$\dot{H} = \frac{H}{t}$
C	$A = \frac{N}{t}$	$H = \frac{D}{Q}$	$\dot{H} = Ht$
D	$A = Nt$	$H = \frac{D}{Q}$	$\dot{H} = \frac{H}{t}$
E	$A = \frac{N}{t}$	$H = DQ$	$\dot{H} = \frac{H}{t}$

30. The three statements below refer to the fission process.

- I Fission may be spontaneous.
- II Fission can be produced when neutrons bombard a nucleus, which has a large mass number.
- III When fission occurs, a nucleus with a large mass number may split into nuclei with smaller mass numbers, along with several neutrons.

Which statement(s) is/are true?

- A III only
 B I and II only
 C I and III only
 D II and III only
 E I, II and III

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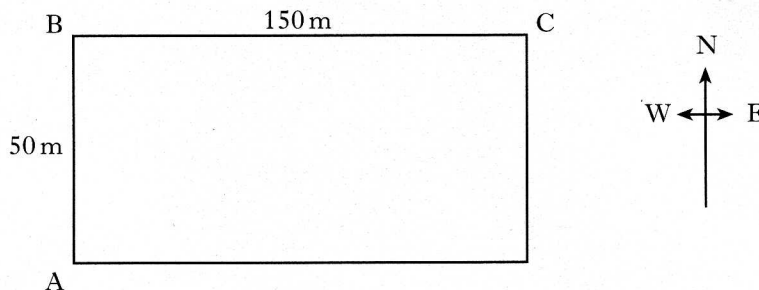
SECTION B

Write your answers to questions 31 to 37 in the answer book.

Marks

31. A spectator at A walks to C, the opposite corner of a playing field, by walking from A to B and then from B to C as shown in the diagram below.

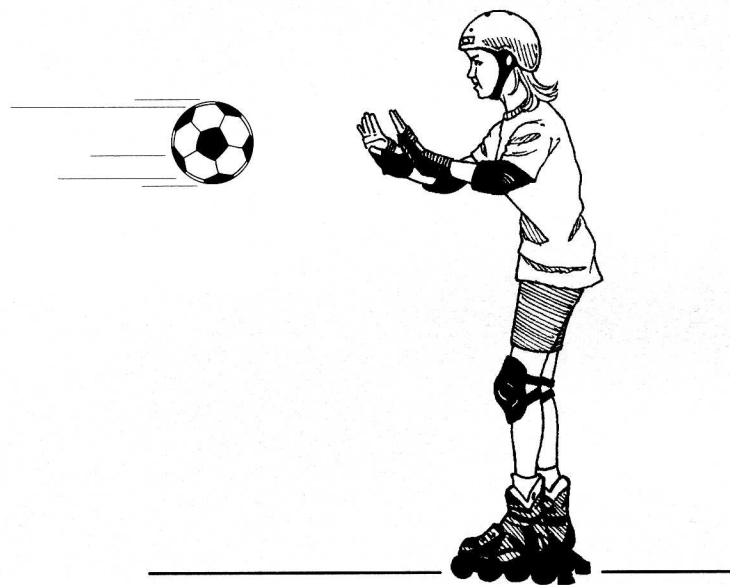
The distance from A to B is 50 m. The distance from B to C is 150 m.



By scale drawing or otherwise, find the resultant displacement. Magnitude and direction are required.

2

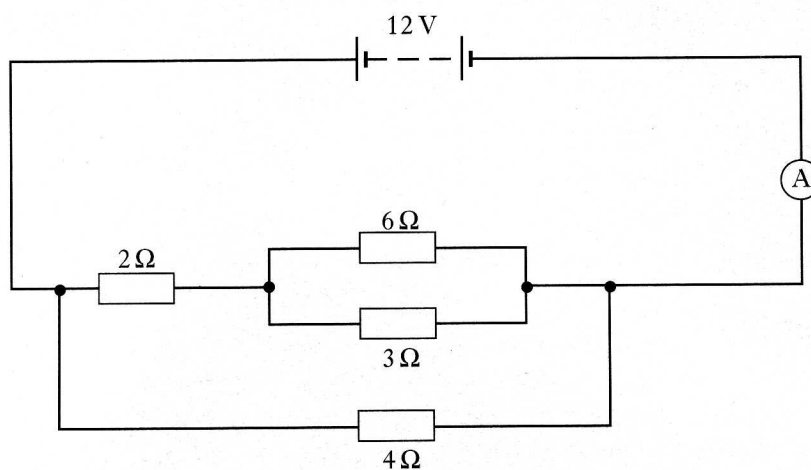
32. A football of mass 0.42 kg is thrown at a stationary student of mass 50.0 kg who is wearing roller blades, as shown in the diagram below. When the student catches the moving ball she moves to the right.



The instantaneous speed immediately after she catches the ball is 0.10 m s^{-1} . Calculate the speed of the ball just before it is caught.

2

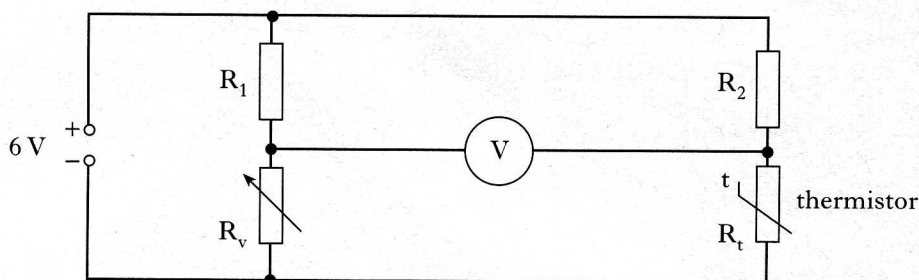
33. Calculate the size of the current in the ammeter in the circuit below. The battery has negligible internal resistance.



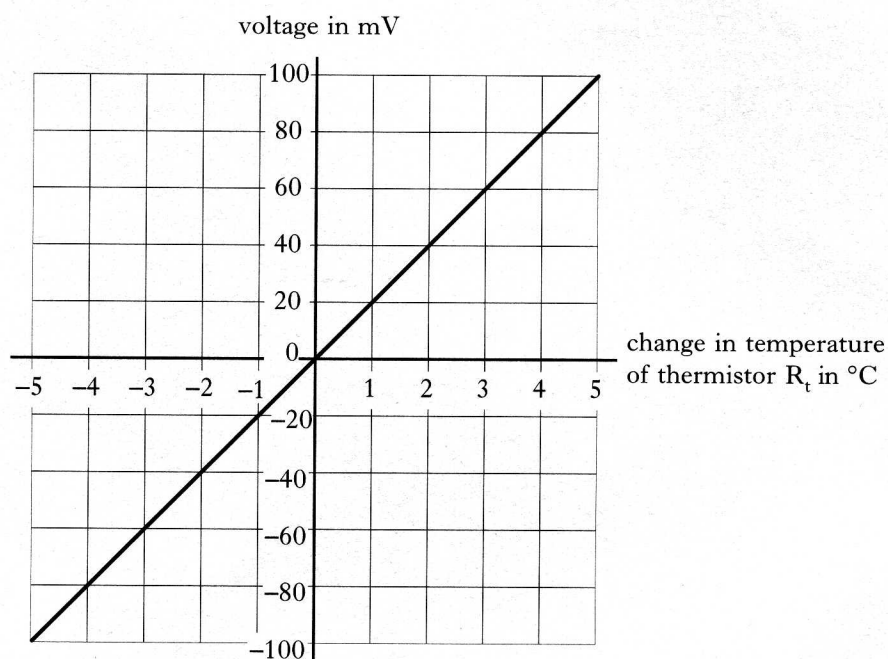
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34. The Wheatstone bridge shown below is balanced.



- (a) R_1 has a resistance of $3.3 \text{ k}\Omega$, R_2 has a resistance of $2.2 \text{ k}\Omega$ and the variable resistor R_v is set at 225Ω . Calculate the resistance of the thermistor R_t .
- (b) The graph below shows what happens to the reading on the voltmeter as the temperature of thermistor R_t is changed.



The bridge was initially balanced at 20°C .

The temperature of R_t is increased until the reading on the voltmeter is 80 mV. What is the new temperature of the thermistor R_t ?

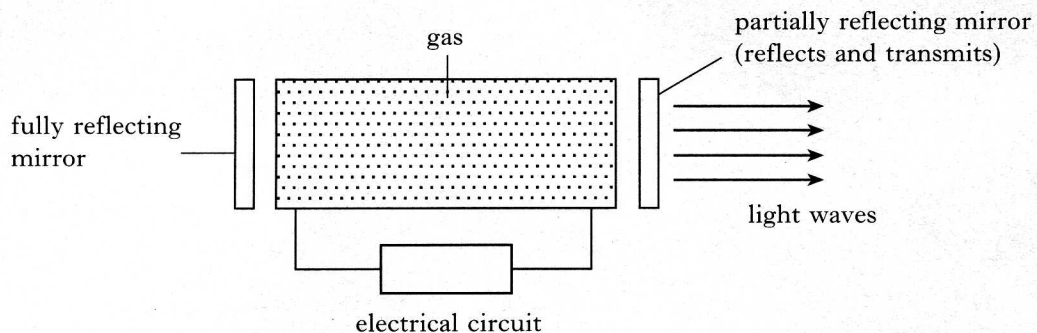
3

35. The minimum energy required to cause an electron to be emitted from a clean zinc surface is $6.9 \times 10^{-19} \text{ J}$.

- (a) Calculate the maximum wavelength of electromagnetic radiation which will cause an electron to be emitted from the clean zinc surface.
- (b) What would be the effect of irradiating a clean zinc surface with radiation of wavelength $4.0 \times 10^{-7} \text{ m}$? You must justify your answer.

4

36. The diagram shows a simplified view of a gas laser.



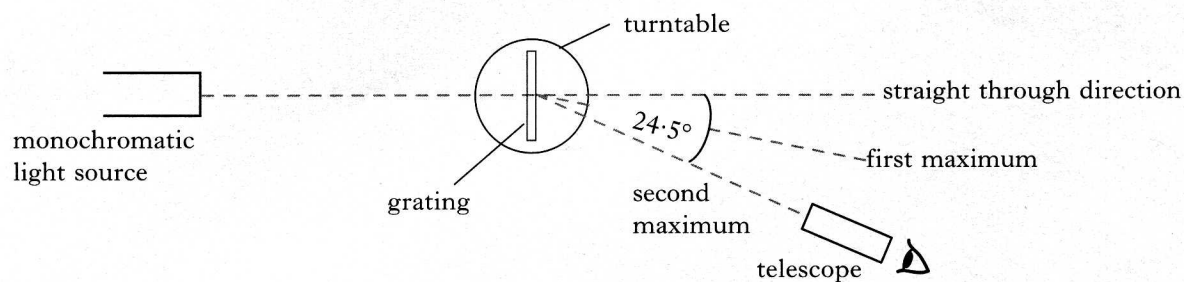
Laser stands for Light Amplification by Stimulated Emission of Radiation.

(a) Explain what is meant by *stimulated emission of radiation*.

(b) State **two** ways in which the incident radiation and the radiation it stimulates are similar.

3

37. A grating with 300 lines/mm is used with a spectrometer and a source of monochromatic light to view an interference pattern as shown below.



The second maximum of interference is observed when the telescope is at an angle of 24.5° . Calculate the wavelength of the light.

3

[END OF QUESTION PAPER]