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PIER 1A

HONG KONG EXAMINATIONS AND ASSESSMENT AUTHORITY
HONG KONG DIPLOMA OF SECONDARY EDUCATION EXAMINATION 2020

PHYSICS PAPER 1

8:30 am – 11:00 am (2½ hours)
This paper must be answered in English

GENERAL INSTRUCTIONS

(1) There are **TWO** sections, A and B, in this Paper. You are advised to finish Section A in about 50 minutes.

(2) Section A consists of multiple-choice questions in this question paper, while Section B contains conventional questions printed separately in Question-Answer Book **B**.

(3) Answers to Section A should be marked on the Multiple-choice Answer Sheet while answers to Section B should be written in the spaces provided in the Question-Answer Book. **The Answer Sheet for Section A and the Question-Answer Book for Section B will be collected separately at the end of the examination.**

(4) The diagrams in this paper are **NOT** necessarily drawn to scale.

(5) The last two pages of this question paper contain a list of data, formulae and relationships which you may find useful.

INSTRUCTIONS FOR SECTION A (MULTIPLE-CHOICE QUESTIONS)

(1) Read carefully the instructions on the Answer Sheet. After the announcement of the start of the examination, you should first stick a barcode label and insert the information required in the spaces provided. No extra time will be given for sticking on the barcode label after the 'Time is up' announcement.

(2) When told to open this book, you should check that all the questions are there. Look for the words **'END OF SECTION A'** after the last question.

(3) All questions carry equal marks.

(4) **ANSWER ALL QUESTIONS.** You are advised to use an HB pencil to mark all the answers on the Answer Sheet, so that wrong marks can be completely erased with a rubber. You must mark the answers clearly; otherwise you will lose marks if the answers cannot be captured.

(5) You should mark only **ONE** answer for each question. If you mark more than one answer, you will receive **NO MARKS** for that question.

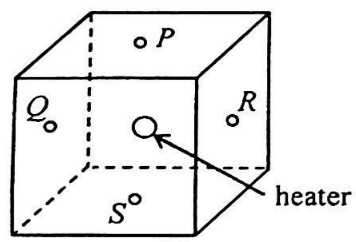
(6) No marks will be deducted for wrong answers.

Not to be taken away before the end of the examination session

Section A

There are 33 questions. Questions marked with * involve knowledge of the extension component.

1. A heater is installed at the centre of a fully filled cubic water tank. Temperature sensors P, Q, R and S are fixed at the respective centres of the top, left, right and bottom surfaces of the tank.



After the heater is switched on for a **short duration**, which pair of sensors below would indicate the largest temperature difference ?

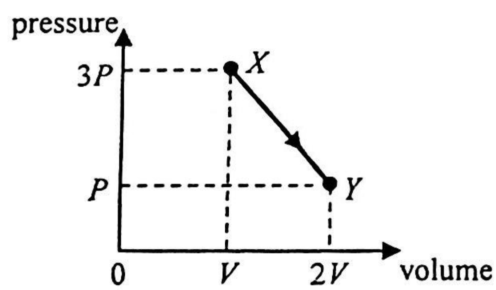
A. Q and R
B. R and S
C. Q and S
D. P and R

2. An electric kettle which contains 1 kg of water at room temperature takes 168 s to heat up the water to boiling point. The kettle's rated value is '220 V, 2000 W'. Assume that all the electrical energy consumed by the kettle is transferred to the water. Which of the following statements is/are correct ?
Given: specific heat capacity of water = 4200 J kg^{-1} °C^{-1}

(1) The initial temperature of the water is 20 °C.
(2) The resistance of the kettle's heating element is about 24 Ω.
(3) If the electric kettle is operated with 110 V, the time taken to heat up the water to boiling point will be doubled.

A. (1) only
B. (3) only
C. (1) and (2) only
D. (1), (2) and (3)

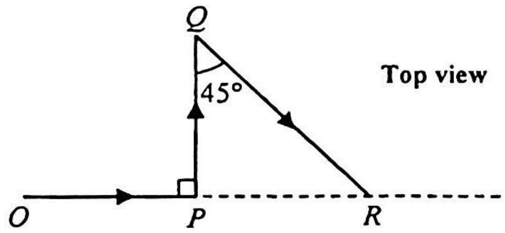
*3. A fixed mass of an ideal gas expands from state X to state Y through a process as represented in the pressure-volume graph below.



If the temperature of the gas at state Y is 25 °C, what is its temperature at state X ?

A. −74.3 °C
B. 16.7 °C
C. 37.5 °C
D. 174 °C

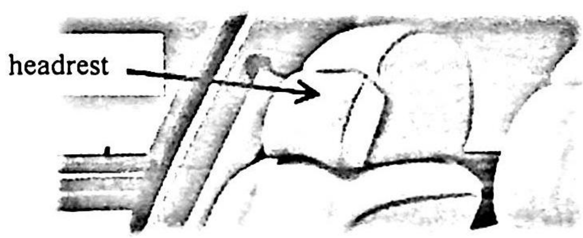
4.



A car takes 8 minutes to travel along a path *OPQR* on a horizontal surface as shown. Given that *OP* = *PQ* = 2 km, find the magnitude of the average velocity of the car in this journey.

A. 30 km h^{-1}
B. 36 km h^{-1}
C. 41 km h^{-1}
D. 51 km h^{-1}

5.

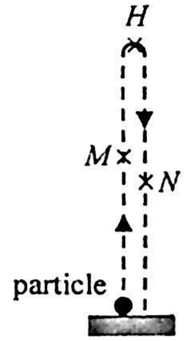


For a car travelling on a highway, which of the following statements about the safety design of the headrest is/are correct ?

(1) As the headrest is soft, it can reduce the force exerted on the passenger's head during impact.
(2) It can minimise injury of the passenger when the car is struck by another one from behind.
(3) It can minimise injury of the passenger when the car brakes suddenly.

A. (1) only
B. (3) only
C. (1) and (2) only
D. (2) and (3) only

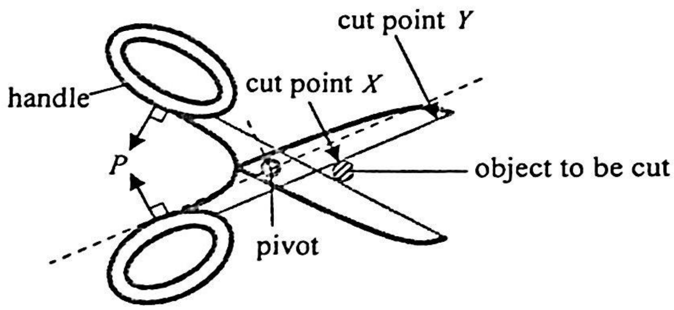
6. A particle is thrown vertically upward and its path is shown below. *H* is the highest point that the particle reached. Which of the following statements about the particle is/are correct ? Neglect air resistance.



(1) Its acceleration at *M* is upward.
(2) Its acceleration at *H* is zero.
(3) Its acceleration at *N* is downward.

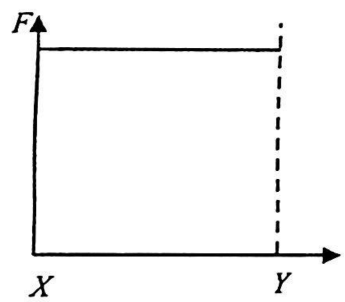
A. (1) only
B. (3) only
C. (2) and (3) only
D. (1), (2) and (3)

7. The figure shows that a pair of forces P of constant magnitude is applied at right angles to the handles of a pair of scissors in order to cut an object.

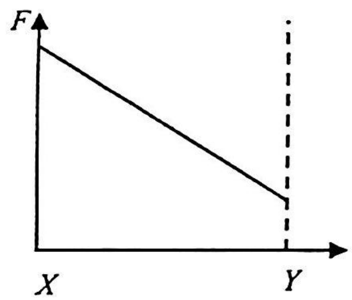


Which graph below best shows the variation of force F produced at cut point from X to Y when the pair of scissors is closed ?

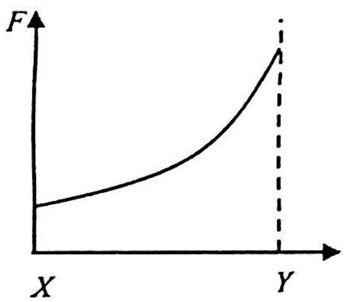
A.



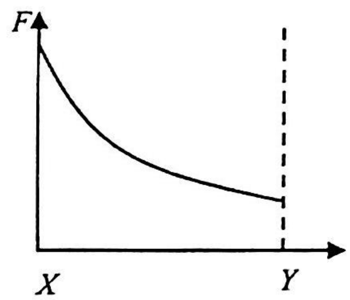
B.



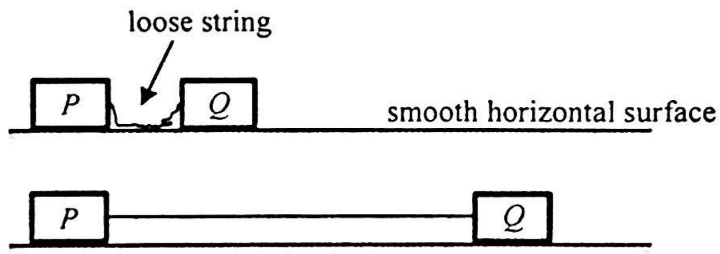
C.



D.



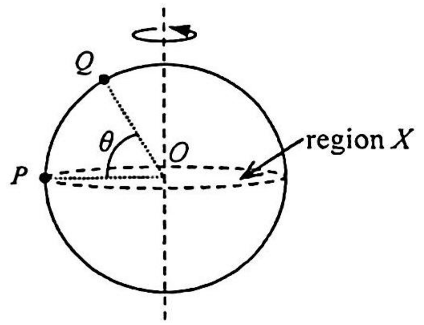
8. On a smooth horizontal surface, two identical blocks P and Q are connected by a light inextensible string. The blocks are at rest and the string is loose initially.



Q is given a speed of 4 m s^{-1} and moves to the right. Find the speeds of the blocks when the string just becomes taut and P starts to move.

	block P	block Q
A.	1 m s^{-1}	1 m s^{-1}
B.	2 m s^{-1}	1 m s^{-1}
C.	2 m s^{-1}	2 m s^{-1}
D.	4 m s^{-1}	2 m s^{-1}

*9. Particles P and Q are fixed on the surface of a sphere rotating about a vertical axis passing through the centre O of the sphere as shown. The horizontal shaded region X divides the sphere into two halves. P is at the edge of region X while Q is at an angle of elevation θ above region X.



Find the ratio of the centripetal acceleration of P to that of Q.

A. $1 : \cos\theta$
B. $1 : \sin\theta$
C. $\cos\theta : 1$
D. $\sin\theta : 1$

*10. The diameter of Neptune is about 4 times that of the Earth and its mass is about 17 times that of the Earth. Estimate the acceleration due to gravity on Neptune's surface.
Given: acceleration due to gravity on Earth's surface $g = 9.81\ \text{m s}^{-2}$

A. $2.3\ \text{m s}^{-2}$
B. $9.2\ \text{m s}^{-2}$
C. $10.4\ \text{m s}^{-2}$
D. $41.7\ \text{m s}^{-2}$

11.

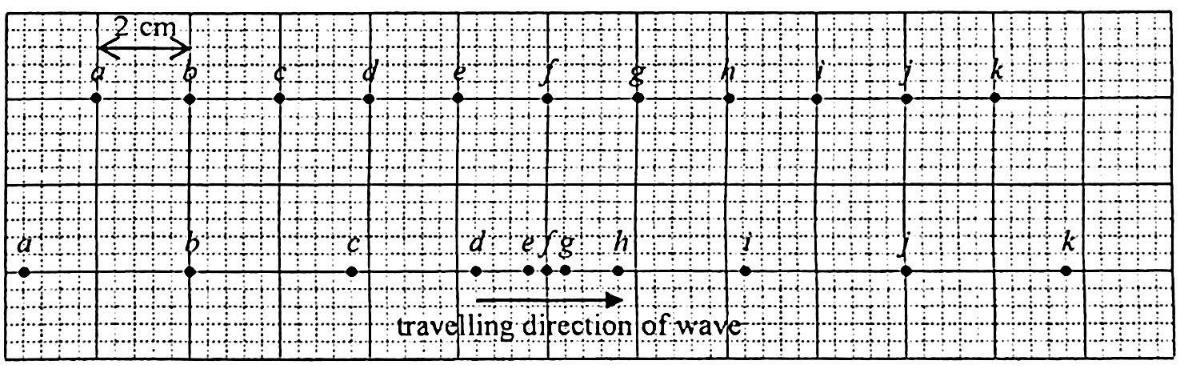
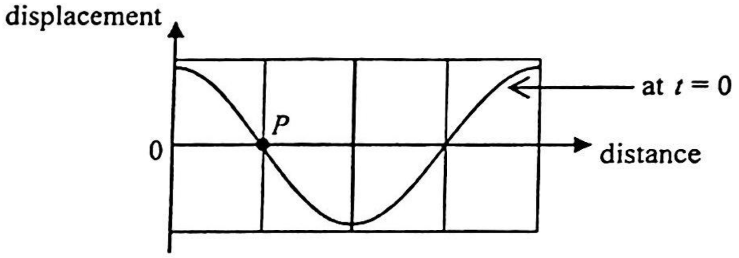


Figure (1) shows the equilibrium positions of particles a to k in a medium. The particles are separated by 2 cm from each other. A longitudinal wave of frequency 5 Hz is travelling from left to right. At a certain instant, the positions of the particles are shown in Figure (2). Determine the amplitude and speed of the wave.

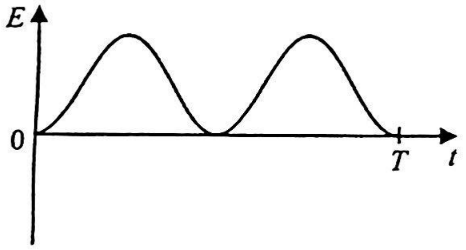
	amplitude	speed
A.	3.6 cm	$40\ \text{cm s}^{-1}$
B.	3.6 cm	$80\ \text{cm s}^{-1}$
C.	2.4 cm	$40\ \text{cm s}^{-1}$
D.	2.4 cm	$80\ \text{cm s}^{-1}$

12. The figure shows part of the displacement-distance graph of a travelling wave of period T at time $t = 0$. P is a particle on the wave.

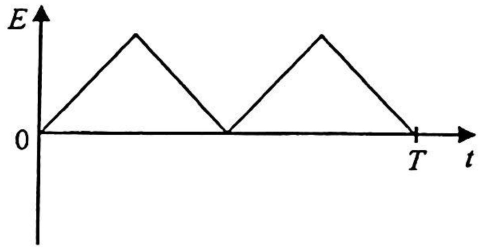


Which graph below correctly shows the variation of the particle's kinetic energy E within a period starting from $t = 0$?

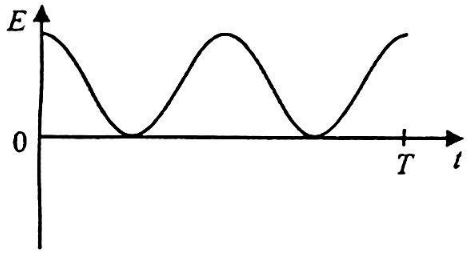
A.



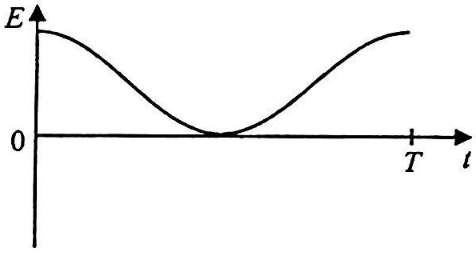
B.



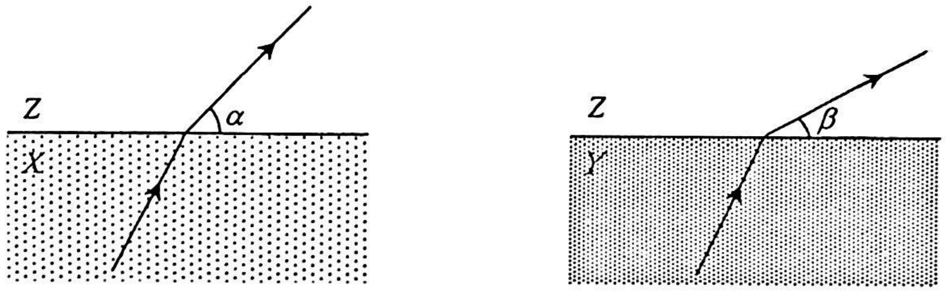
C.



D.



13. Monochromatic light travels with the same incident angle from media X and Y respectively to another medium Z as shown.



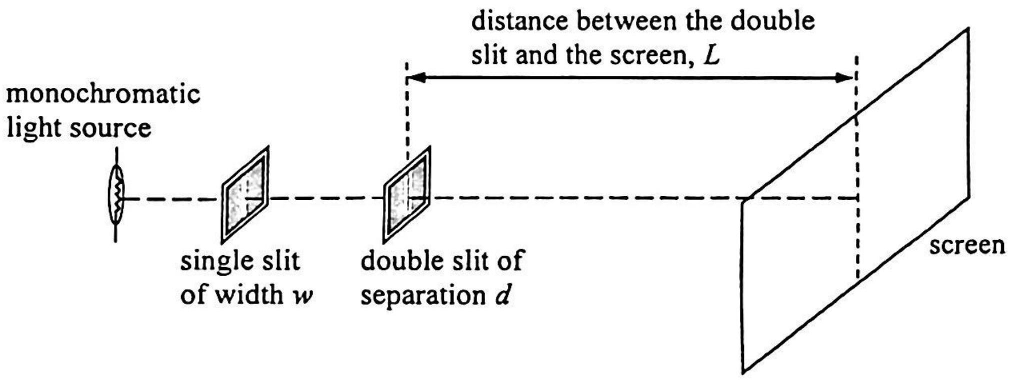
The corresponding refracted rays in Z make angles α and β respectively with the boundary plane (with $\alpha > \beta$). Which medium, X or Y, has a greater refractive index ? In which medium, X or Y, does light travel faster ?

	medium with a greater refractive index	medium in which light travels faster
A.	X	X
B.	X	Y
C.	Y	X
D.	Y	Y

*14. A light beam consisting of wavelengths λ_1 and λ_2 is incident normally on a diffraction grating. The third-order diffraction of wavelength λ_1 coincides with the fourth-order diffraction of wavelength λ_2 in the resulting pattern. If λ_1 is 680 nm, find λ_2.

A. 510 nm
B. 680 nm
C. 907 nm
D. It cannot be determined because the grating spacing is unknown.

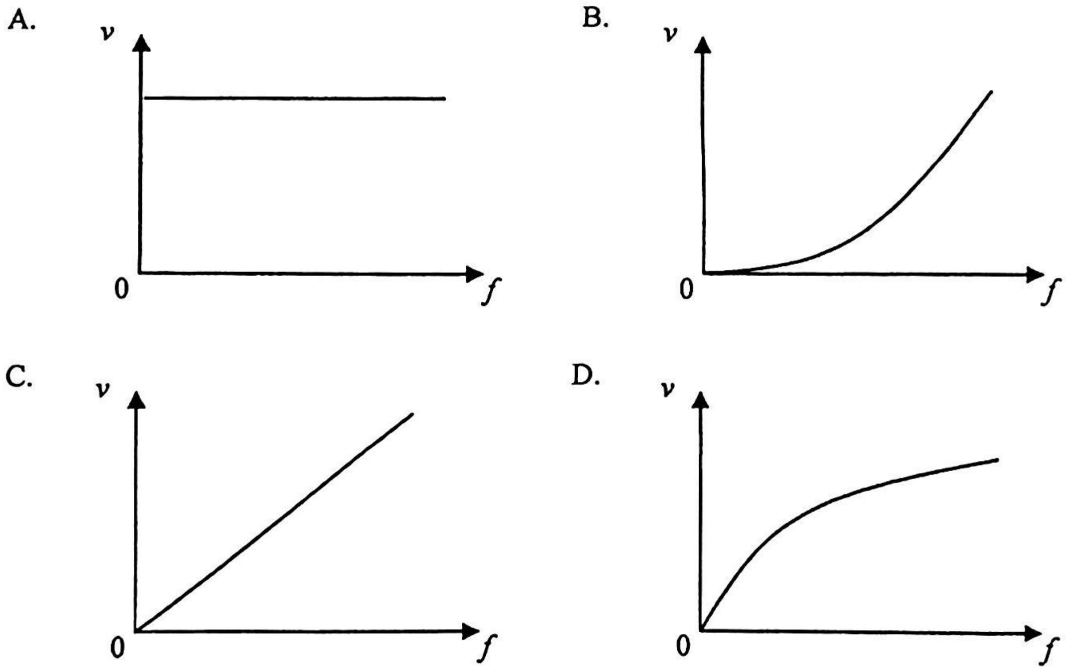
15. The figure shows a typical set-up of Young's double slit experiment.



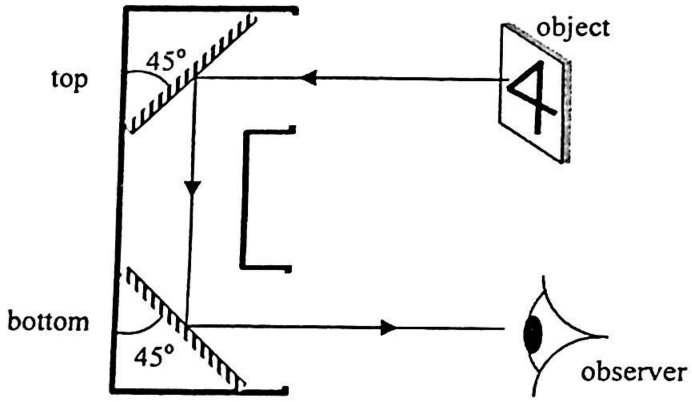
Which combination below is the best setting for displaying an observable fringe pattern on the screen ?

	w	d	L
A.	0.1 mm	1 mm	10 m
B.	0.1 mm	1 mm	1 m
C.	1 mm	0.1 mm	1 m
D.	1 mm	0.1 mm	0.1 m

16. A transverse wave propagates along a stretched string. Which graph below correctly shows the variation of the speed v of the wave with its frequency f?

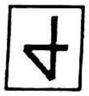


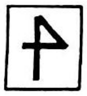
17. The figure shows a periscope designed by a student. An object is observed via the periscope.

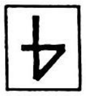


Which image will the observer see ?

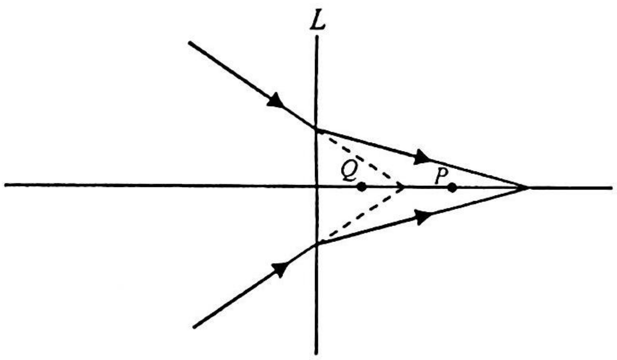
A. 

B. 

C. 

D. 

18.



Referring to the above ray diagram, what kind of lens is represented by L ? Which point, P or Q, can be its focus ?

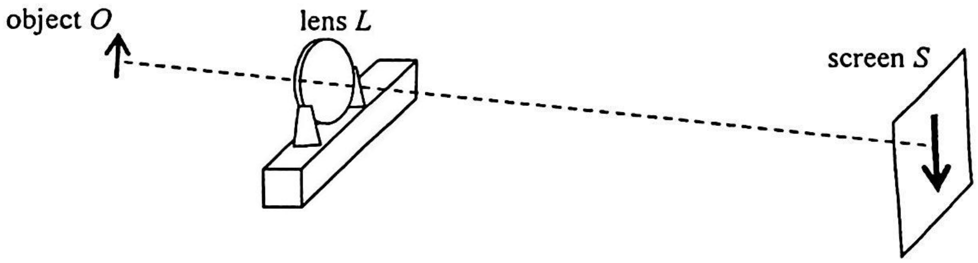
	lens L	focus
A.	concave	P
B.	convex	P
C.	concave	Q
D.	convex	Q

19. Which of the following phenomena provides conclusive evidence that sound is a wave ?

(1) reflection of sound from a wall
(2) refraction of sound at the boundary between two media
(3) interference of sound

A. (2) only
B. (3) only
C. (1) and (2) only
D. (1) and (3) only

20. The figure shows an enlarged sharp image of an object *O* formed on a screen *S* by a convex lens *L*.



Which of the following can give a diminished sharp image on the screen ?

(1) Keeping the positions of *O* and *L* unchanged, move *S* suitably closer to *L*.
(2) Keeping the positions of *L* and *S* unchanged, move *O* suitably farther away from *L*.
(3) Keeping the positions of *O* and *S* unchanged, move *L* suitably closer to *S*.

A. (1) only
B. (3) only
C. (1) and (2) only
D. (2) and (3) only

21. Which of the following statements about ultrasound is/are correct ?

(1) Ultrasound has a shorter wavelength than audible sound.
(2) Ultrasound cannot be produced by vibrating objects.
(3) Ultrasound cannot be heard as it cannot travel through air.

A. (1) only
B. (3) only
C. (1) and (2) only
D. (2) and (3) only

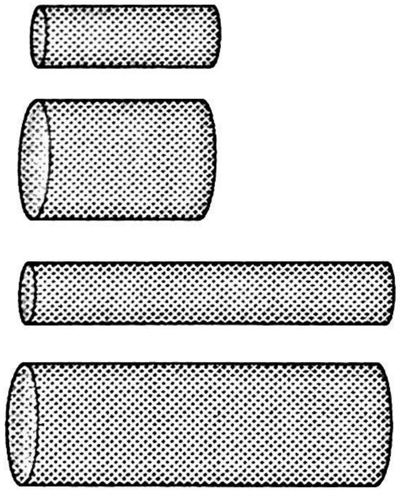
22. The cylindrical resistors below are made from the same metal. Which one would produce the most power when the same voltage is applied in turns across the two ends of each resistor ?

A.

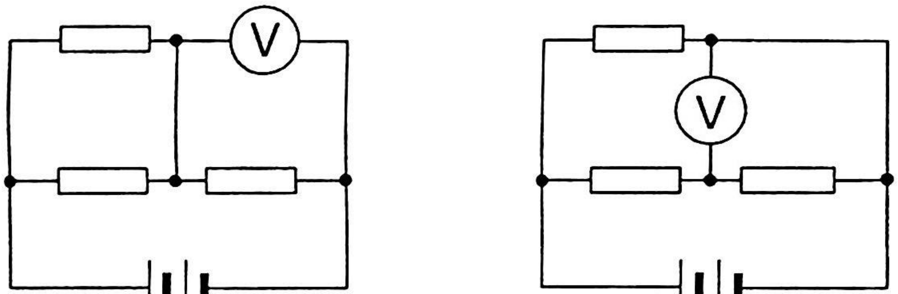
B.

C.

D.



23. Three identical resistors, a battery of negligible internal resistance and an ideal voltmeter are connected to form Circuits (a) and (b) respectively.

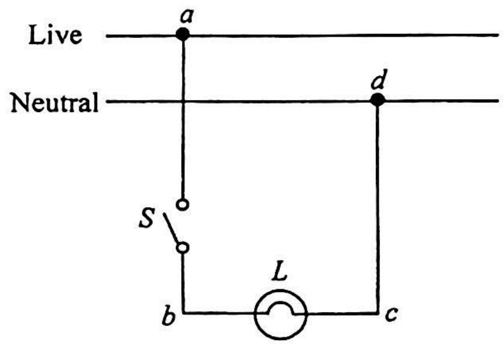


Circuit (a) Circuit (b)

Given that the voltmeter reading is 8 V in Circuit (a), what is the voltmeter reading in Circuit (b) ?

A. 4 V
B. 6 V
C. 8 V
D. 12 V

24. The figure shows part of a domestic lighting circuit in which the bulb L does not light up when switch S is closed.



The circuit is then checked with switch S closed. Using a voltage tester to touch points b and c in turns, the tester indicates that both points are at high voltage. When touching points a and d in turns, the tester indicates only point a is at high voltage. Which of the following can be a reason for the fault ?

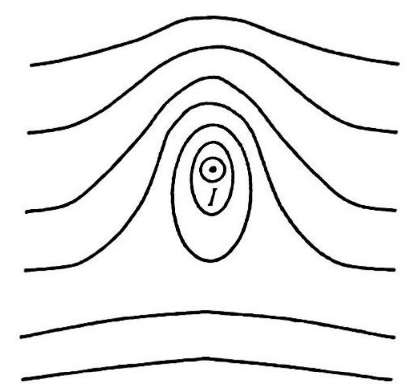
A. The switch S has been damaged.
B. The filament of bulb L has been burnt out and becomes an open circuit.
C. There is a short circuit between a and d.
D. There is an open circuit between c and d.

25.

The battery shown has a capacity of 1100 mA h. How much energy is delivered when the battery operates normally at a current of 250 mA for one hour ? Assume that the battery's operating voltage remains at 3.7 V during that period.

A. $(3.7 \times \frac{250}{1000} \times 3600)$ J
B. $(3.7 \times \frac{1100}{1000} \times 3600)$ J
C. $(3.7 \times \frac{250}{1000} \times 1)$ J
D. $(3.7 \times \frac{1100}{1000} \times 1)$ J

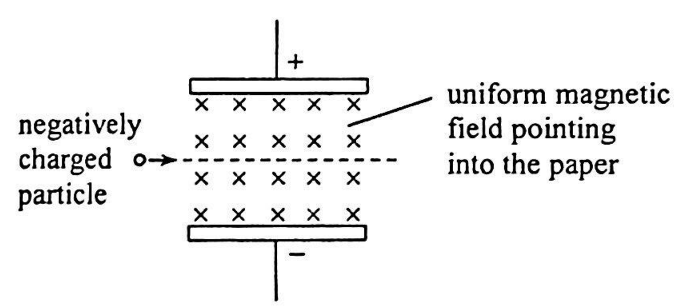
26. The figure below shows the magnetic field pattern on a horizontal surface around a long vertical straight wire carrying a steady current I pointing out of the paper. The Earth's magnetic field is **NOT** neglected.



What are the directions of the following ?

	the horizontal component of the Earth's magnetic field	**the magnetic force experienced by the current-carrying wire**
A.	←	↓
B.	←	↑
C.	→	↓
D.	→	↑

*27.

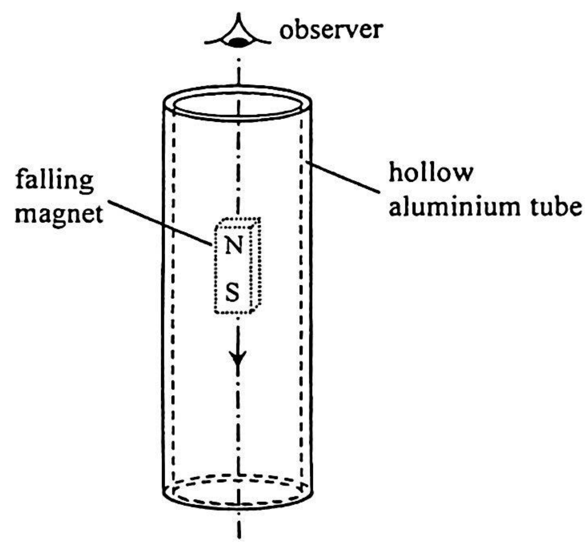


A negatively charged particle goes undeflected through a region in which a uniform electric field and a uniform magnetic field are set up as shown. The electric field is set up by the potential difference across the two parallel metal plates. Which of the following changes may cause the charged particle to deflect downward ? Neglect the effects of gravity.

(1) increasing the potential difference across the plates
(2) increasing the magnitude of the charge on the particle
(3) increasing the particle's speed entering the region

A. (1) only
B. (3) only
C. (1) and (2) only
D. (2) and (3) only

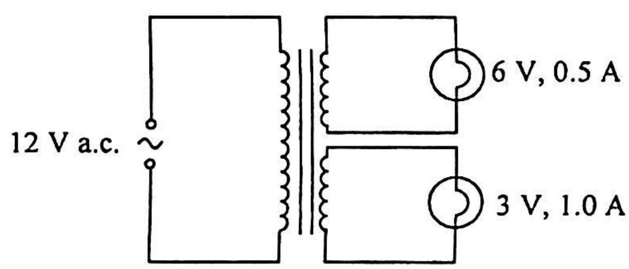
28.



When a small strong magnet falls through a hollow aluminium tube as shown, eddy currents are induced. Which of the following correctly describes the direction of current induced in the tube when viewed by an observer from above ?

A. clockwise both above and below the magnet
B. anti-clockwise both above and below the magnet
C. clockwise above the magnet and anti-clockwise below the magnet
D. anti-clockwise above the magnet and clockwise below the magnet

*29.



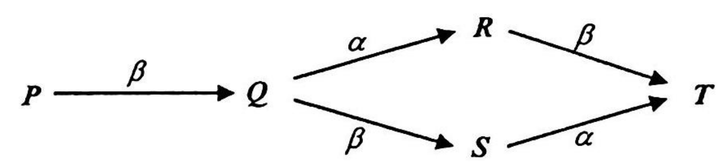
The figure shows an ideal transformer with two secondary coils connected to two light bulbs marked '6 V, 0.5 A' and '3 V, 1.0 A' respectively. When a 12 V a.c. supply is connected to the primary coil, the bulbs work at their respective rated values. Estimate the current in the primary coil.

A. 0.25 A
B. 0.50 A
C. 0.75 A
D. 1.0 A

30. The background count rate in an experiment is determined using a GM counter. Four readings of the count rate in each minute are taken. Which set of readings below is the most probable ?

	1st minute	2nd minute	3rd minute	4th minute
A.	5	62	8	69
B.	40	40	40	40
C.	60	50	30	20
D.	29	26	31	35

31.



Nuclide P can decay into nuclide T through either process $P - Q - R - T$ or process $P - Q - S - T$ as shown. Which deductions below are correct ?

(1) P and T are isotopes of the same element.
(2) Q and S have the same number of protons.
(3) S has one more neutron than R.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

*32. The decay constant of a radioisotope of an element

A. is random.
B. depends on pressure and temperature.
C. is directly proportional to the number of nucleons in the isotope.
D. is an identifying characteristic of that isotope.

33. Two radioactive samples P and Q are freshly prepared. It is found that when $\frac{15}{16}$ of all the nuclei of P have decayed, $\frac{63}{64}$ of all the nuclei of Q have also decayed. Find the ratio $\frac{\text{half-life of } P}{\text{half-life of } Q}$.

A. 1 : 4
B. 2 : 3
C. 3 : 2
D. 4 : 1

END OF SECTION A

List of data, formulae and relationships

Data

molar gas constant	$R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}$	
Avogadro constant	$N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$	
acceleration due to gravity	$g = 9.81 \text{ m s}^{-2}$ (close to the Earth)	
universal gravitational constant	$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$	
speed of light in vacuum	$c = 3.00 \times 10^8 \text{ m s}^{-1}$	
charge of electron	$q_e = 1.60 \times 10^{-19} \text{ C}$	
electron rest mass	$m_e = 9.11 \times 10^{-31} \text{ kg}$	
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2}$	
permeability of free space	$\mu_0 = 4\pi \times 10^{-7} \text{ H m}^{-1}$	
atomic mass unit	$\text{u} = 1.661 \times 10^{-27} \text{ kg}$	(1 u is equivalent to 931 MeV)
astronomical unit	$\text{AU} = 1.50 \times 10^{11} \text{ m}$	
light year	$\text{ly} = 9.46 \times 10^{15} \text{ m}$	
parsec	$\text{pc} = 3.09 \times 10^{16} \text{ m} = 3.26 \text{ ly} = 206265 \text{ AU}$	
Stefan constant	$\sigma = 5.67 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$	
Planck constant	$h = 6.63 \times 10^{-34} \text{ J s}$	

Rectilinear motion

For uniformly accelerated motion :

$$v = u + at$$
$$s = ut + \frac{1}{2}at^2$$
$$v^2 = u^2 + 2as$$

Mathematics

Equation of a straight line	$y = mx + c$
Arc length	$= r\theta$
Surface area of cylinder	$= 2\pi rh + 2\pi r^2$
Volume of cylinder	$= \pi r^2 h$
Surface area of sphere	$= 4\pi r^2$
Volume of sphere	$= \frac{4}{3}\pi r^3$

For small angles, $\sin\theta \approx \tan\theta \approx \theta$ (in radians)

Astronomy and Space Science

$U = -\frac{GMm}{r}$	gravitational potential energy
$P = \sigma AT^4$	Stefan's law
$\left\lvert\frac{\Delta f}{f_0}\right\rvert \approx \frac{v}{c} \approx \left\lvert\frac{\Delta\lambda}{\lambda_0}\right\rvert$	Doppler effect

Energy and Use of Energy

$E = \frac{\Phi}{A}$	illuminance
$\frac{Q}{t} = \kappa\frac{A(T_H - T_C)}{d}$	rate of energy transfer by conduction
$U = \frac{\kappa}{d}$	thermal transmittance U-value
$P = \frac{1}{2}\rho A v^3$	maximum power by wind turbine

Atomic World

$\frac{1}{2} m_e v_{max}^2 = hf - \phi$	Einstein's photoelectric equation
$E_n = -\frac{1}{n^2}\left\{\frac{m_e q_e^4}{8h^2\varepsilon_0^2}\right\} = -\frac{13.6}{n^2} \text{ eV}$	energy level equation for hydrogen atom
$\lambda = \frac{h}{p} = \frac{h}{mv}$	de Broglie formula
$\theta \approx \frac{1.22\lambda}{d}$	Rayleigh criterion (resolving power)

Medical Physics

$\theta \approx \frac{1.22\lambda}{d}$	Rayleigh criterion (resolving power)
$\text{power} = \frac{1}{f}$	power of a lens
$L = 10 \log\frac{I}{I_0}$	intensity level (dB)
$Z = \rho c$	acoustic impedance
$\alpha = \frac{I_r}{I_0} = \frac{(Z_2 - Z_1)^2}{(Z_2 + Z_1)^2}$	intensity reflection coefficient
$I = I_0 e^{-\mu x}$	transmitted intensity through a medium

A1.	$E = mc\,\Delta T$	energy transfer during heating and cooling	D1.	$F = \dfrac{Q_1 Q_2}{4\pi\varepsilon_0 r^2}$	Coulomb's law
A2.	$E = l\,\Delta m$	energy transfer during change of state	D2.	$E = \dfrac{Q}{4\pi\varepsilon_0 r^2}$	electric field strength due to a point charge
A3.	$pV = nRT$	equation of state for an ideal gas	D3.	$E = \dfrac{V}{d}$	electric field between parallel plates (numerically)
A4.	$pV = \dfrac{1}{3}Nm\overline{c^2}$	kinetic theory equation	D4.	$R = \dfrac{\rho l}{A}$	resistance and resistivity
A5.	$E_K = \dfrac{3RT}{2N_A}$	molecular kinetic energy	D5.	$R = R_1 + R_2$	resistors in series
			D6.	$\dfrac{1}{R} = \dfrac{1}{R_1} + \dfrac{1}{R_2}$	resistors in parallel
B1.	$F = m\dfrac{\Delta v}{\Delta t} = \dfrac{\Delta p}{\Delta t}$	force	D7.	$P = IV = I^2 R$	power in a circuit
B2.	moment = $F \times d$	moment of a force	D8.	$F = BQv\sin\theta$	force on a moving charge in a magnetic field
B3.	$E_P = mgh$	gravitational potential energy	D9.	$F = BIl\sin\theta$	force on a current-carrying conductor in a magnetic field
B4.	$E_K = \dfrac{1}{2}mv^2$	kinetic energy	D10.	$B = \dfrac{\mu_0 I}{2\pi r}$	magnetic field due to a long straight wire
B5.	$P = Fv$	mechanical power	D11.	$B = \dfrac{\mu_0 NI}{l}$	magnetic field inside a long solenoid
B6.	$a = \dfrac{v^2}{r} = \omega^2 r$	centripetal acceleration	D12.	$\varepsilon = N\dfrac{\Delta\Phi}{\Delta t}$	induced e.m.f.
B7.	$F = \dfrac{Gm_1 m_2}{r^2}$	Newton's law of gravitation	D13.	$\dfrac{V_s}{V_p} \approx \dfrac{N_s}{N_p}$	ratio of secondary voltage to primary voltage in a transformer
C1.	$\Delta y = \dfrac{\lambda D}{a}$	fringe separation in double-slit interference	E1.	$N = N_0 e^{-kt}$	law of radioactive decay
C2.	$d\sin\theta = n\lambda$	diffraction grating equation	E2.	$t_{\frac{1}{2}} = \dfrac{\ln 2}{k}$	half-life and decay constant
C3.	$\dfrac{1}{u} + \dfrac{1}{v} = \dfrac{1}{f}$	equation for a single lens	E3.	$A = kN$	activity and the number of undecayed nuclei
			E4.	$\Delta E = \Delta mc^2$	mass-energy relationship