HWA CHONG INSTITUTION
JC2 Preliminary Examination
Higher 2

CANDIDATE NAME		**CT GROUP**	**23S**
CENTRE NUMBER		**INDEX NUMBER**	

PHYSICS

9749/01

Paper 1 Multiple Choice

17 September 2024

1 hour

Additional Materials: Optical Mark Sheet

INSTRUCTIONS TO CANDIDATES

Write in soft pencil.

Do not use staples, paper clips, glue or correction fluid.

Write your name, CT, NRIC or FIN number on the optical mark sheet (OMS). Shade your NRIC or FIN in the spaces provided.

There are **thirty** questions on this paper. Answer **all** questions. For each question, there are four possible answers **A**, **B**, **C** and **D**.

Choose the **one** you consider correct and record your choice in **soft pencil** on the separate OMS.

Each correct answer will score one mark. A mark will **not** be deducted for a wrong answer.

Any rough working should be done in this booklet.

The use of an approved scientific calculator is expected, where appropriate.

Data

speed of light in free space,
$c = 3.00 \times 10^{8}$ m s^{-1}

permeability of free space,
$\mu_o = 4\pi \times 10^{-7}$ H m^{-1}

permittivity of free space,
$\varepsilon_o = 8.85 \times 10^{-12}$ F m^{-1}
$\approx (1/(36\pi)) \times 10^{-9}$ F m^{-1}

elementary charge,
$e = 1.60 \times 10^{-19}$ C

the Planck constant,
$h = 6.63 \times 10^{-34}$ J s

unified atomic mass constant,
$u = 1.66 \times 10^{-27}$ kg

rest mass of electron,
$m_e = 9.11 \times 10^{-31}$ kg

rest mass of proton,
$m_p = 1.67 \times 10^{-27}$ kg

molar gas constant,
$R = 8.31$ J K^{-1} mol^{-1}

the Avogadro constant,
$N_A = 6.02 \times 10^{23}$ mol^{-1}

the Boltzmann constant,
$k = 1.38 \times 10^{-23}$ J K^{-1}

gravitational constant,
$G = 6.67 \times 10^{-11}$ N m^2 kg^{-2}

acceleration of free fall,
$g = 9.81$ m s^{-2}

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
work done on / by a gas	$W = p\,\Delta V$
hydrostatic pressure	$p = \rho gh$
gravitational potential	$\phi = -\frac{Gm}{r}$
temperature	$T/\text{K} = T/\,^\circ\text{C} + 273.15$
pressure of an ideal gas	$P = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean kinetic energy of a molecule of an ideal gas	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_o \sin \omega t$
velocity of particle in s.h.m.	$v = v_o \cos \omega t$ $= \pm\omega\sqrt{(x_o^2 - x^2)}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \ldots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential	$V = \frac{Q}{4\pi\varepsilon_o r}$
alternating current / voltage	$x = x_o \sin \omega t$
magnetic flux density due to a long straight wire	$B = \frac{\mu_o I}{2\pi d}$
magnetic flux density due to a flat circular coil	$B = \frac{\mu_o N I}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_o n I$
radioactive decay	$x = x_o \exp(-\lambda t)$
decay constant	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

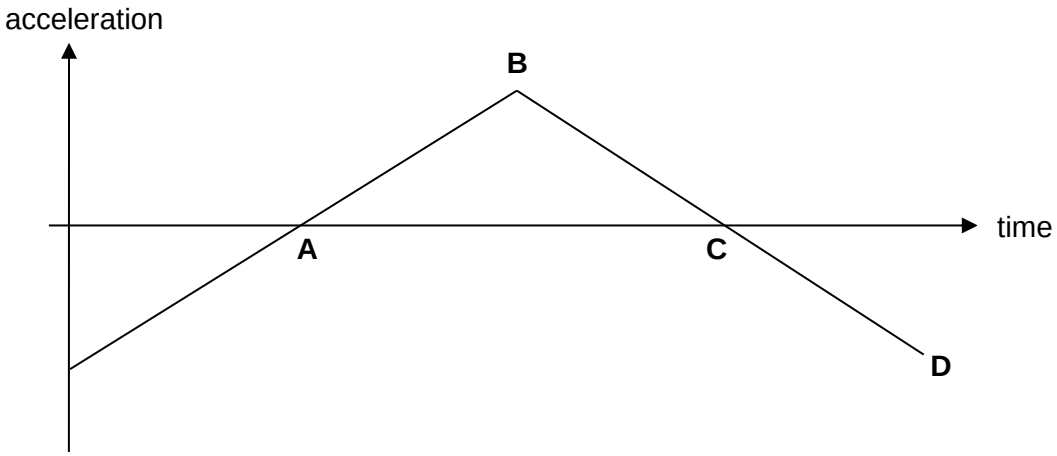
1 A thermometer can be read to an accuracy of ± 0.5 °C. This thermometer is used to measure a temperature rise from 20 °C to 80 °C.

What is the percentage uncertainty in the measurement of the temperature rise?

A 0.5 % **B** 0.8 % **C** 1.3 % **D** 1.7%

2 The acceleration−time graph of an object moving along a straight line is shown below. The object was initially at rest.

At which point on the graph is the object farthest from the starting point?



3 An elevator is moving downwards with a downward acceleration of 5.8 m s^{-2}. A ball, held 2.0 m above the floor of the elevator and at rest with respect to the elevator, is released.

How long does it take for the ball to reach the floor of the elevator?

A 0.51 s **B** 0.64 s **C** 0.83 s **D** 1.0 s

4 A man walking inside a shallow swimming pool managed to accelerate himself forward with a constant horizontal acceleration, a. Given the following information, which equation describes the horizontal motion of the man?

Mass of man: m

Upthrust: U

Drag force of water: f_D

Frictional force from the floor of the pool: f

Acceleration due to gravity: g

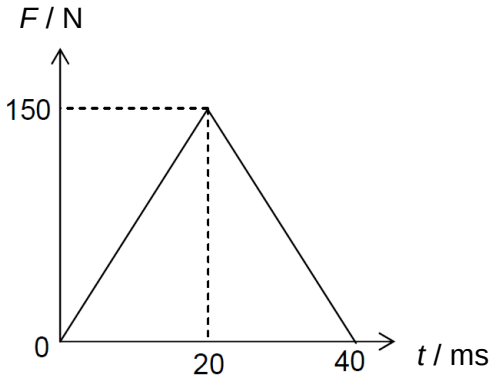
A $f - f_D = ma$

B $mg - U = ma$

C $f_D - f + mg - U = ma$

D $f - f_D + U = ma$

5 The graph shows the force delivered to an incoming ball by a tennis player. After the impact, the 60 g ball leaves the racket with a speed of 30 m s^{-1}.



What was the magnitude of the momentum, in N s, of the tennis ball before the player hit it?

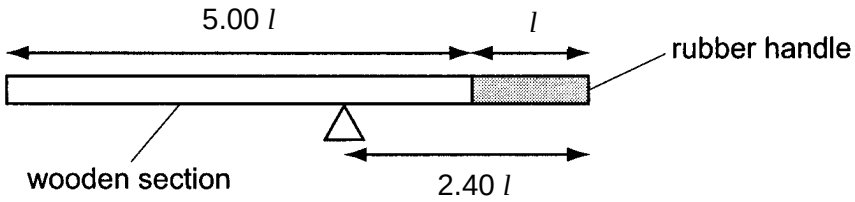
A 1.2 **B** 1.8 **C** 4.8 **D** 20

6 A thruster is used to launch a 500 kg rocket vertically upward from rest. This thruster ejects exhaust at a speed of 1000 m s^{-1}.

What should be the minimum rate, in kg s^{-1}, at which the exhaust leaves the thruster at the instant of launch?

A 0.5 **B** 2.0 **C** 4.9 **D** 20

7 A uniform rod has a wooden section and a solid rubber handle, as shown.

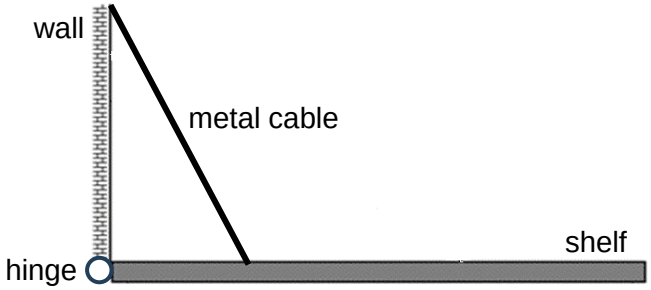


The length of the handle is l and the length of the wooden section is 5.00 l. The rod balances a distance 2.40 l from the rubber end.

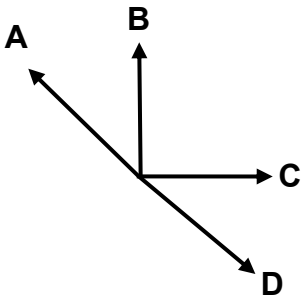
What is the ratio $\frac{\text{density of rubber}}{\text{density of wood}}$?

A 5.42 **B** 5.00 **C** 2.89 **D** 0.345

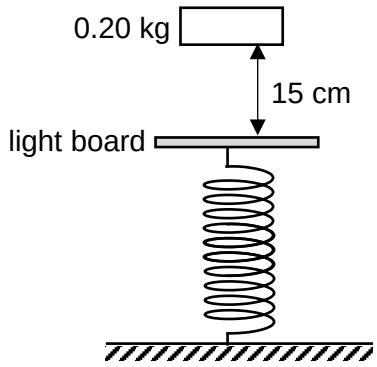
8 A shelf made of uniform material is held horizontally against a wall by a metal cable. The forces acting on the shelf are its weight, the force exerted by the metal cable, and the force exerted by the hinge.



Which arrow could represent the direction of the force the hinge exerts on the shelf?



9 A block of mass 0.20 kg is dropped from a height of 15 cm above a light spring of spring constant 85 N m^{-1}, as shown below. The block lands on a light board and compresses the spring.



Determine the maximum compression of the spring.

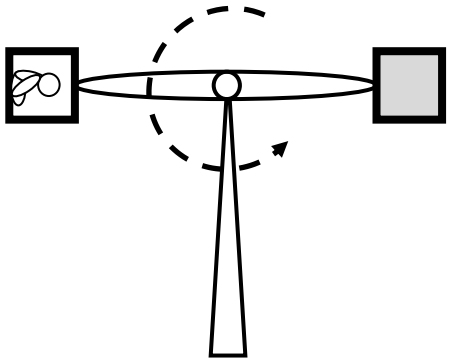
A 2.3 cm **B** 4.6 cm **C** 8.3 cm **D** 11 cm

10 A speed boat with two engines, each of power 32 kW, can travel at a maximum speed of 14 m s^{-1}. The total drag force on the boat is directly proportional to the speed of the boat.

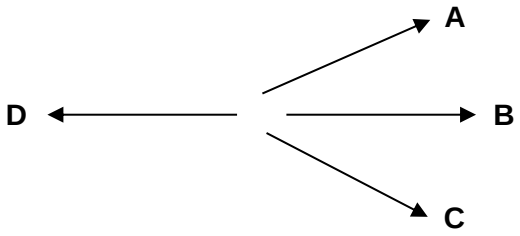
What is the maximum speed of the boat when only one engine is working?

A 3.5 m s^{-1} **B** 7.0 m s^{-1} **C** 9.9 m s^{-1} **D** 11 m s^{-1}

11 In an amusement park ride, a person sits in a cage which moves in a vertical circle at a constant speed. The person stays stationary with respect to the cage.

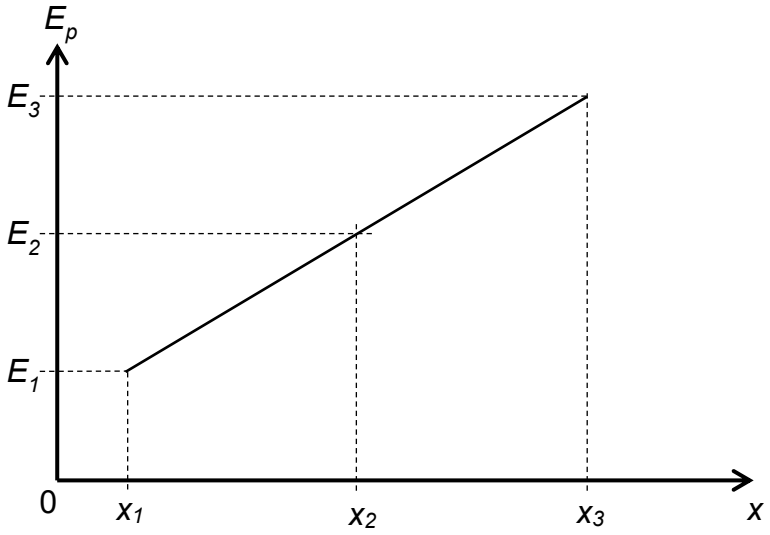


At the instant shown, what is the direction of the force exerted by the cage on the person?



12 An object of mass *m* is moving radially away from Earth of mass *M*.

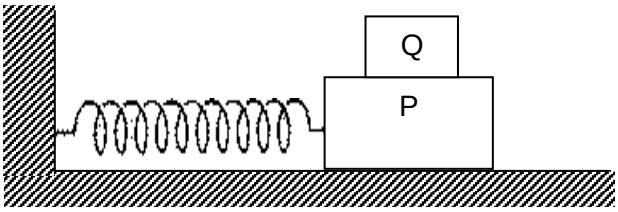
For a small distance *x* above the surface of the Earth, the variation with *x* of the stone's gravitational potential energy E_p is shown. At a point a distance x_2 from the surface of the Earth, the potential energy of the stone is E_2.



What is the magnitude of the force acting on the stone?

A $\dfrac{GMm}{(x_2)^2}$ **B** $\dfrac{E_2}{x_2}$ **C** $\dfrac{E_3 - E_1}{x_3 - x_1}$ **D** $\dfrac{(x_1 + x_2) \times (E_2 + E_1)}{4}$

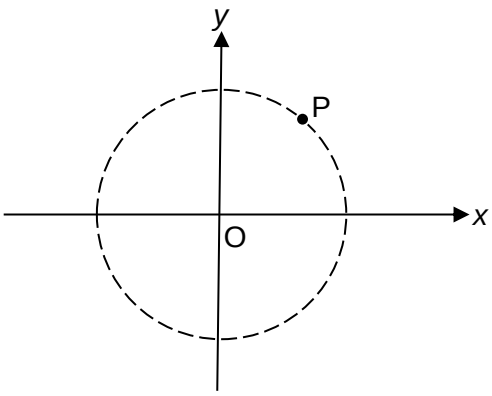
13 A system consisting of a large block P with a smaller block Q resting on it, oscillates on a frictionless surface with a frequency of 1.5 Hz. The maximum static friction *between* the two blocks is 5.0 N.



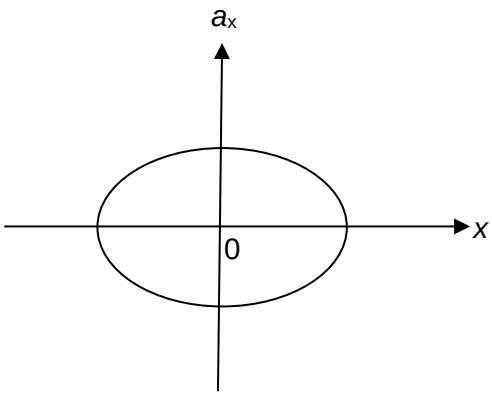
If the mass of P is 2.0 kg and the mass of Q is 0.20 kg, what is the maximum amplitude of oscillation of the system in order that block Q does not slip?

A 0.026 m **B** 0.028 m **C** 0.056 m **D** 0.28 m

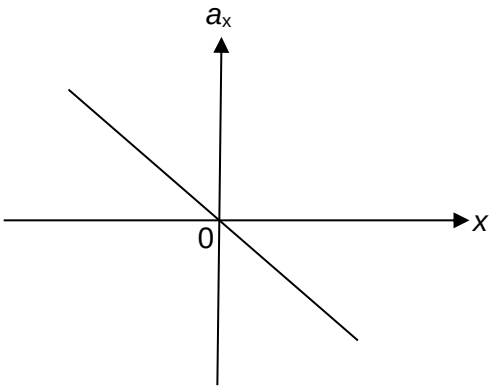
14 A particle P performs uniform circular motion about the origin O in the *x*-*y* plane as shown below.



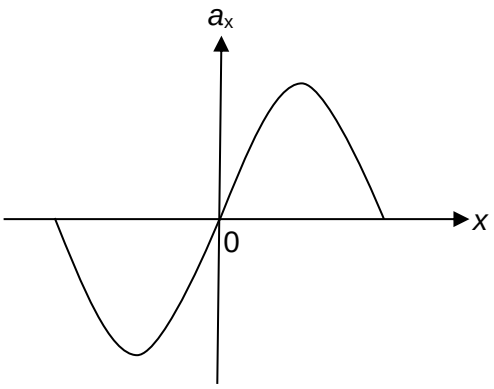
Which of the following graphs shows the relationship between the *x*-component of the acceleration a_x and the displacement in the *x*-direction?



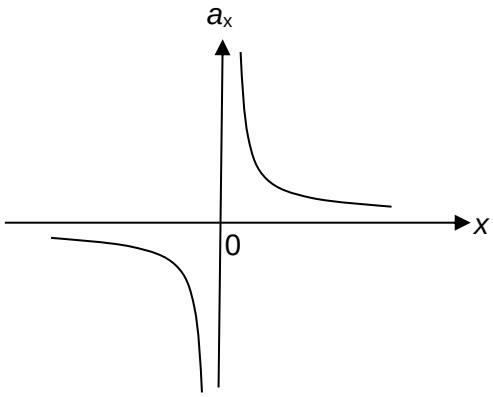
A



B

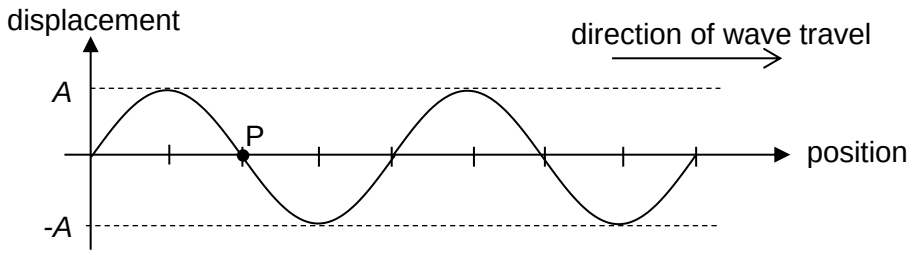


C



D

15 The displacement-position graph of a progressive wave is shown below. Particle P is a point along the wave.



Which of the following statements is **true** about particle P at the instant shown in the graph?

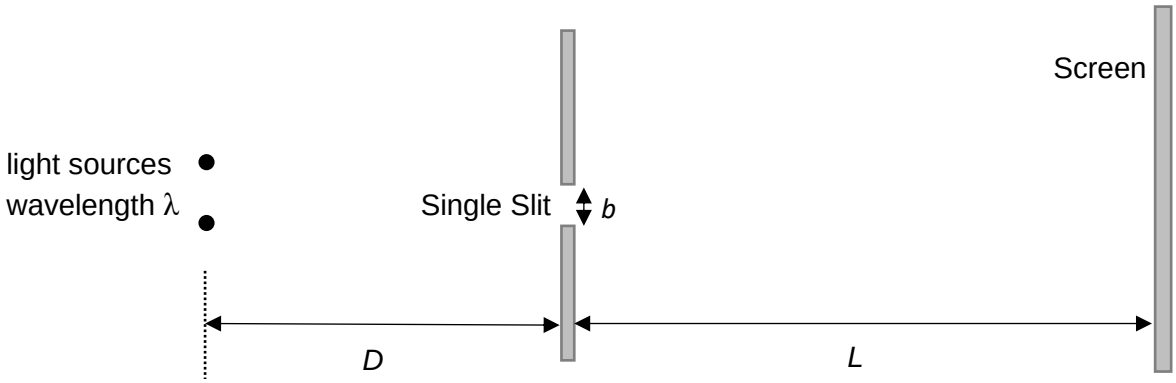
A It is moving towards the negative direction.

B It has zero velocity.

C It has an amplitude of *A*.

D It is experiencing the largest acceleration.

16 Two monochromatic light sources of wavelength λ are separated by a fixed distance. Light from the sources pass through a single slit of width *b* at a distance of *D*. The image of the light sources is projected on a screen at a distance *L* from the single slit.



One is just able to distinguish that there are two light sources from the image captured on the screen.

For the image captured on screen, which of the following changes will make it easier to distinguish that there are two light sources?

A λ is increased.

B *D* is reduced.

C *b* is decreased.

D *L* is increased.

17 White light (400 - 700 nm) is directed perpendicularly towards a diffraction grating. The diffraction grating has 300 lines per mm and the resulting image is projected on a screen.

What is the highest order of diffraction whereby a complete spectrum (red to violet) which does not overlap with the next order is clearly visible?

A 1st order **B** 2nd order **C** 3rd order **D** 4th order

18 In deriving the equation $p = \frac{1}{3}\rho\langle c^2\rangle$ using the kinetic theory of gases, which of the following is **not** a valid assumption?

A The volume of the molecules is negligible compared with the volume of the gas.

B The duration of a collision is negligible compared with the time between collisions.

C The molecules experience negligible change of momentum on collision with the walls of the container.

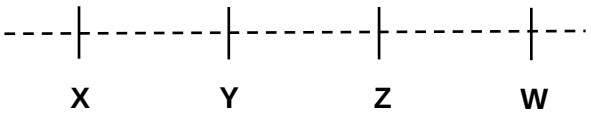
D Collisions with the walls of the container and with other molecules cause no change in the average kinetic energy of the molecules.

19 *N* molecules of a monatomic ideal gas are contained in a rigid box at pressure *p* and temperature *T*. An additional *N* molecules of the same gas are added to the box in such a way that the internal energy is kept constant at its original value.

Which of the following indicates the values of the temperature and pressure of the gas after the addition?

	temperature	**pressure**
A	$\frac{1}{2}T$	p
B	$\frac{1}{2}T$	$\frac{1}{2}p$
C	T	$2p$
D	T	p

20 X, Y, Z and W are four points on a straight line as shown below. The points are equally spaced apart.



A point charge +*Q* is fixed at X. When another point charge -*Q* is moved from Y to Z, which of the following statements is **false**?

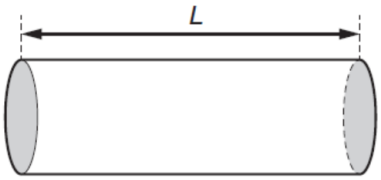
A The electric potential energy of the system of charges will increase.

B The magnitude of the electric field strength at point W will increase.

C The electric potential at point W will increase.

D The electric potential at point Y will become zero.

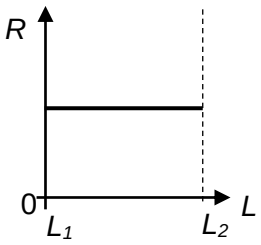
21 A piece of conducting modelling clay of constant resistivity is formed into a cylindrical shape. The resistance *R* between its flat ends (shaded) is measured.



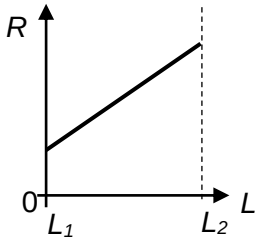
The same volume of modelling clay is re-formed into cylinders of different lengths *L* in the range of L_1 to L_2 and the resistance *R* between the flat ends is measured for each value of *L*.

Which graph best shows the variation of *R* with *L*?

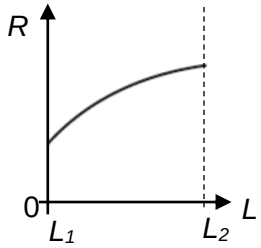
A



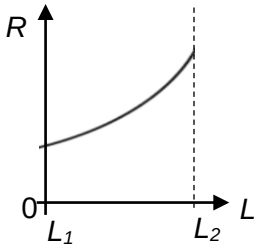
B



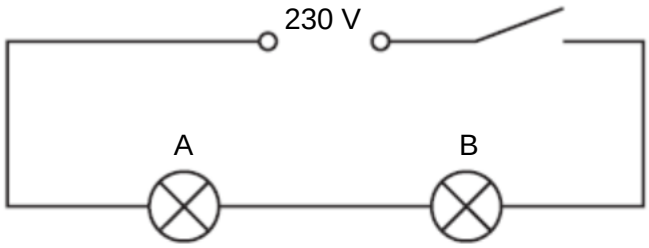
C



D



22 In the circuit shown, lamp A is rated 230 V, 10 W and lamp B is rated 230 V, 40 W. The two lamps are connected in series to a 230 V power supply.



Assume that the resistance of each lamp remains constant at all temperatures.

Which statement most accurately describes what happens when the switch is closed?

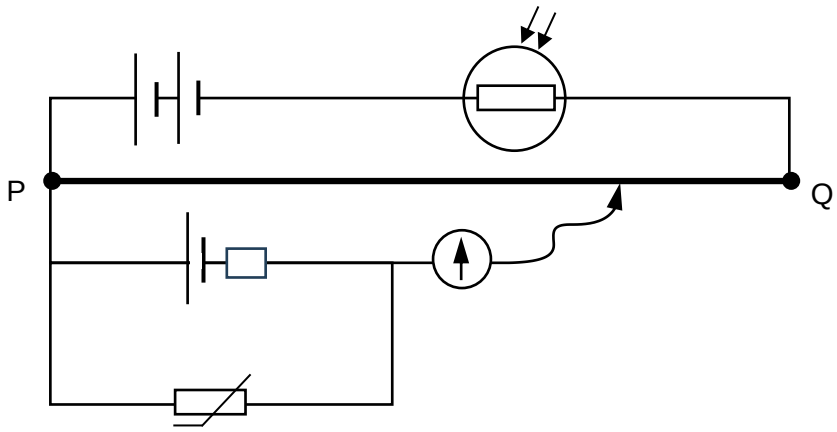
A Lamp A emits twice as much power as lamp B.

B Lamp A emits four times as much power as lamp B.

C Lamp B emits twice as much power as lamp A.

D Lamp B emits four times as much power as lamp A.

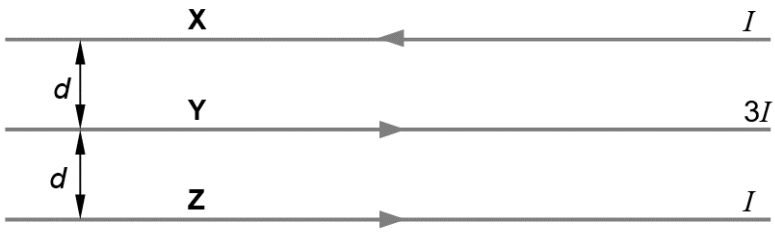
23 A NTC thermistor and a light-dependent resistor are connected in a potentiometer circuit. PQ is a resistance wire.



Which combination of temperature and lighting condition maximises the balance length?

	temperature	**lighting**
A	low	dark
B	low	bright
C	high	dark
D	high	bright

24 The diagram below shows three long, parallel, straight wires X, Y and Z placed in the same plane in a vacuum. Wires X and Z each carries a current of I, and wire Y carries a current of $3I$. Wire Y is halfway between wire X and wire Z.

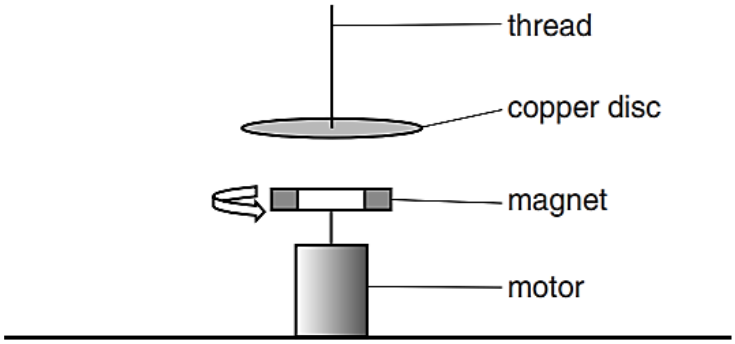


The magnitude of the force per unit length acting between X and Z is *F.*

What is the direction and magnitude of the net force per unit length acting on Z?

	Direction	**Magnitude**
A	Towards Y	F
B	Towards Y	$5F$
C	Away from Y	$5F$
D	Away from Y	$7F$

25 A magnet is attached to a motor and rotates below a freely-suspended copper disc as shown below.



Which of the following statements is correct?

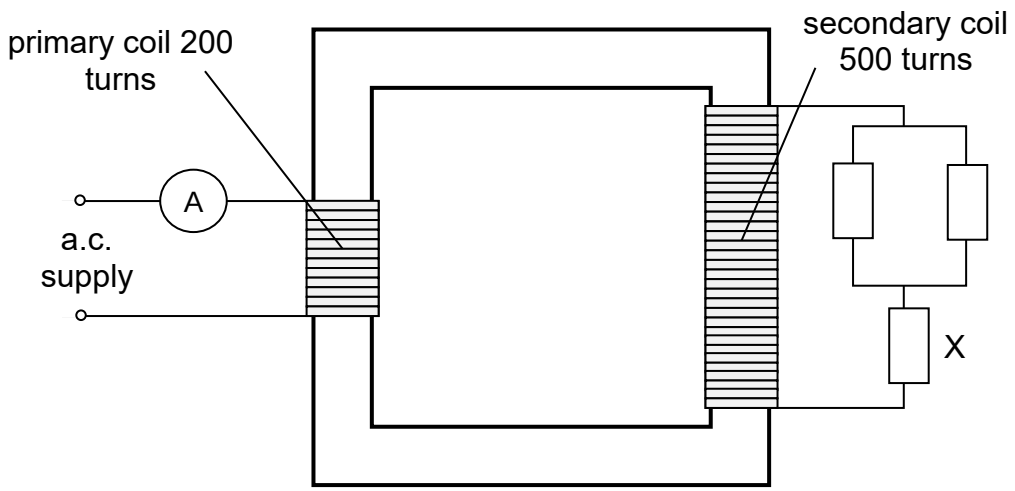
A The disc remains stationary as copper is not magnetic.

B The disc rotates in the same direction as the magnet as copper is magnetic.

C The disc rotates in the same direction as the magnet as eddy currents are induced in the disc.

D The disc rotates in the opposite direction as the magnet as eddy currents are induced in the disc.

26 A 100% efficient transformer is connected to a sinusoidal a.c. supply as shown below. The secondary coil is connected to 3 identical resistors, each of resistance 1000 Ω. The potential difference across resistor X is 80 V.



What is the reading on the ammeter?

A 0.080 A **B** 0.20 A **C** 0.40 A **D** 2.3 A

27 Which of the following statements is **true** when the photoelectric effect occurs?

A The maximum speed of emitted electron is proportional to the intensity of the incident light.

B The maximum energy of the emitted electrons increases with the wavelength of the incident light.

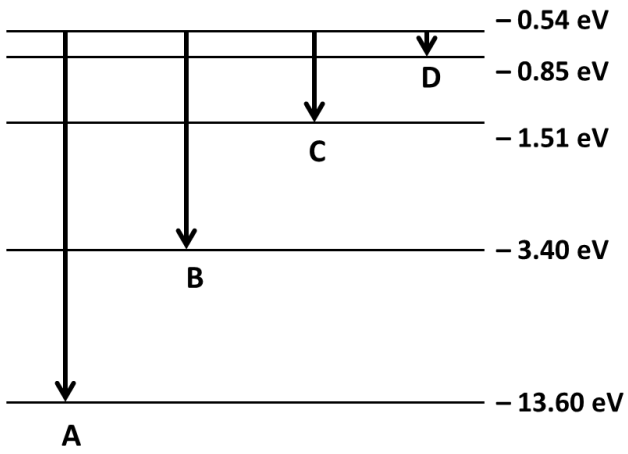
C The number of electrons emitted per unit time is proportional to the intensity of the incident light.

D The wavelength of the incident light must be greater than a certain threshold value.

28 The energy level diagram represents the five lowest energy levels of hydrogen.

A spectral line of wavelength 435 nm corresponds to one of the lines in the spectrum of hydrogen.

Which of the transitions gives this particular spectral line?



29 Two deuterium nuclei undergo a fusion reaction to form a helium nucleus as represented by

$$^{2}_{1}\mathrm{H} + {}^{2}_{1}\mathrm{H} \rightarrow {}^{4}_{2}\mathrm{He} + \text{energy}$$

The binding energy per nucleon of helium is 2.54 MeV.
The minimum amount of energy released in this reaction is 3.26 MeV.

What is the binding energy per nucleon of deuterium?

A 1.45 MeV **B** 1.73 MeV **C** 3.36 MeV **D** 3.45 MeV

30 A detector detects an average count-rate of 600 counts min^{-1}. Two half-lives later, the count-rate drops to 180 counts min^{-1}.

Determine the average background count-rate, in counts min^{-1}.

A 15 **B** 40 **C** 60 **D** 120

END OF PAPER