Anglo-Chinese Junior College

Physics Preliminary Examination
Higher 2

A Methodist Institution
(Founded 1886)

PHYSICS **9646/01**

Paper 1 Multiple Choice 18 September 2014
1 hour 15 minutes

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your Name and Index number in the answer sheet provided.

There are **forty** questions in this section. 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 Answer Sheet.

Read the instructions on the Answer sheet very carefully.

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 Question Paper.

DATA AND FORMULAE

Data

speed of light in free space,	c	=	3.00×10^{8} m s^{-1}
permeability of free space,	μ_o	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	ε_o	=	8.85×10^{-12} F m^{-1} $(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge,	e	=	1.60×10^{-19} C
the Planck constant,	h	=	6.63×10^{-34} J s
unified atomic mass constant,	u	=	1.66×10^{-27} kg
rest mass of electron,	m_e	=	9.11×10^{-31} kg
rest mass of proton,	m_p	=	1.67×10^{-27} kg
molar gas constant,	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant,	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant,	k	=	1.38×10^{-23} J K^{-1}
gravitational constant,	G	=	6.67×10^{-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	=	$\rho g h$
gravitational potential,	ϕ	=	$-\frac{Gm}{r}$
displacement of particle in s.h.m.,	x	=	$x_o \sin \omega t$
velocity of particle in s.h.m.,	v	=	$v_o \cos \omega t$
		=	$\pm \omega \sqrt{x_o^2 - x^2}$
mean kinetic energy of a molecule of an ideal gas	E	=	$\frac{3}{2}kT$
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	=	$x_o \sin \omega t$
transmission coefficient,	T	$\propto$	$\exp(-2kd)$
	where k	=	$\sqrt{\frac{8\pi^2 m(U-E)}{h^2}}$
radioactive decay,	x	=	$x_o \exp(-\lambda t)$
decay constant,	λ	=	$\frac{0.693}{t_{1/2}}$

1 A student uses a digital ammeter to measure a current. The reading of the ammeter is found to fluctuate between 1.98 A and 2.02 A.

The manufacturer of the ammeter states that any reading has a systematic uncertainty of $\pm 1\%$.

Which value of the current should be quoted by the student?

A (2.00 ± 0.01) A

B (2.00 ± 0.02) A

C (2.00 ± 0.03) A

D (2.00 ± 0.04) A

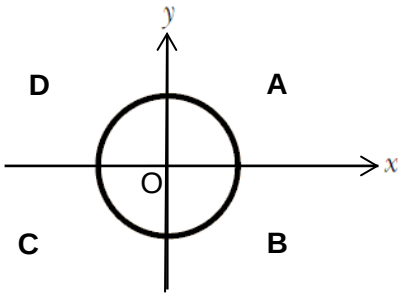
2 An athlete of mass 80 kg competes in a 100 m race.

What is the best estimate of his mean kinetic energy during the race?

A 4×10^2 J **B** 4×10^3 J **C** 4×10^4 J **D** 4×10^5 J

3 The figure below shows a circular path taken by a particle. At a certain instant, the particle's horizontal velocity, v_x , is + 2 m s^{-1}, and its vertical velocity, v_y, is – 2 m s^{-1}.

Horizontally, right is taken to be positive *x*-direction.
Vertically, upward is taken to be positive *y*-direction.



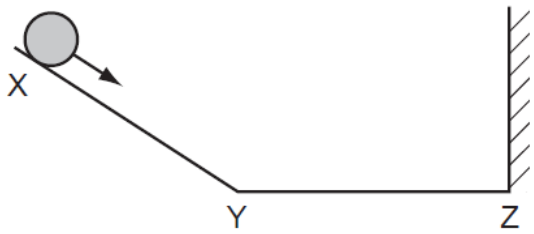
Through which quadrant is the particle moving at this instant if it is travelling anti-clockwise around the circle?

4 Two diamonds begin free fall from rest from the same height 1.0 s apart.

How long after the first diamond begin to fall will the two diamonds be 10 m apart?

A 0.43 s **B** 1.43 s **C** 1.52 s **D** 2.43 s

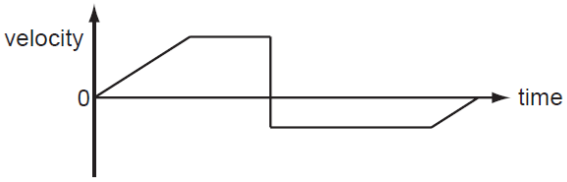
5 A ball is released from rest on a smooth slope XY.



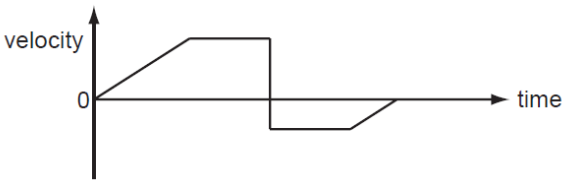
It moves down the slope, along a smooth surface YZ and rebounds inelastically at Z. Then it moves back to Y and comes to rest momentarily somewhere on XY.

Which velocity-time graph represents the motion of the ball?

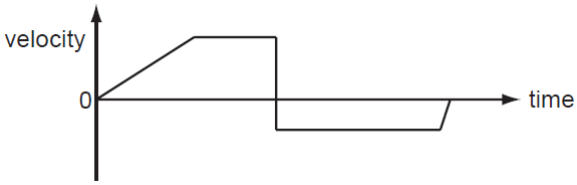
A



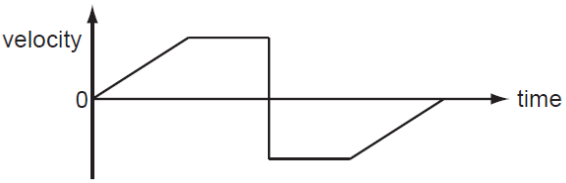
B



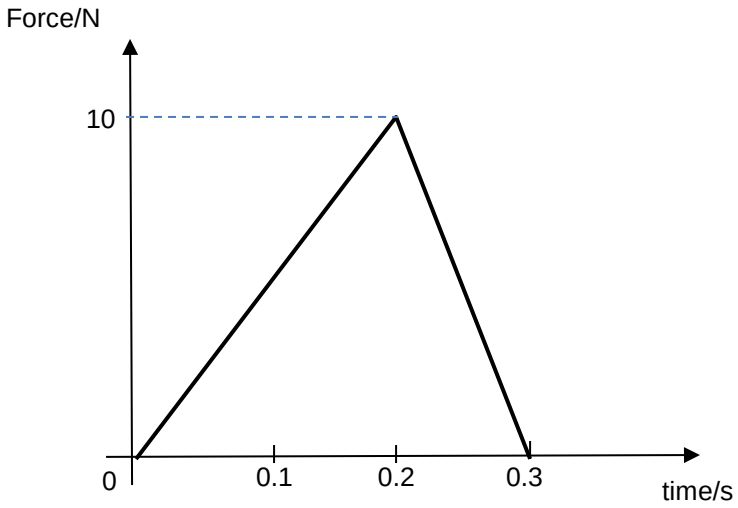
C



D



6 A varying force acts upon an object. The graph below shows how the force acting on the object varies with time.



The magnitude of the maximum change in momentum of the object is

A 3.0 Ns **B** 2.0 Ns **C** 1.5 Ns **D** 1.0 Ns

7 A stationary Thoron nucleus of mass 220*u* emits an alpha particle of mass 4*u* with kinetic energy E_α.

Which of the following gives the correct value of

the ratio $\dfrac{\textit{speed of alpha particle}}{\textit{speed of the recoiling daughter nucleus}}$

and

kinetic energy of the daughter nucleus immediately after the emission?

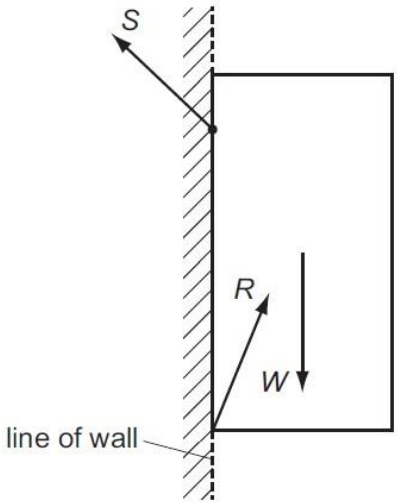
	$\dfrac{\textbf{\textit{speed of alpha particle}}}{\textbf{\textit{speed of the recoiling daughter nucleus}}}$	***kinetic energy of the recoiling daughter nucleus***
A	55	$\frac{1}{55}\ E_\alpha$
B	54	$(\frac{1}{54})^2\ E_\alpha$
C	54	$\frac{1}{54}\ E_\alpha$
D	$\frac{1}{54}$	$54\ E_\alpha$

8 A cupboard is attached to a wall by a screw.

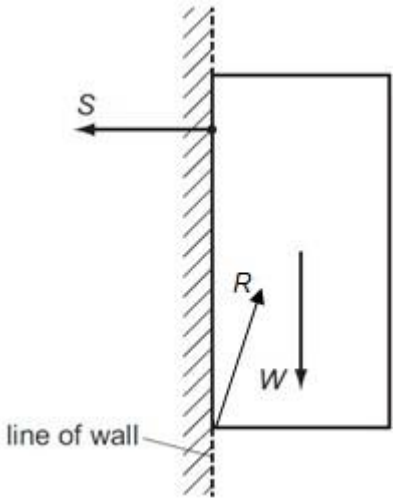
Which force diagram shows the cupboard in equilibrium, with the weight W of the cupboard, the force S that the screw exerts on the cupboard and the force R that the wall exerts on the cupboard?

The magnitude of the forces are not drawn to scale.

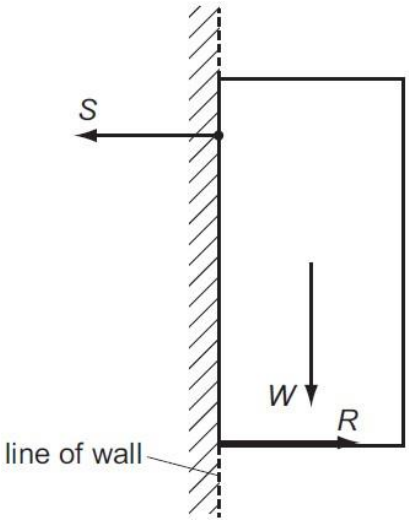
A



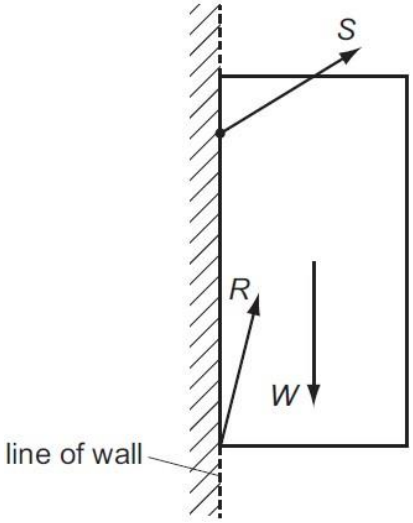
B



C



D



9 The hull of a ship may be assumed to have a uniform horizontal cross-sectional area in the region above and below the water line.

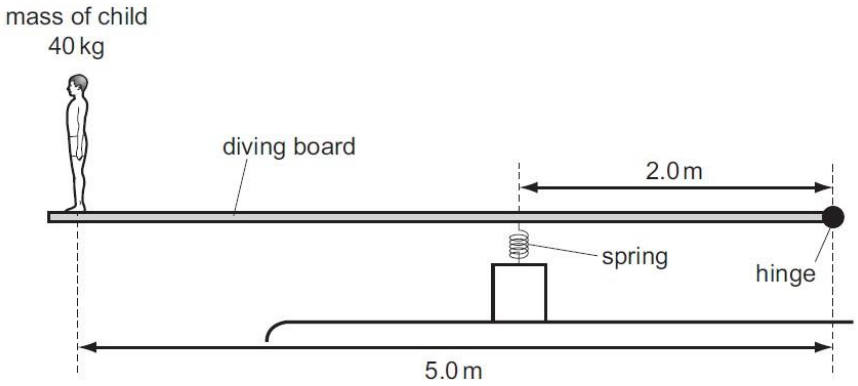
When in seawater of density 1.06 x 10^3 kg m^{-3}, the ship floats with 3.00 m of its hull below water. The ship then travels into a river estuary when the density of the water is 1.01 x 10^3 kg m^{-3}.

What is the new submerged depth of the hull?

A 3.35 m **B** 3.15 m **C** 3.05 m **D** 2.86 m

10 A uniform diving board of length 5.0 m and mass 35 kg hangs horizontally in equilibrium when it is hinged at one end and supported 2.0 m from this end by a spring of spring constant 10 kN m^{-1}.

When a child of mass 40 kg stands at the far end of the board as shown in the diagram below, what is the extra compression of the spring caused by the child standing on the end of the board?

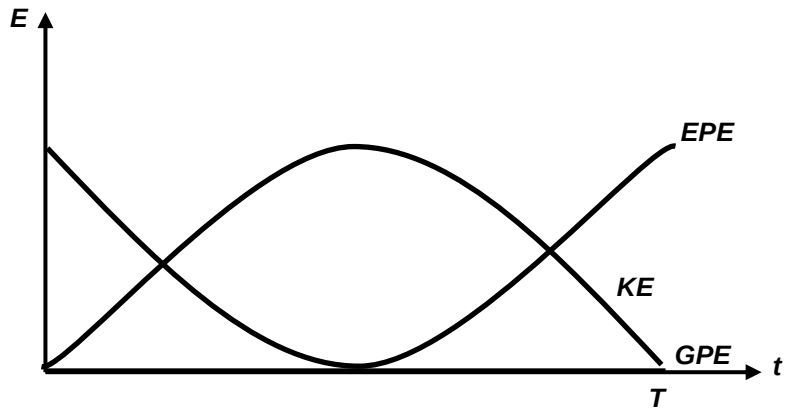


A 1.0 cm **B** 5.9 cm **C** 9.8 cm **D** 19.6 cm

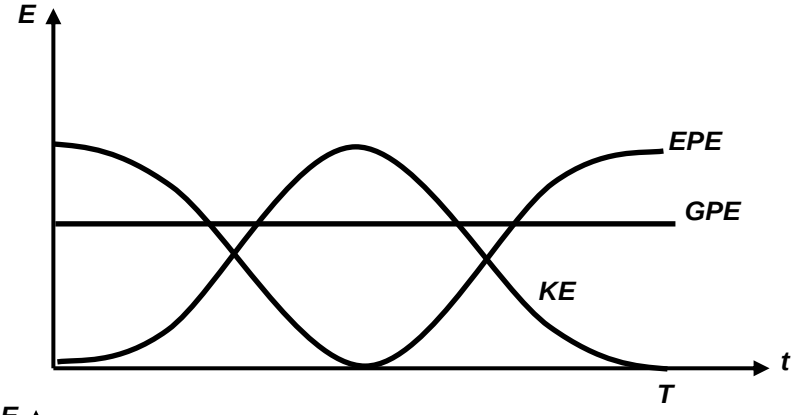
11 A mass on a smooth horizontal table is attached by two light springs to two fixed supports. The mass executes linear simple harmonic motion.

Which of the graphs correctly show how the kinetic energy (*KE*), elastic potential energy (*EPE*) and gravitational potential energy (*GPE*) would vary with time?

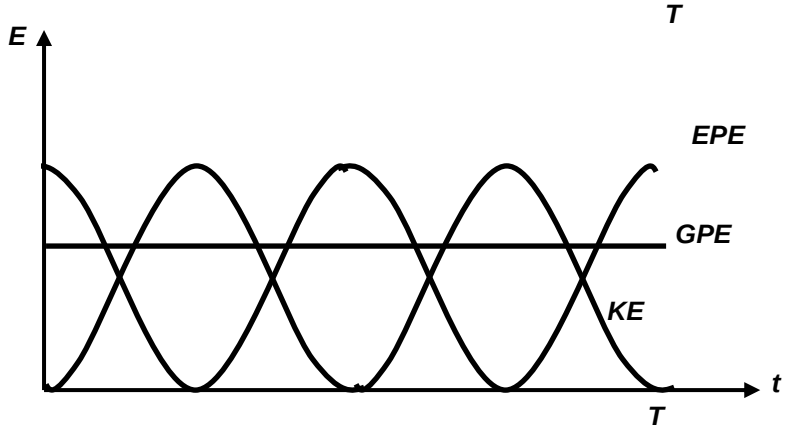
A



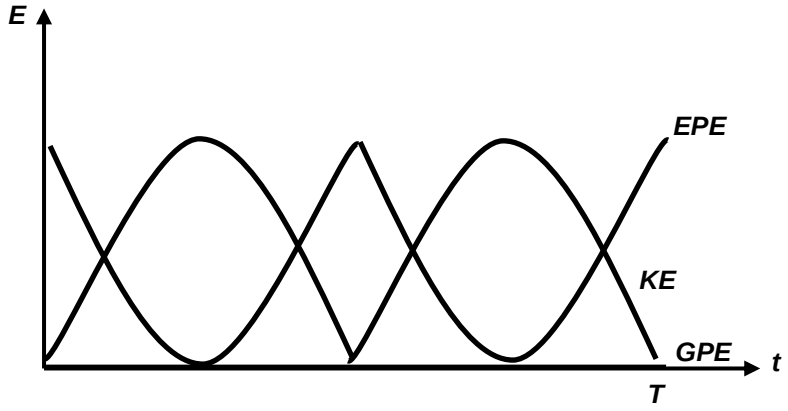
B



C



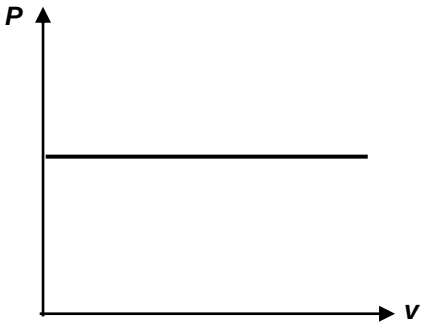
D



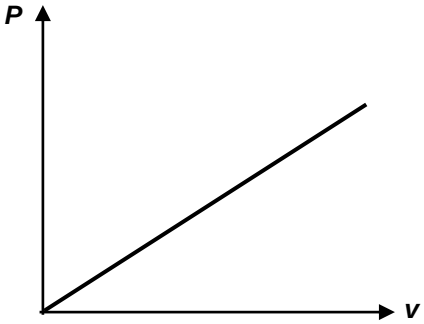
12 A car moving through air at velocity v experiences a resistive force F given by the expression $F = kv^2$ where k is a constant.

Which of the following graphs show how the power supplied to the car P will vary at various v to ensure that the car is moving without any acceleration?

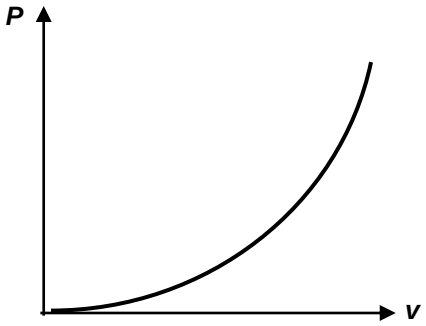
A



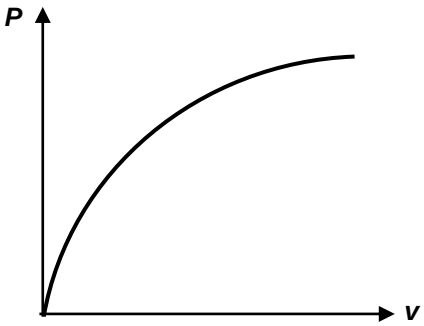
B



C



D



13 A wind turbine has blades that sweep an area of 2000 m^2. It converts the power available in the wind to electrical power with an efficiency of 50%.

What is the electrical power generated if the wind speed is 10 m s^{-1}?

(The density of air is 1.3 kg m^{-3}.)

A 130 kW **B** 650 kW **C** 1300 kW **D** 2600 kW

14 A car is making a turn at speed v. The radius of the turn is r and the centripetal force on the car is F. If the car rounds the same curve at speed $2v$, the required centripetal force is

A $\frac{1}{2}F$ **B** F **C** $2F$ **D** $4F$

15 The Earth has approximately 81 times the mass of the Moon. There is a point between the Earth and the Moon where the resultant gravitational force on a mass m is zero. If the distance to this point from the centre of the Earth is *y* and from the centre of the Moon it is *x*, the ratio *y* / *x*

A $(81)^{\frac{1}{4}}$ **B** $(81)^{\frac{1}{2}}$ **C** 81 **D** $(81)^{2}$

16 **Fig. 16** shows the gravitational equipotentials near a certain non-spherical body.

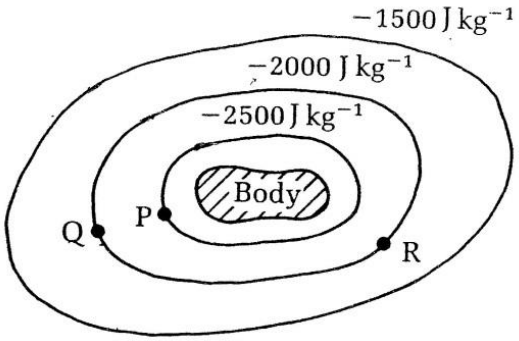


Fig. 16

What is the work that must be done on 100 g mass to move it from P to Q

A 50 J **B** - 50 J **C** 5000 J **D** -5000 J

17 Simple harmonic motion is defined as the motion of a particle such that

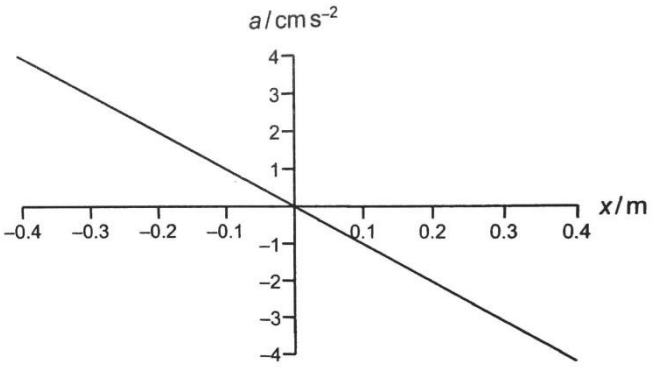
A its displacement x from the equilibrium position is always given by the expression $x = x_o sin\omega t$

B its displacement x from the equilibrium position is related to its velocity by the expression $v = \omega x$

C its acceleration is proportional to, and in the opposite direction to, the displacement from the equilibrium position.

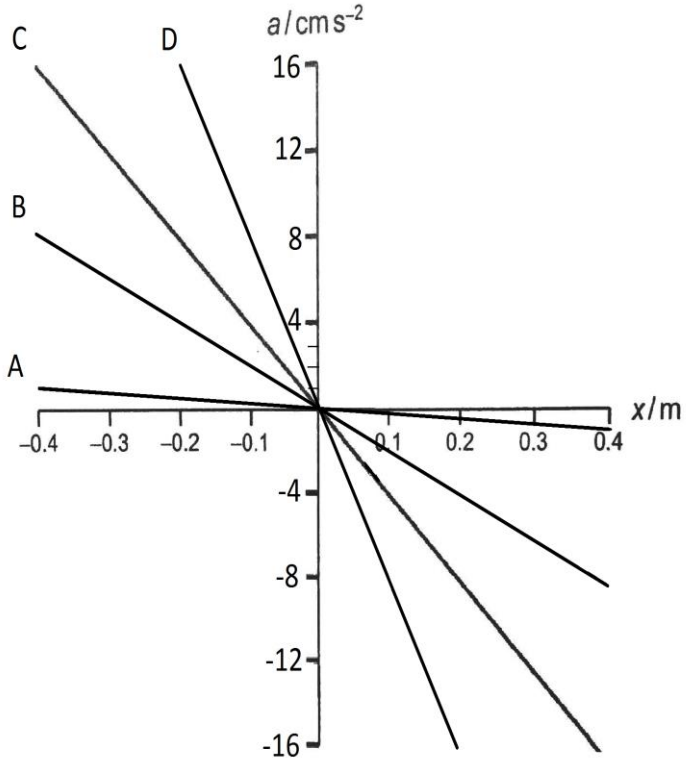
D Its acceleration is always $\omega^2 x_o$ and is directed at right angles to its motion.

18 The graph shows the variation of acceleration *a* with displacement *x* for an object undergoing simple harmonic motion.



The simple harmonic motion system is altered so that it has a period half of that before.

Which line shows the new variation of acceleration *a* with displacement *x* for the object?

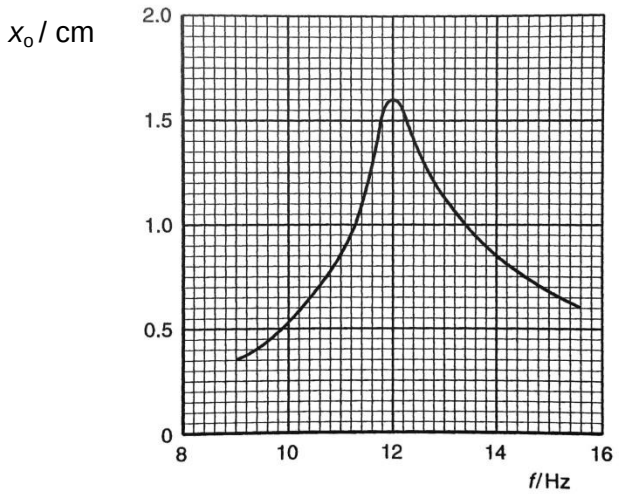


19 A particle is in simple harmonic motion.

What is the magnitude of the phase difference between the velocity and displacement of particle?

A $\frac{\pi}{4} rad$ **B** $\frac{\pi}{2} rad$ **C** $\pi\ rad$ **D** $\frac{3\pi}{2} rad$

20 The variation with frequency f of the amplitude x_o of the forced oscillations of a machine is as shown.



Which of the following statement is false?

A Resonance frequency of the above system is 12 Hz

B For no damping, the maximum amplitude is 1.6 cm.

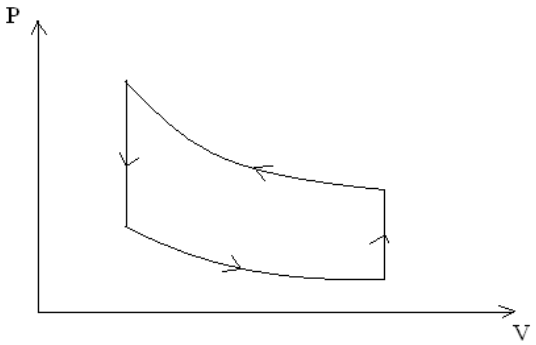
C Increased damping reduces the sharpness of the resonance peak

D Damping decreases the maximum amplitude of the oscillations

21 Argon and chlorine are gases. One mole of argon has mass 40 g and one mole of chlorine has mass 71 g.
What is the ratio of the $\frac{Number\ of\ atoms\ in\ 1\ mole\ of\ argon}{Number\ of\ molecules\ in\ 1\ mole\ of\ chlorine}$

A 0.56
B 1
C 1.8
D 2

22 An ideal gas undergoes a cycle of processes as shown in the P–V diagram below.



Which statement correctly describes the situation?

A The internal energy of the gas increases over one complete cycle.
B The gas gives out more heat than it absorbs over the whole cycle.
C Over the entire cycle, the gas absorbs heat and does network on its environment.
D The two curved portions of the graph represent adiabatic process.

23 Equal masses of four different liquids (A, B, C and D) at 20°C are separately heated at the same rate. Their boiling points and specific heat capacities are as shown in the table below.

Liquid	Boiling Point / °C	Specific Heat Capacity / J kg^{-1} K^{-1}
A	50	1000
B	60	530
C	80	850
D	360	140

Which liquid will be the last to boil?

A Liquid A **B** Liquid B **C** Liquid C **D** Liquid D

24 A progressive wave in a stretched string has a speed of 2 m s^{-1} and a frequency of 100 Hz. What is the phase difference between two points 25 mm apart?

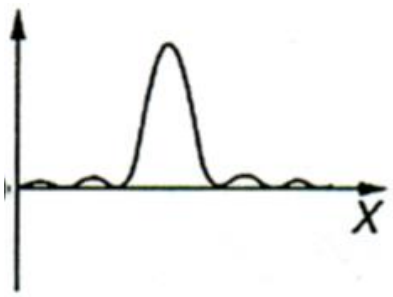
A zero **B** $\frac{\pi}{4}$ **C** $\frac{\pi}{2}$ **D** π

25 Two coherent monochromatic waves of equal amplitude are brought together to form an interference pattern on a screen.

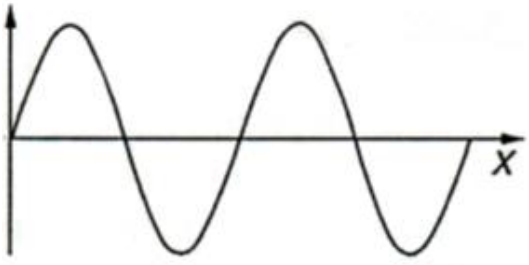
Which of the following graphs could represent the variation of intensity with position x across the pattern of fringes.

A

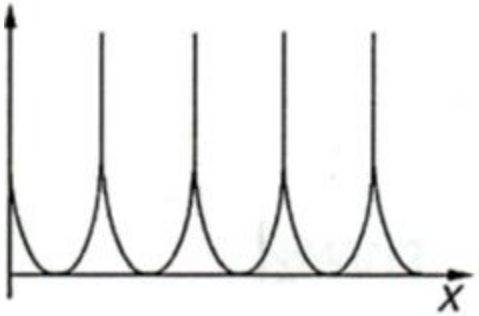
B



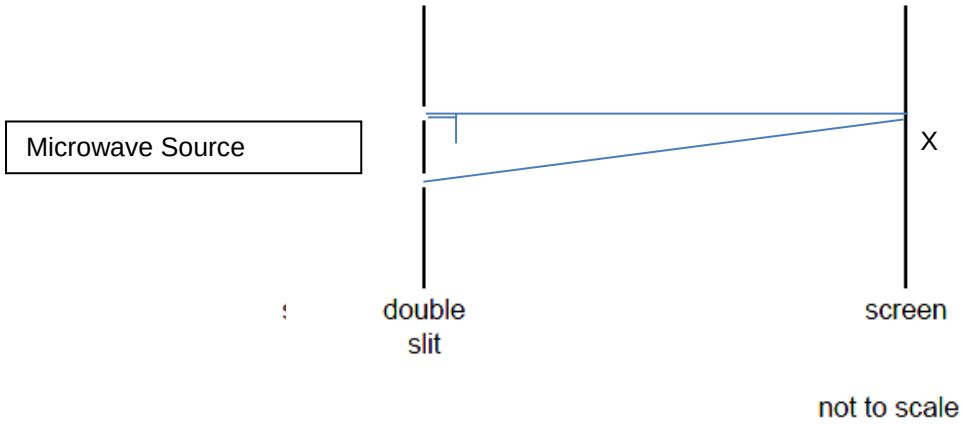
C



D



26 A double-slit interference experiment is set up as shown.



Fringes are formed on the screen which is 40.0 cm away. The distance between the slits is 9.0 cm apart. The microwave source has a wavelength of 2.0 cm and intensity of *I*.

What is the resultant intensity at X?

A Zero **B** *I* **C** 2*I* **D** 4*I*

27 **Fig 27** shows some equipotential lines in an electric field.

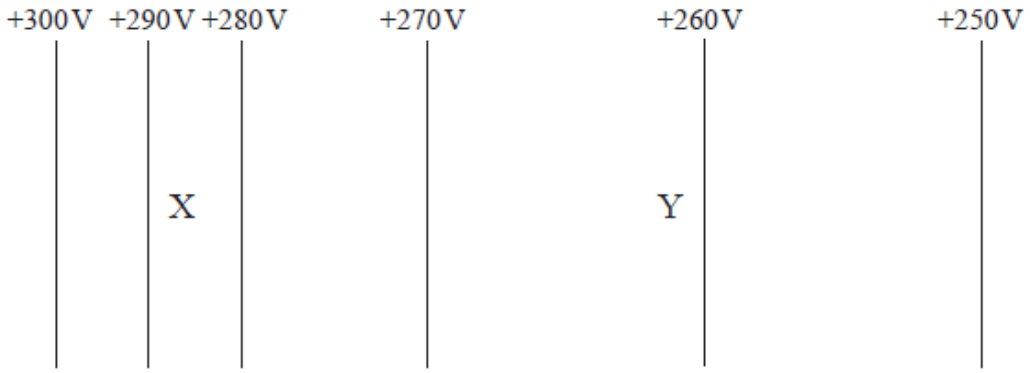


Fig 27

The magnitude of the electric field strength at X is E_X and at Y is E_Y.

Which of one of the following correctly compares E_X and E_Y and gives the correct directions of the electric field?

	Magnitude of electric field strength	Direction of electric field
A	$E_X > E_Y$	X → Y
B	$E_X > E_Y$	Y → X
C	$E_X < E_Y$	X → Y
D	$E_X < E_Y$	Y → X

28 Two charged conducting spheres each of radius 1.0 cm are placed with their centres 10.0 cm apart, as shown in **Fig 28.1**.

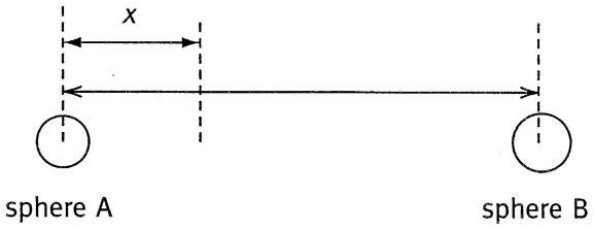


Fig 28.1

Sphere A carries a charge of + 2.0 x 10^{-10} C.

The graph in Fig 28.2 shows how the resultant electric field strength *E*, between the two spheres varies with distance *x*.

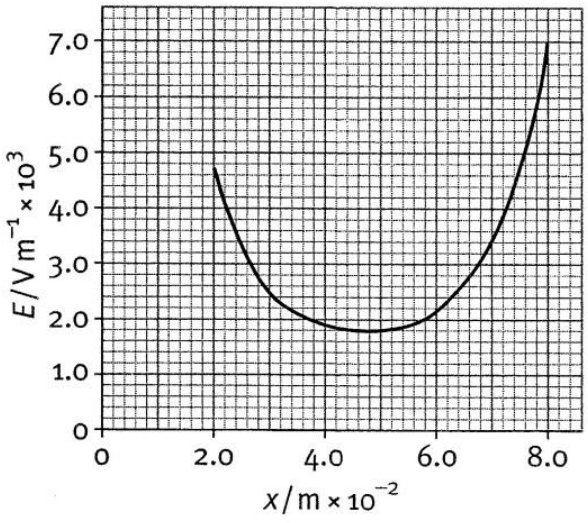


Fig 28.2

What is the magnitude of the electric field strength due to the charge on sphere B at the 5.0 cm mark. Identify the nature of the charge on sphere B.

	Magnitude of E_B / Vm^{-1}	**Nature of charge on sphere B**
A	1.08 x 10^3	positive
B	1.08 x 10^3	negative
C	1.76 x 10^3	positive
D	1.76 x 10^3	negative

29 A battery of internal resistance *r* and e.m.f. *E* can supply a current of 6.0 A to a resistor R as shown in **Fig 29.1.**

The *I V* characteristics of the resistors R and R_1 respectively is shown in **Fig 29.2.**

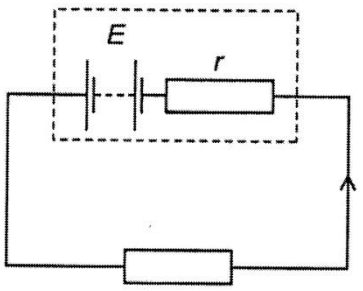


Fig 29.1.

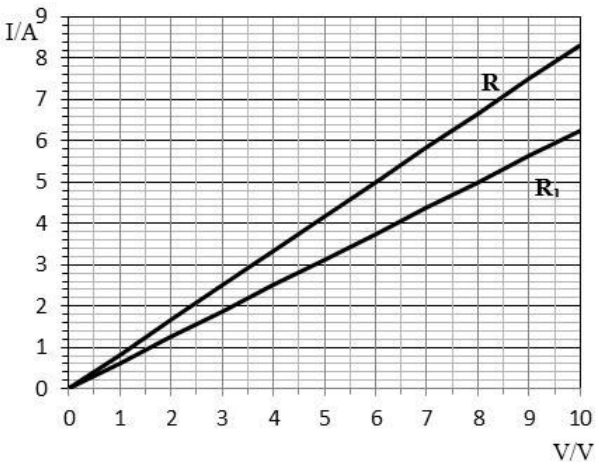


Fig 29.2

When the resistor R is replaced by R_1, the current becomes 5.0 A.

What are the values of the e.m.f. *E* and the internal resistance *r*?

	***E* / V**	***r* / Ω**
A	7.6	0.073
B	12	2.0
C	12	0.80
D	15	8.0

30 Four identical resistors are connected as shown in **Fig 30**.

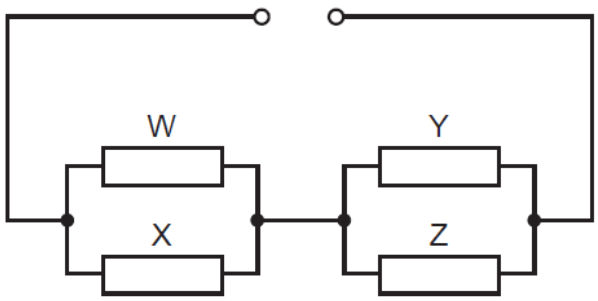


Fig 30

How will the powers to the resistors change when the resistor W is removed?

A The powers to X,Y and Z will all increase.
B The powers X will decrease and the powers to Y and Z will increase.
C The powers to X will increase and the powers to Y and Z will decrease.
D The powers to X will increase and the powers Y and Z will remain unaltered.

31 Fig 31 shows the top view of a current balance. The wire frame ABCD is supported by the pivots P and Q. PBCQ lies within the magnetic field, whose flux density is to be measured. The sides AD and BC are equidistant from the pivots. Electrical connections are made to the frame through the pivots.

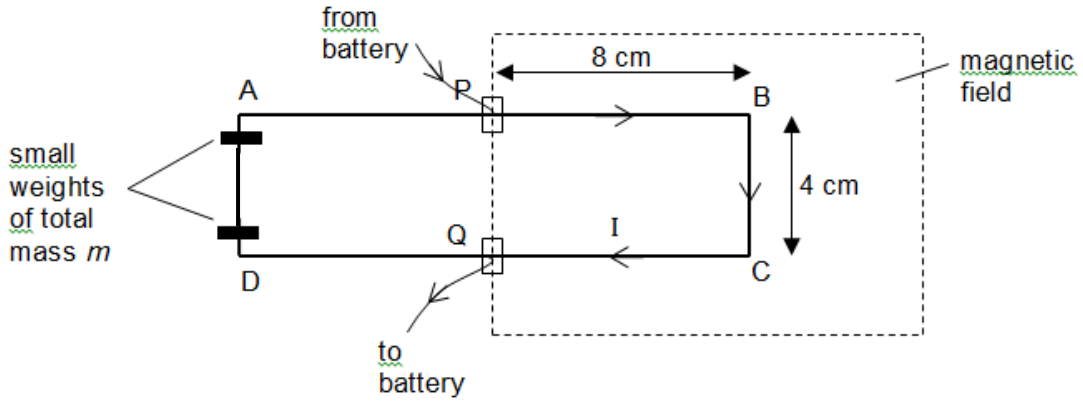


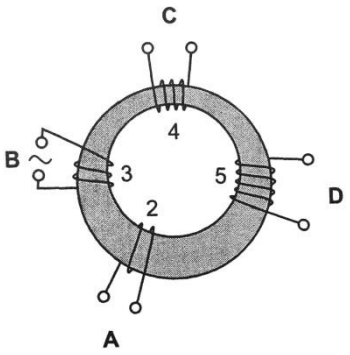
Fig 31

Given that the current I flowing in the current balance is 1.2 A, and the total mass of small weights *m* is 30 g, calculate the flux density of the magnetic field.

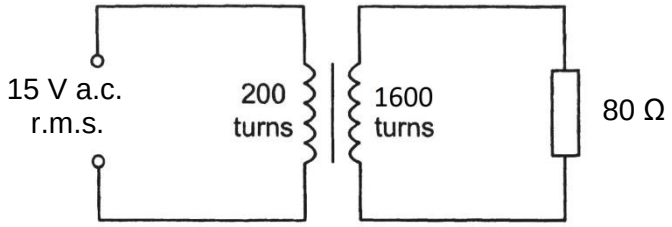
A 0.625 T **B** 3.1 T **C** 6.1 T **D** 625 T

32 A soft-iron ring of variable cross-section has four coils wound round it at the positions shown. The coils have 2, 3, 4 and 5 turns. The 3-turn coil is connected to an a.c. supply.

In which coil does the magnitude of the magnetic flux density have the least variation?



33 The primary of an ideal transformer has 200 turns and is connected to a 15 V root-mean-square (r.m.s.) supply. The secondary 1600 turns and is connected to a resistor of resistance 80 Ω, as shown in the diagram.



What are possible values of the secondary voltage, the secondary current and the mean power dissipated in the resistor?

	secondary voltage / V r.m.s.	**secondary current / A r.m.s.**	**mean power in resistor / W**
A	1.9	0.02	0.38
B	1.9	42	80
C	120	0.67	80
D	120	1.5	180

34 A laser point creates a spot on a screen as it reflects 70% of the light striking it. This light exerts radiation pressure on the screen.

The laser point is now moved twice as far away from the screen.

i. The radiation pressure remains the same because the intensity of the laser light remains constant.

ii. The radiation pressure decreases because the beam diverges and area of illumination increases.

iii. The radiation pressure decreases because energy of the light is lost due to scattering from air molecules and dust particles light travels a longer distance to the screen.

Which of the statements above is/are correct?

A i only

B ii only

C iii only

D ii and iii only

35 Which of the following statement on photoelectric effect is **not** an evidence for particulate nature of light?

A Emission of electrons happens as soon as light shines on metal.

B Increasing intensity of light increases rate at which electrons leave metal.

C Maximum speed of emitted electrons is dependent on the frequency of incident light.

D A minimum threshold frequency of light is needed.

36 Which of the following about doped semiconductors is correct?

		Charge of semiconductor	**Majority charge carriers**
A	**p – type**	positive	holes
	n – type	negative	electrons
B	**p – type**	neutral	holes
	n – type	neutral	electrons
C	**p – type**	positive	protons
	n – type	neutral	neutrons
D	**p – type**	neutral	protons
	n – type	neutral	electrons

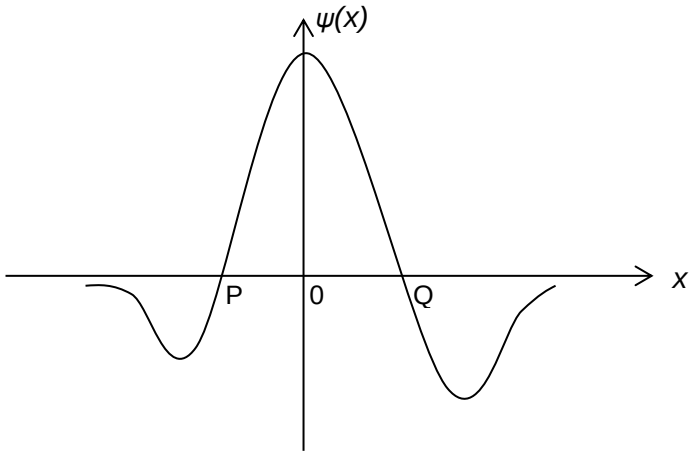
37 Suppose *Fuzzy*, a quantum-mechanical duck of mass 2.00 kg, lives in a world in which *h*, the Planck constant, is 2π J s.

Fuzzy is initially known to be within a pond 1.00 m wide.

What is the minimum uncertainty in the component of his velocity parallel to the width of the pond?

A 0.250 m s^{-1} **B** 1.00 m s^{-1} **C** 2.50 m s^{-1} **D** 3.14 m s^{-1}

38 The figure below shows the wave function $\psi(x)$ of an electron.



Which of the following statements is correct?

A The probability of locating the electron between positions P and Q is $\int_P^Q |\psi(x)|\, dx$.

B $|\psi(x)|^2$ is the probability of locating the electron within a given region.

C There is greater probability of locating the electron on the left of the vertical axis.

D The probability of locating the electron at $x = 0$ is the highest.

39 An electron is incident on a rectangular potential barrier with a kinetic energy of 2.0 eV. The barrier height is 6.0 eV and its width is $d = 1.0\times10^{-10}$ m. If the width of the barrier is reduced to d' and the transmission coefficient is doubled, the ratio $\frac{d'}{d}$ is

A 0.50 **B** 0.66 **C** 0.72 **D** 2.0

40 The activity of a radioactive sample decreases to one third of its original activity A_o in a period of 3 years. After 3 more years, its activity would be

A $\frac{1}{9}A_0$ **B** $\frac{1}{6}A_0$ **C** $\frac{1}{3}A_0$ **D** $\frac{2}{3}A_0$