MERIDIAN JUNIOR COLLEGE
Preliminary Examination
Higher 2

H2 Physics 9646/1

Paper 1 **25 September 2013**

1 hour 15 min

Class	Reg Number

Candidate Name _____

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.

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 Optical Mark Sheet (OMS).

Read very carefully the instructions on the OMS.

Write your name and class in the spaces provided on the OMS.

Shade your Index Number column using the following format:

1) first 2 digits is your index number in class (e.g. 5th student is shaded as "05");
2) ignore the last row of alphabets.

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_0	=	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	=	ρgh
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	=	$\frac{Q}{4\pi\varepsilon_0 r}$
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	=	$\frac{0.693}{t_{\frac{1}{2}}}$

Answer all 40 questions in this paper and shade your answers on the answer sheet provided.

1 When comparing systematic and random errors, the following pairs of properties of errors in an experimental measurement may be contrasted.

P_1 : error can possibly be eliminated
P_2 : error cannot possibly be eliminated
Q_1 : error is of constant sign and magnitude
Q_2 : error is of varying sign and magnitude
R_1 : error will be reduced by averaging repeated measurements
R_2 : error will not be reduced by averaging repeated measurements

Which properties apply to random errors?

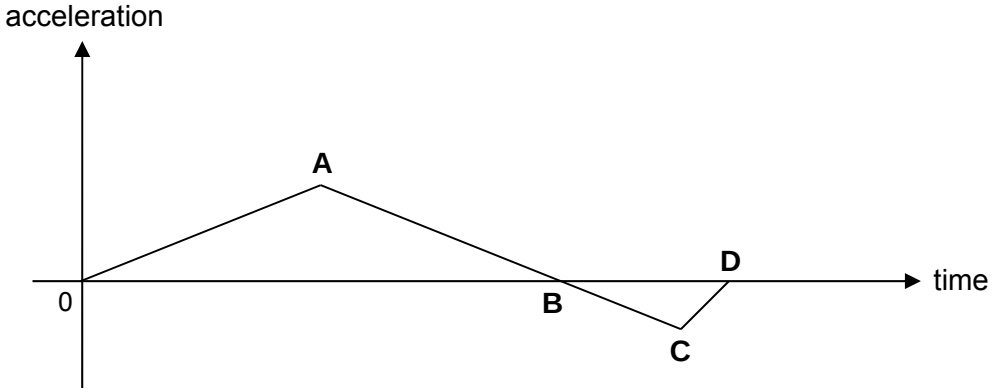
A P_1, Q_1, R_2
B P_1, Q_2, R_2
C P_2, Q_1, R_1
D P_2, Q_2, R_1

2 The formula for the period of a simple pendulum is $T = 2\pi\sqrt{\frac{l}{g}}$. Such a pendulum can be used to determine *g*.

The fractional error in measurement of the period *T* is $\pm x$ and that in the measurement of the length *l* is $\pm y$. The fractional error in the calculated value of *g* is no greater than

A 2x + y
B 2x – y
C x + y
D x – y

3 The acceleration-time graph of an object moving in a straight line is as shown. The object started its motion from rest.

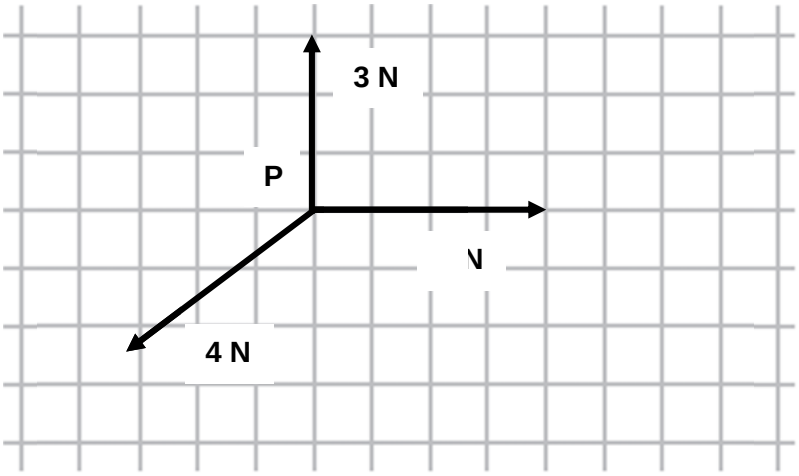


At which point is the body moving with the largest speed?

4 A car decelerates uniformly from 20 m s^{-1} to 15 m s^{-1} in 70 m. What further distance will it need to travel before it stops completely?

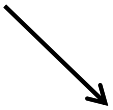
A 13 m
B 90 m
C 160 m
D 210 m

5 The vector diagram shows three coplanar forces acting on an object at **P**.



What is the direction of the resultant force?

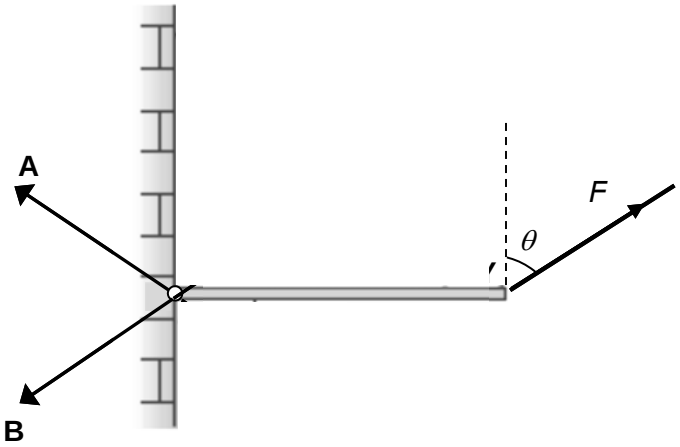
A 

B 

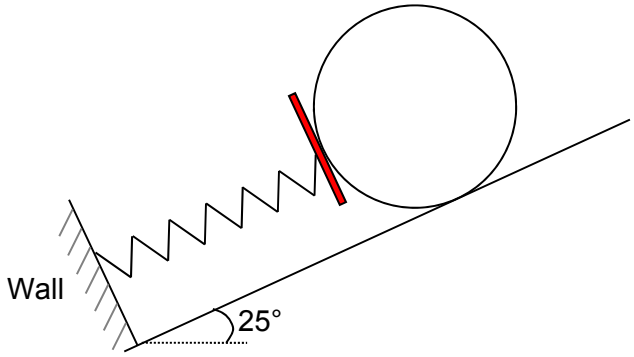
C 

D 

6 A uniform rod **XY** is freely hinged to the wall at **X**. It is held horizontal by a force *F* acting from **Y** at an angle θ to the vertical as shown in the diagram. Which arrow shows the direction of the reaction force exerted by the wall on the rod?



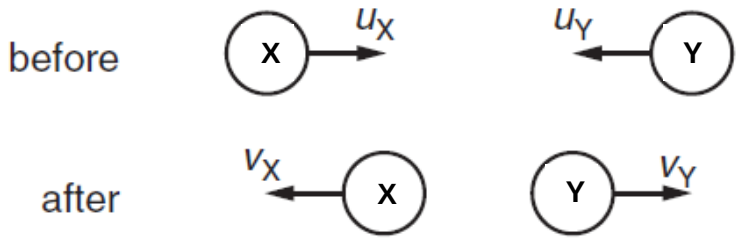
7 A sphere of mass 3.00 kg rests on a rough slope as shown. The frictional force between the sphere and the slope is given as 2.0 N. The spring obeys Hooke's Law. The spring constant is 500 N m^{-1}.



What is the compression of the spring?

A 0.0208 m
B 0.0248 m
C 0.0493 m
D 0.0548 m

8 Two balls **X** and **Y** approach each other along the same straight line and collide elastically. Their speeds are u_x and u_y respectively. After the collision they move apart with speeds v_x and v_y respectively. Their directions are shown on the diagram.



Which of the following equation is correct?

A $u_x - u_y = v_y - v_x$
B $u_x + u_y = v_x - v_y$
C $u_x + u_y = v_x + v_y$
D $u_x - u_y = v_x - v_y$

9 A box of weight 100 N is pushed 10 m up a slope inclined at 30° above the horizontal by a force of 150 N along the slope. The frictional force opposing the motion is 60 N. How much of the work done by the 150 N force is converted into kinetic energy and internal energy?

	Kinetic Energy / J	Internal Energy / J
A	400	600
B	900	600
C	400	0
D	600	900

10 An airplane has two jet engines. If each of the jet engines has an efficiency of 80%, what is the power input of each engine required to allow the plane to fly with a thrust of 200 kN at a speed of 250 m s^{-1}?

A 20.0 MW
B 31.3 MW
C 40.0 MW
D 62.5 MW

11 A model car moves in a horizontal circle of radius *R* at constant speed. The mass of the car is *M* and it makes one complete revolution in time *T*. Which of the following is the magnitude of the net force acting on the car?

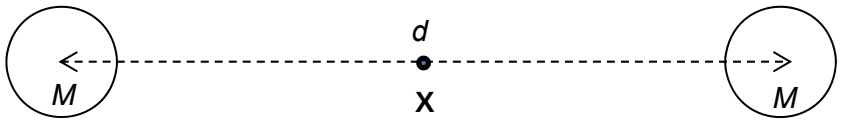
A $\frac{4\pi^2 MR}{T^2}$
B $4\pi^2 RMT^2$
C $\frac{2\pi MR}{T}$
D $2\pi RMT$

12 An artificial satellite travels in a circular orbit about the Earth. Its rocket engine is then fired and produces a force on the satellite exactly equal and opposite to that exerted by the Earth's gravitational field.

The satellite would then start to move

A along a spiral path towards Earth
B along the line joining it to the centre of the Earth (i.e. radially)
C along a tangent to the orbit
D in a circular orbit with a longer period

13 The centres of two isolated spherical stars each of mass *M* and radius *R* are separated by a distance *d* as shown in the diagram.



Point **X** is mid-way between the stars. The gravitational potential at point **X** due to the two stars is

A $-\frac{4GM}{d}$
B $-\frac{2GM}{d}$
C $-\frac{GM}{R}$
D zero

14 Planet **X** has a density of ρ, radius R and gravitational acceleration of a. What is the gravitational acceleration of Planet **Y** with density 2ρ and radius $2R$?

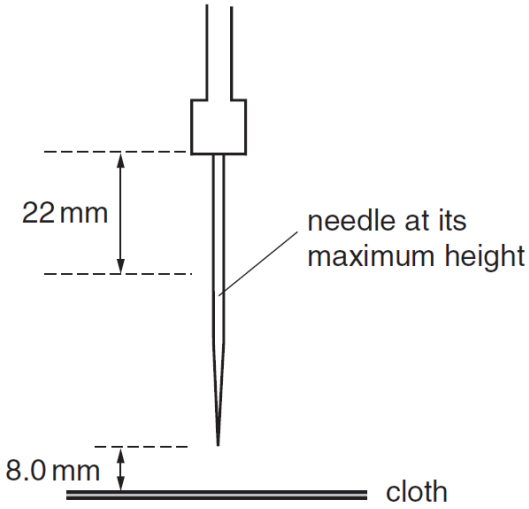
A $4a$ **B** $8a$
C a **D** $0.5a$

15 A particle of mass 5.0×10^{-3} kg performing simple harmonic motion of amplitude 150 mm takes 47 s to make 50 oscillations.

What is the maximum kinetic energy of the particle?

A 2.0×10^{-3} J **B** 2.5×10^{-3} J **C** 3.9×10^{-3} J **D** 5.0×10^{-3} J

16 The needle of a sewing machine is made to oscillate vertically through a total distance of 22 mm, as shown below.

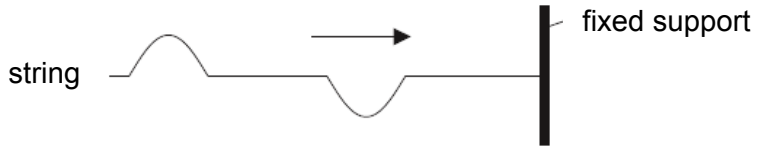


The oscillation is simple harmonic with a frequency of 4.5 Hz. The cloth that is being sewn is positioned 8.0 mm below the point of the needle when the needle is at its maximum height.

What is the speed of the needle as its tip just touches the cloth?

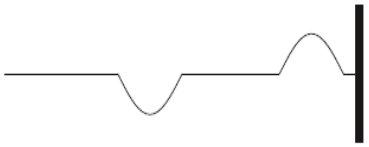
A 0.00317 m s^{-1} **B** 0.0848 m s^{-1} **C** 0.226 m s^{-1} **D** 0.299 m s^{-1}

17 A string is held horizontally with one end attached to a fixed support. Two pulses are created at the free end of the string. The pulses are moving towards the fixed support as shown in the diagram below.

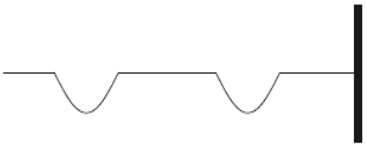


Which one of the following diagrams is a possible subsequent picture of the string?

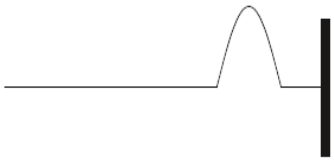
A



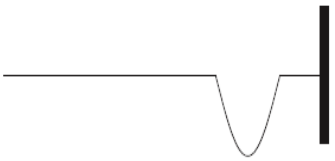
B



C

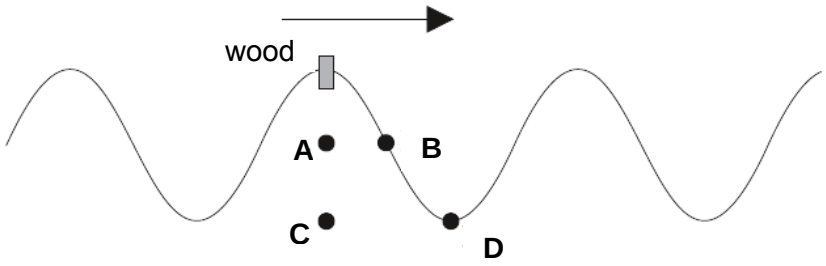


D



18 A water surface wave (ripple) is travelling to the right on the surface of a lake. The wave has period *T*. The diagram below shows the surface of the lake at a particular instant of time. A piece of wood is floating in the water in the position shown.

Which is the correct position of the wood a time $\frac{T}{4}$ later?



19 Interference maxima produced by a double source are observed at a distance of 1.0 m from the sources. In which one of the following cases are the maxima closest together?

A sound waves of wavelength 20 mm from sources 50 mm apart
B surface water waves of wavelength 10 mm from sources 200 mm apart
C red light from sources 4.0 mm apart
D blue light from sources 2.0 mm apart

20 Two pipes **A** and **B** are of the same length. Pipe **A** is closed at one end and pipe **B** is open at both ends. The fundamental frequency (first harmonic) of the closed pipe **A** is 220 Hz.

The best estimate for the fundamental frequency of the open pipe **B** is

A 880 Hz
B 440 Hz
C 110 Hz
D 55 Hz

21 80 J of energy is supplied to an ideal gas of volume 2.0×10^{-3} m^3 and at pressure of 1.0×10^5 Pa. The volume increases to 2.2×10^{-3} m^3, while the pressure remains constant. What is the increase in the internal energy of the gas?

A 50 J **B** 60 J **C** 100 J **D** 220 J

22 The temperature at which a liquid begins to boil is dependent on

A the mass of the liquid.
B the surface area of the liquid surface.
C the pressure acting on the liquid surface.
D the rate at which energy is supplied to the liquid.

23 Which of the following correctly describes the nature of electric potential and electric field strength?

	Electric Potential	**Electric Field Strength**
A	scalar	scalar
B	scalar	vector
C	vector	scalar
D	vector	vector

24 Which of the following is correct?

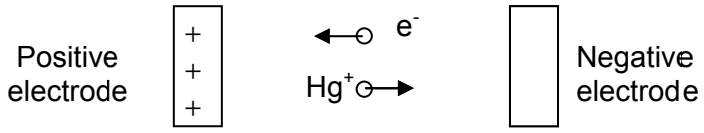
A Both gravitational and electric potential can be either negative or positive.
B It is possible to obtain a sphere of charge of 2.1×10^{-19} C.
C Electric field strength at a point due to two point charges is proportional to the product of the two charges.
D Electric field strength between two charged parallel plates is inversely proportional to the distance between the plates.

25 Four light bulbs are connected to a battery as shown in the diagram below. Each bulb operates at normal brightness and the ammeter (of negligible resistance) registers a steady current. Light bulbs **R** and **S** have double the resistance of light bulbs **P** and **Q**.

The filament of light bulb **S** breaks. What happens to the ammeter reading and to the brightness of the remaining bulbs?

	Ammeter reading	**Bulb brightness**
A	decrease	unchanged
B	decrease	decrease
C	increase	unchanged
D	increase	increase

26 A high potential difference is applied between the electrodes of a mercury discharge tube such that the gas between the electrodes is ionised.

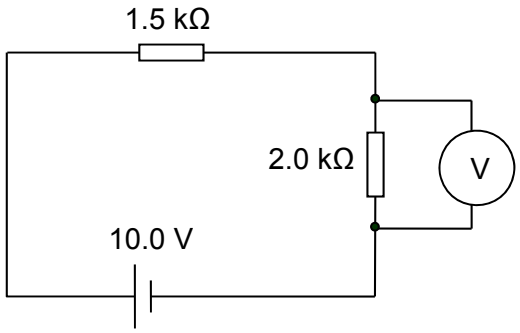


In each minute, 1.5×10^{15} electrons and 4.4×10^{15} positive mercury ions (singly charged) move past a cross-section of the tube in opposite directions.

What is the total current between the electrodes?

A 8.0 μA **B** 16 μA **C** 0.46 mA **D** 0.94 mA

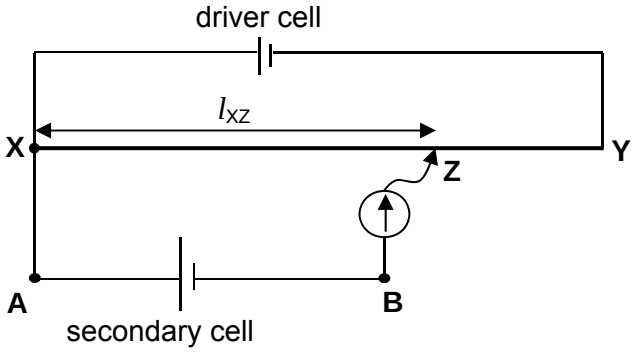
27 A 10.0 V cell of negligible internal resistance is connected to two resistors of resistance 2.0 kΩ and 1.5 kΩ. A voltmeter of resistance 1.0 kΩ is connected across the 2.0 kΩ resistor.



What is the voltmeter reading?

A 2.7 V **B** 3.1 V **C** 4.3 V **D** 5.7 V

28 In a typical potentiometer circuit as shown below, the balance length l_{XZ} can be increased by the following methods except by



A decreasing the emf of the driver cell.

B increasing the emf of the secondary cell.

C adding a fixed resistor in series with the secondary cell.

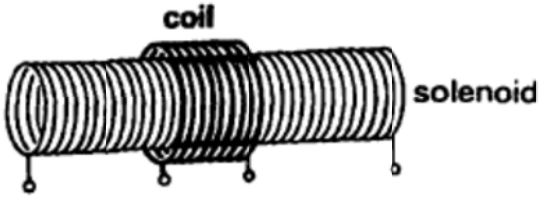
D adding a fixed resistor in series with the driver cell.

29 A horizontal wire carries current at right angles to a horizontal magnetic field. The wire is then turned through 90° and so becomes parallel with the magnetic field.

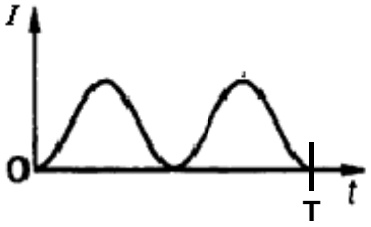
What is the direction of the initial and final force on the wire?

	Initial force	**Final force**
A	vertical	horizontal
B	vertical	zero
C	horizontal	zero
D	zero	vertical

30 The diagram shows a short coil wound over the middle part of a long solenoid.

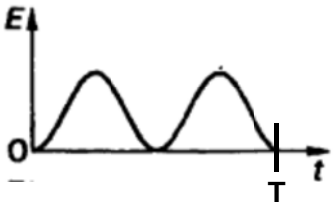


The solenoid current I is varied with time t as shown in the sketch graph. As a consequence, the flux density of the magnetic field due to the solenoid varies with time. The relation between B and I is $B = \mu_o n I$ where n is the number turns per unit length.

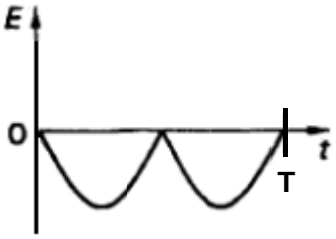


Which graph shows how the e.m.f. E induced in the short coil varies with time t?

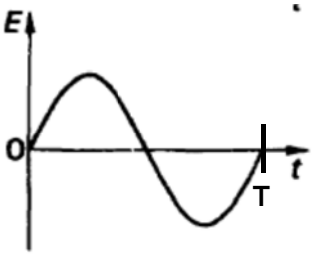
A



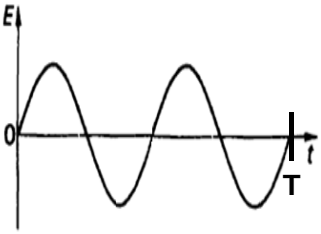
B



C



D



31 A circular coil has area A and is placed in a uniform magnetic field such that its plane is perpendicular to the magnetic field. If the magnetic field has magnitude B and the plane of the coil is turned through 180° about the axis along the diameter in time t, what is the magnitude of the average induced e.m.f.?

A zero **B** $\frac{BA}{t}$ **C** $\frac{2BA}{t}$ **D** $\frac{BA}{2t}$

32 A neutral sub-atomic particle is at rest in a magnetic field of flux density B. It splits into two particles each of mass m, one of which has a negative charge $-q$. The particles then move with velocities perpendicular to the magnetic field.

After what time will the particles collide?

A $\frac{m\pi}{Bq}$ **B** $\frac{Bq}{m}$ **C** $\frac{2m\pi}{Bq}$ **D** will not collide

33 A generator produces a r.m.s current of 60 A at a r.m.s voltage of 120 V. The r.m.s voltage is stepped up to 4500 V by an ideal transformer and transmitted through a power line of total resistance 1.0 Ω.

What is the percentage of power lost in the transmission line?

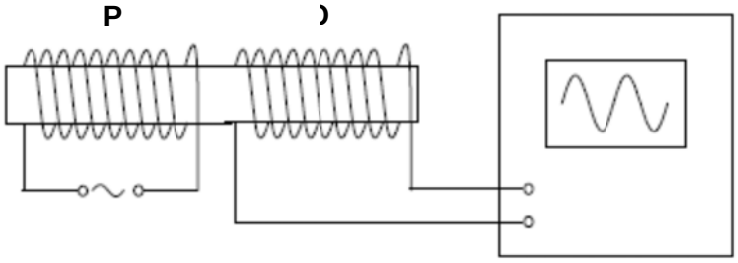
A 0.012 %

B 0.036 %

C 0.048 %

D 0.060 %

34 A coil **P** is connected to a 50 Hz alternating supply of constant peak voltage. Coil **P** is linked via a soft-iron core to a separate coil which is connected to the Y-input terminals of a cathode-ray oscilloscope. A sinusoidal trace appears on the screen of the oscilloscope.



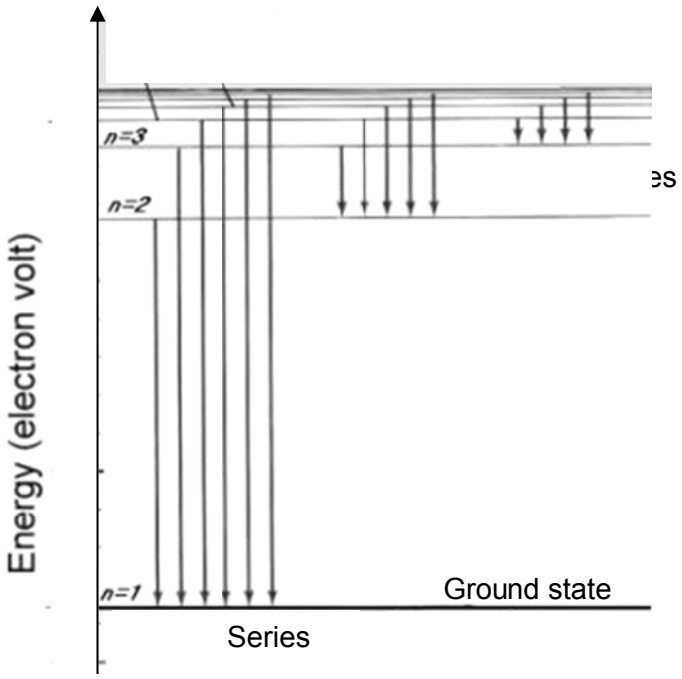
What would be the effect on the trace if the soft-iron core is removed?

	Height of trace	**Number of cycles on screen**
A	Decreases	Stays the same
B	Decreases	Decreases
C	Increases	Stays the same
D	Increases	Decreases

35 When a parallel beam of white light passes through sodium vapour, dark lines appear in the spectrum of the emergent light. This is because energy is absorbed by the sodium atoms and

A is re-radiated uniformly in all directions
B is re-radiated gradually over time.
C is re-radiated as ultra-violet radiation.
D is not re-radiated at all.

36 The diagram below shows the energy level diagram of hydrogen.



Which one of the following gives the correct region of the electromagnetic spectrum of the observed spectral lines?

	Lyman Series	Balmer Series	Paschen Series
A	Infra-red	Infra-red	Visible light
B	Infra-red	Visible light	Ultra-violet
C	Ultra-violet	Visible light	Infra-red
D	Ultra-violet	Infra-red	Visible light

37 Which statement about an ideal intrinsic semiconductor is correct?

A The donor energy level lies just below the conduction band.
B There are equal number of electrons in the valence band and the holes in the conduction band.
C It can behave like an insulator at low temperature.
D There is an energy gap of 5 eV to 10 eV between the valence and conduction band.

38 Which statement about stimulated emission is correct?

A The emitted photon may be of a different phase as the incident photon.
B An excited atom will undergo stimulated emission when any photon is incident on it.
C An electron can trigger a stimulated emission.
D A photon that can cause an atom to de-excite from state $\mathbf{E_2}$ to $\mathbf{E_1}$ through stimulated emission is just as likely to cause another atom to excite from state $\mathbf{E_1}$ to $\mathbf{E_2}$ through stimulated absorption.

39 An isotope of carbon, ^{14}C is unstable and decays by β-emission with a half-life of 5740 years. Two archeological samples of organic matter were found at a site. The number of ^{14}C in one sample is greater than the other by a factor of 16. The difference in age (in years) between the two samples is

A 1 913
B 17 220
C 22 960
D 45 920

40 A detector is used for monitoring an α-source and a reading of 120 counts is observed. After a time equal to the half-life of the α-source, the reading has fallen to 64 counts. If a 5 mm thick lead sheet is inserted between the α-source and the detector, the reading would probably be

A 0 count
B 4 counts
C 8 counts
D 32 counts

End of Paper