福建中學

FUKIEN SECONDARY SCHOOL

S6 Mock Examination (2021-2022)

Physics Paper 1

(2 hours 30 minutes)

Section A: Multiple-Choice Questions

Date: 25th January 2022 Name: ______________________

Time: 8:30a.m. – 11:00a.m. Class: __________ No.: ________

Instructions to students:

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.
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 on Question-Answer Book. **The Answer Sheet for Section A and the Question-Answer Book for Section B must be handed in 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.

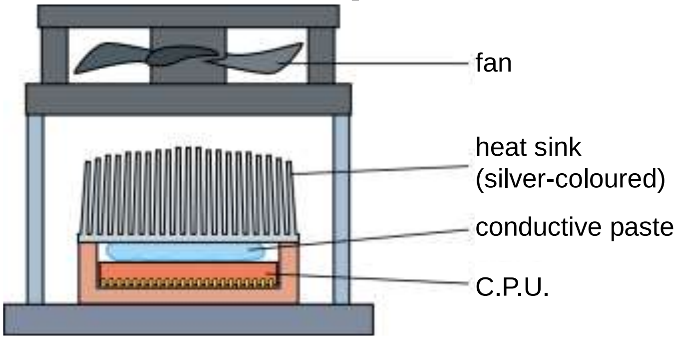
INSTRUCTIONS FOR SECTION A (MULTIPLE-CHOICE QUESTIONS)

1. Read the instructions on the Answer Sheet carefully. Insert the information required in the spaces provided.
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 should use an **HB** pencil to mark all your answers on the Answer Sheet. Wrong marks must be completely erased.
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.

Section A

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

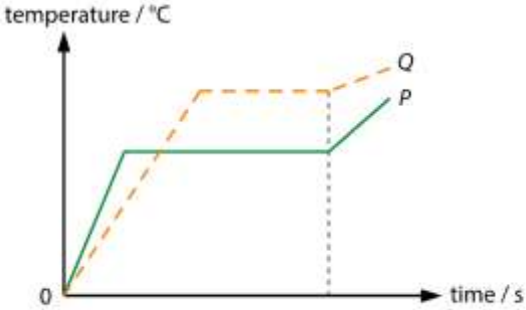
1. The following figure shows the central processing unit (C.P.U.) of a computer. A heat sink and a fan are installed on the unit to help it lose heat.



What are the main processes of heat transfer facilitated by the heat sink and the fan respectively?

	silvered heat sink	fan
A.	conduction	convection
B.	conduction	radiation
C.	radiation	convection
D.	radiation	radiation

2. Two substances *P* and *Q*, both in solid form initially, are heated up by two heaters of equal power. The figure below shows how their temperatures vary with time.



Which of the following statements about *P* and *Q* must be correct?

(1) *P* has a lower melting point than *Q*.

(2) *P* has a larger specific latent heat of fusion than *Q*.

(3) The solid form of *P* has a smaller heat capacity than that of *Q*.

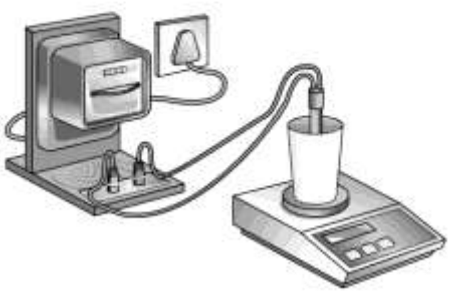
A. (1) and (2) only

B. (1) and (3) only

C. (2) and (3) only

D. (1), (2) and (3)

3. The diagram below shows the apparatus used to find the specific latent heat of vaporization of water.



Which of the following factors will make the result obtained smaller than the true value?

(1) Some energy supplied by the heater is lost to the surroundings.

(2) Some water splashes out of the cup as it boils.

(3) Some steam condenses and drips back into the cup.

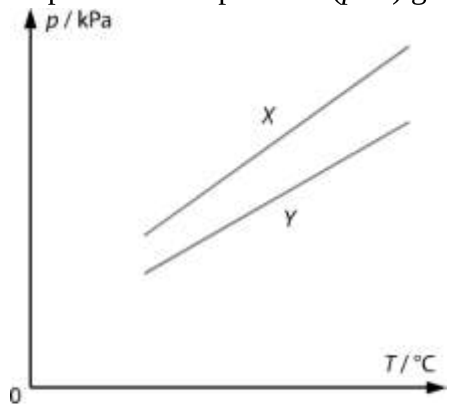
A. (1) only

B. (2) only

C. (1) and (2) only

D. (2) and (3) only

*4. Two ideal monatomic gases *X* and *Y* have the same volume and their volumes are kept constant throughout. Their pressure–temperature (*p*–*T*) graphs are shown below.



Which of the following statements **must** be correct?

(1) The two graphs intercept the temperature axis at the same point.

(2) Gas *X* has more atoms than *Y*.

(3) Gas *X* is denser than *Y* (in terms of mass density).

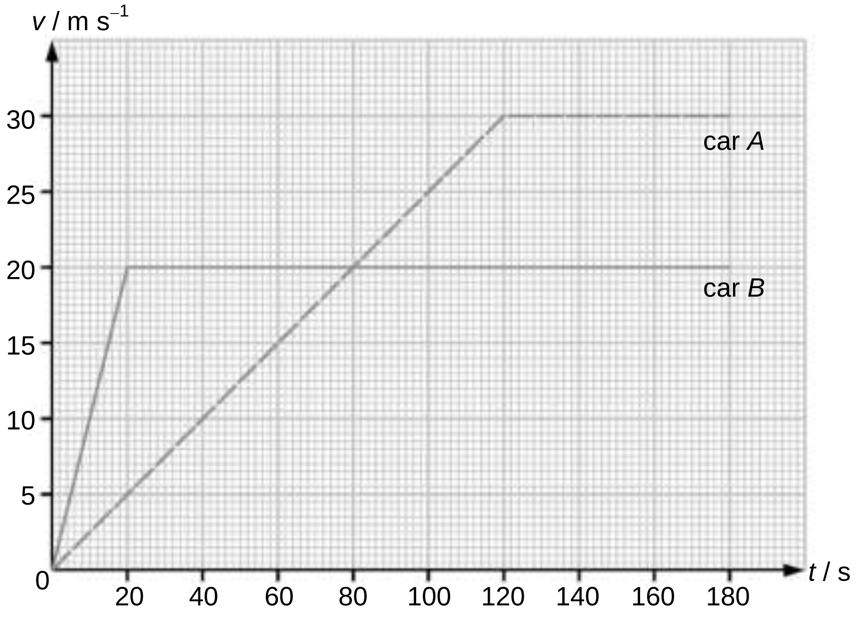
A. (1) and (2) only

B. (1) and (3) only

C. (2) and (3) only

D. (1), (2) and (3)

5. Two cars *A* and *B* are travelling on a straight road. At $t = 0$, they start from the same position. The graph below shows how their velocities v vary with time t.



Which of them finishes 2 km first and which of them finishes 2.5 km first?

	2 km	**2.5 km**
A.	car *A*	car *A*
B.	car *A*	car *B*
C.	car *B*	car *A*
D.	car *B*	car *B*

6. Tom is throwing a ball vertically upwards from the ground to Amy, who is on the second floor of a building and is 6 m above Tom. Amy wants the ball to just reach her. What initial speed should Tom throw the ball? Neglect air resistance.

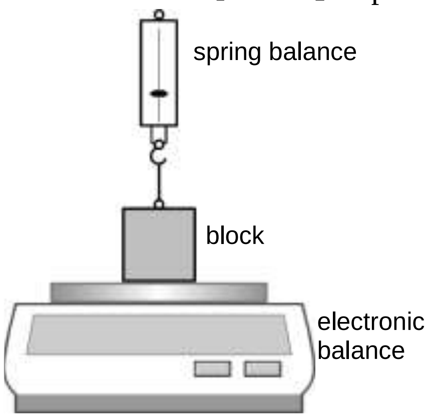
A. 7.67 m s^{-1}

B. 10.8 m s^{-1}

C. 58.9 m s^{-1}

D. 118 m s^{-1}

7. A block of mass 300 g is initially at rest on an electronic balance. It is then pulled using a spring balance in the vertical direction as shown below. The readings of the spring balance and the electronic balance are W_1 and W_2 respectively.



Which of the following statements is/are correct?

(1) When the block is lifted with acceleration, the reading of the spring balance would be smaller than the actual weight of the block.

(2) The sum of W_1 and W_2 is always equal to 3 N as long as the block is still in contact with the electronic balance.

(3) The weight of the block is 3 N.

A. (1) and (2) only

B. (1) and (3) only

C. (2) and (3) only

D. (1), (2) and (3)

8. Two blocks X and Y are placed side by side on a smooth table. The ratio of their masses is $m_X : m_Y = 3 : 2$. When the blocks are pushed from the left by a horizontal force F, they move together to the right.

Block X can be on the left (situation 1) or on the right (situation 2). No matter in which situation, there is a force between the two blocks acting on each other. What is ratio of this force in situation 1 to that in situation 2?

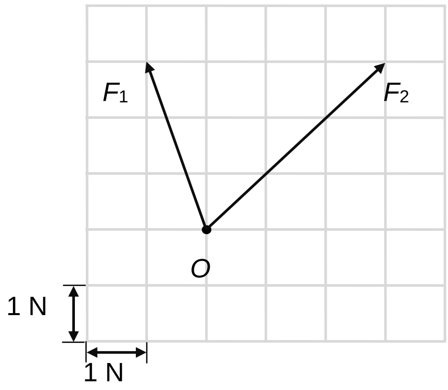
A. 1 : 1

B. 2 : 3

C. 2 : 5

D. 3 : 2

9. The figure below shows two forces F_1 and F_2 acting on a point object O. An additional force F_3 is now added to keep O in equilibrium.



What is the magnitude of F_3?

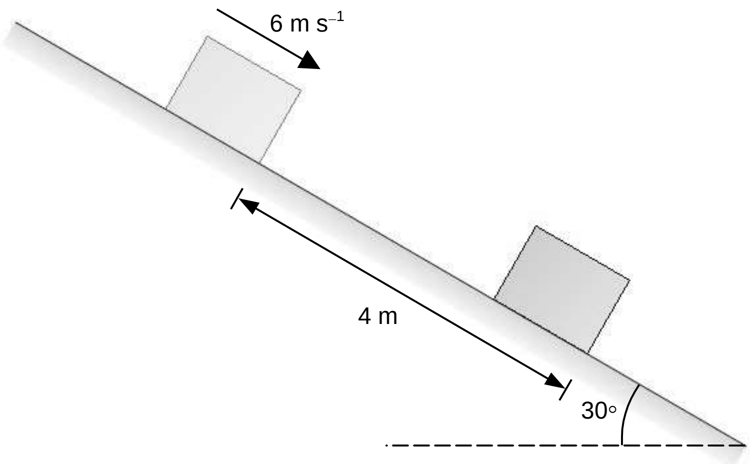
A. 4.0 N

B. 5.3 N

C. 6.3 N

D. 7.4 N

10. A block of mass 2 kg is sliding down an incline that makes an angle of 30° with the horizontal. The block decelerates from $6\,\mathrm{m\,s^{-1}}$ to a stop in a distance of 4 m.



What is the friction between the block and the incline?

A. 1 N

B. 9 N

C. 10 N

D. 19 N

11. A bullet of mass 40 g travels horizontally. It hits a wooden block at 330 m s^{-1} and comes out of the block at 208 m s^{-1}. If it takes the bullet 0.1 s to penetrate the block, what is the energy loss of the bullet?

A. 865 J

B. 1310 J

C. 2178 J

D. 13 100 J

*12. A spacecraft carrying an astronaut of mass m travels back to the Earth from the space. When the spacecraft is at an altitude R above the Earth's surface, its acceleration is $2g$ pointing away from the Earth's centre. What is the apparent weight of the astronaut at this instant? R is the radius of the Earth and g is the acceleration due to gravity on the Earth's surface.

A. $2.25mg$

B. $2.5mg$

C. $2.75mg$

D. $3mg$

13.

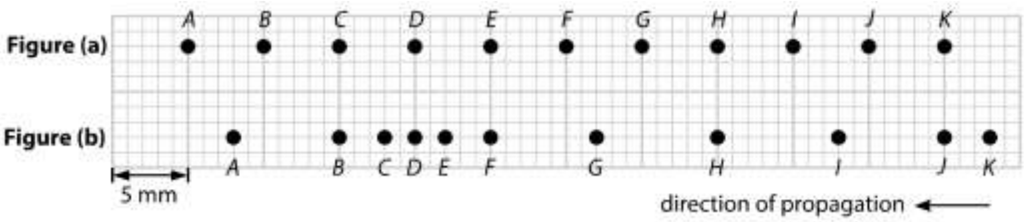


Figure (a) shows the equilibrium positions of a series of particles A to K in a medium. When a longitudinal wave is travelling to the left through the medium, the positions of the particles at a certain instant are shown in Figure (b). Which of the following statements is/are correct?

(1) The wavelength of the longitudinal wave is 4 cm.

(2) Particles C and G are in antiphase.

(3) At the instant shown in Figure (b), particle K is moving to the right.

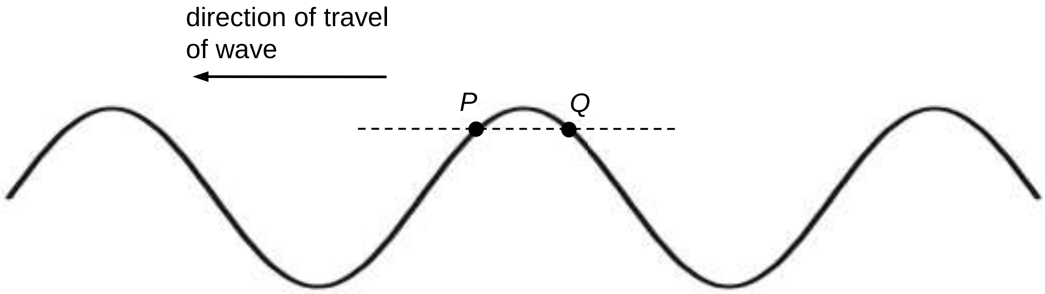
A. (2) only

B. (3) only

C. (1) and (2) only

D. (1) and (3) only

14. A transverse wave of period T travels along a string to the left. The figure below shows its waveform at time t = 0. Particles P and Q are at the same level at this moment.



Which of the following statements about particles P and Q are correct?

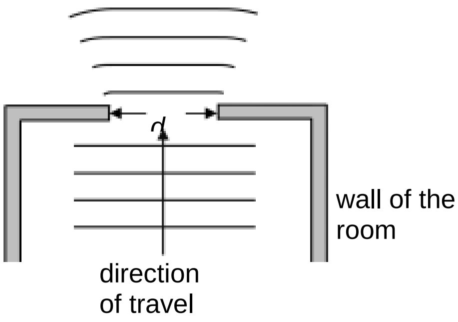
(1) They have the same displacement at $t = \frac{1}{4}T$.

(2) They have the same displacement at $t = \frac{1}{2}T$.

(3) They travel the same distance between t = 0 and $t = \frac{1}{2}T$.

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

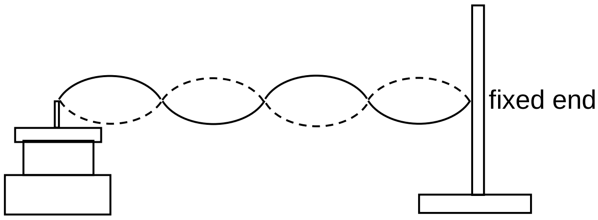
15. A sound wave produced inside a room passes through a doorway and diffracts. The frequency of the sound wave is f. The width d of the doorway is longer than the wavelength of the sound.



Under which of the following changes does the sound wave diffracts most noticeably?

A. Double f and reduce d by half
B. Keep f unchanged and double d
C. Reduce f by half and double d
D. Reduce f by half and keep d unchanged

16. A string is fixed at one end and tied to a vibrator at the other end. The vibrator is moved to a position so that the string is stretched. When the vibrator vibrates at 30 Hz, a stationary wave is formed as shown below.



Which of the following vibrating frequencies of the vibrator does **NOT** produce a stationary wave on the string?

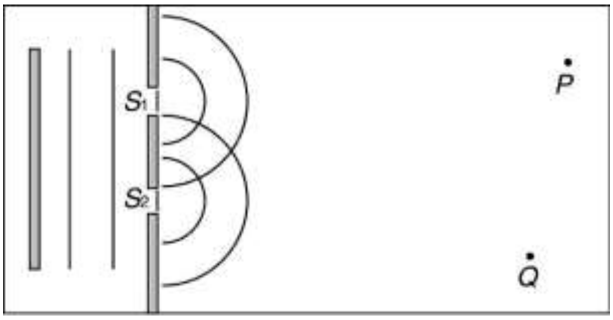
A. 7.5 Hz

B. 20 Hz

C. 37.5 Hz

D. 45 Hz

17. In the following figure, a plane wave travels towards two narrow gaps and circular waves come out from the gaps. *P* is 15 cm away from S_1 and 20 cm away from S_2, while *Q* is 14 cm away from S_1 and 12 cm away from S_2. The wavelengths of the waves are 2 cm.

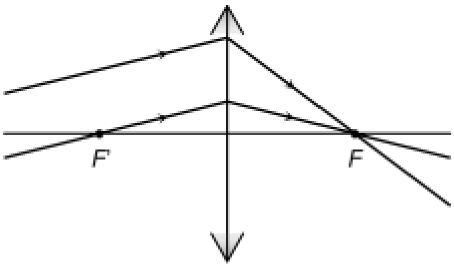


If the frequency of the vibrator is doubled, what kind of interference will occur at *P* and *Q*?

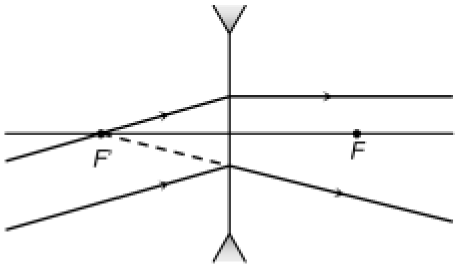
	P	***Q***
A.	Constructive	Constructive
B.	Constructive	Destructive
C.	Destructive	Constructive
D.	Destructive	Destructive

18. Which of the following figures is/are correct? (Note: *F* and *F′* are the foci of the lens.)

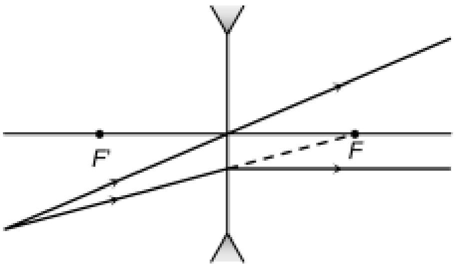
(1)



(2)



(3)



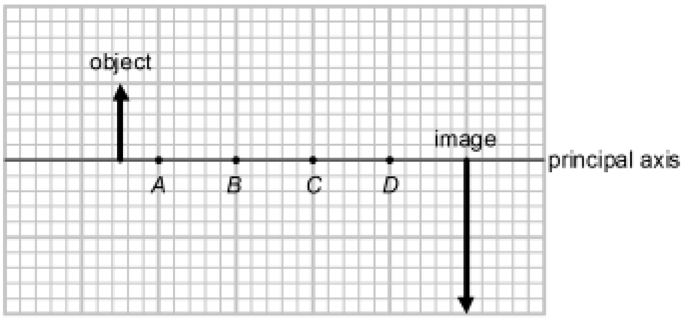
A. (2) only

B. (3) only

C. (1) and (2) only

D. (1) and (3) only

19. The figure above shows an object and its image formed by a convex lens. What are the positions of the lens and its principal focus?

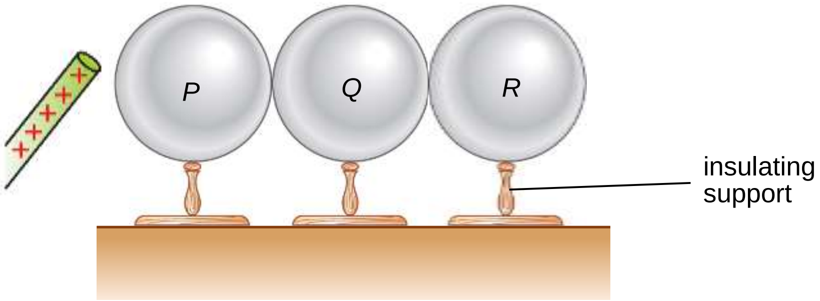


	Position of the lens	Position of the principal focus
A.	*A*	*B*
B.	*A*	*C*
C.	*B*	*C*
D.	*B*	*D*

*20. An object is placed 20 cm in front of a lens and forms an erect image at a position 30 cm from the lens. What are the type and the focal length of the lens?

	Type of lens	**Focal length**
A.	concave	60 cm
B.	concave	12 cm
C.	convex	60 cm
D.	convex	12 cm

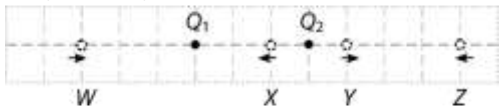
21. The figure below shows three insulated uncharged sphere *P*, *Q* and *R* in contact. A positively charged rod is brought near *P* without touching it. After earthing *Q* momentarily, *R* is isolated from *Q*. Afterwards, the charged rod is removed.



What are the charges on *P*, *Q* and *R* after the charged rod is removed?

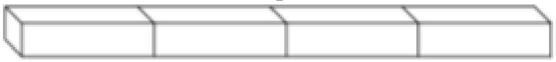
	P	***Q***	***R***
A.	zero	zero	zero
B.	negative	zero	positive
C.	negative	zero	zero
D.	negative	negative	zero

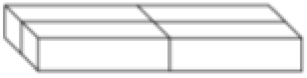
*22. Two point charges Q_1 and Q_2 are fixed on a straight line as shown below. The arrows in the figure indicate the directions of the electric forces acting on a positive test charge placed at those positions. Which of the following can be the sign and magnitude (in the same arbitrary units) of Q_1 and Q_2?

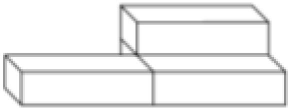


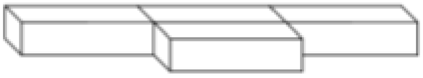
	Q_1	Q_2
A.	−4	+1
B.	+4	−1
C.	−1	+4
D.	+1	−4

23. Four identical conducting blocks are connected in various ways. Which of the following will result in the smallest equivalent resistance across the two ends?

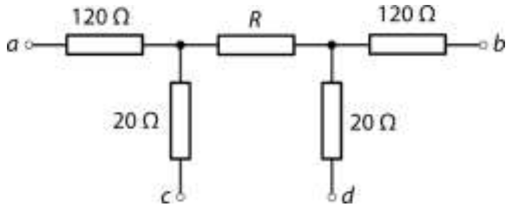
A. 

B. 

C. 

D. 

24. The figure below shows a network of resistors.



If a voltage of 100 V is applied across terminals *a* and *b*, the potential difference between *c* and *d* is 40 V. If the voltage of 100 V is applied across terminal *c* and *d*, what is the potential difference between *a* and *b*?

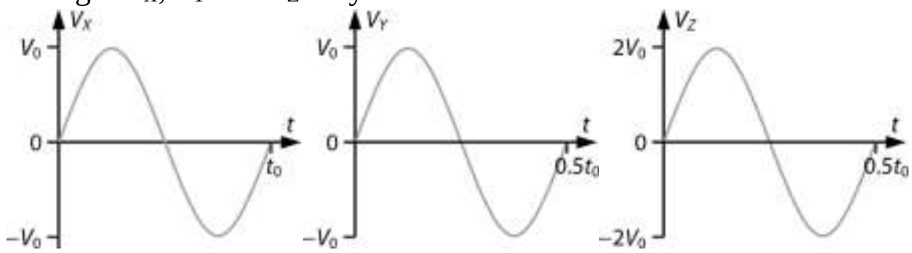
A. 80 V

B. 60 V

C. 40 V

D. 20 V

*25 Three voltages V_X, V_Y and V_Z vary with time *t* as shown below.



Find the ratio of their r.m.s. voltages.

A. $1 : 1 : \sqrt{2}$

B. $1 : 1 : 2$

C. $1 : \sqrt{2} : 2$

D. $1 : \sqrt{2} : 2\sqrt{2}$

26. Current I passes through a long solenoid of N turns. The length and radius of the solenoid are l and r respectively. The magnetic field produced inside the solenoid is B. Another long solenoid has $2N$ turns, a length of $2l$ and a radius of $2r$. If the current passing through this solenoid is $2I$, what is the magnetic field produced inside this solenoid?

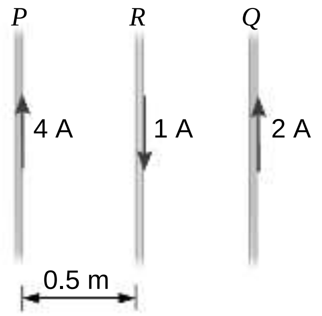
A. $4B$

B. $2B$

C. B

D. $\frac{B}{2}$

27. Three long straight wires P, Q and R are placed on the same plane in vacuum. The wires are equally spaced and the sizes and directions of the currents in the wires are as shown below.



Find the resultant force per unit length acting on Q.

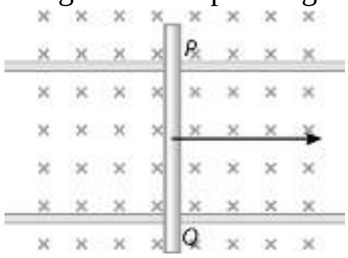
A. 4×10^{-7} N m^{-1} (to the right)

B. 4×10^{-7} N m^{-1} (to the left)

C. 8×10^{-7} N m^{-1} (to the right)

D. 8×10^{-7} N m^{-1} (to the left)

28. A metal rod PQ is placed on two parallel conducting rails as shown below. The whole set-up is placed in a uniform magnetic field pointing into the paper.



The rod is now being pulled to the right. Which of the following statements is correct?

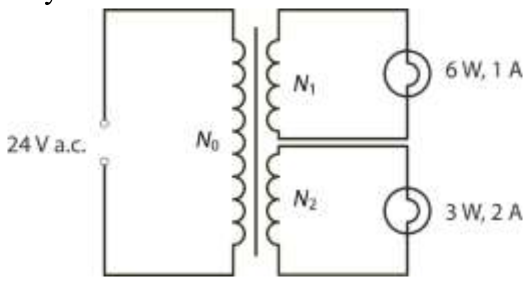
A. Current flows from P to Q.

B. Current flows from Q to P.

C. E.m.f. is induced in the rod and P is at a higher potential.

D. E.m.f. is induced in the rod and Q is at a higher potential.

*29. The figure below shows an ideal transformer with two secondary coils, each connected to a light bulb working at its rated power. The bulbs are marked '6 W, 1 A' and '3 W, 2 A' respectively.



What are the turns ratios $N_0 : N_1 : N_2$ and of the transformer?

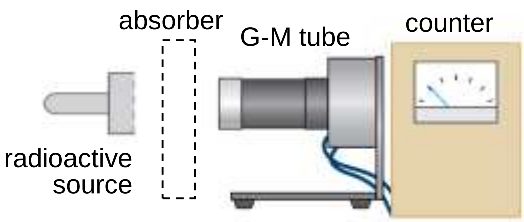
A. 8 : 2 : 1

B. 8 : 1 : 2

C. 16 : 2 : 1

D. 16 : 4 : 1

30. A student puts a radioactive source very close to a G-M tube. Then he puts different absorbers between them in turn. He records the count rate for each absorber in the table below.

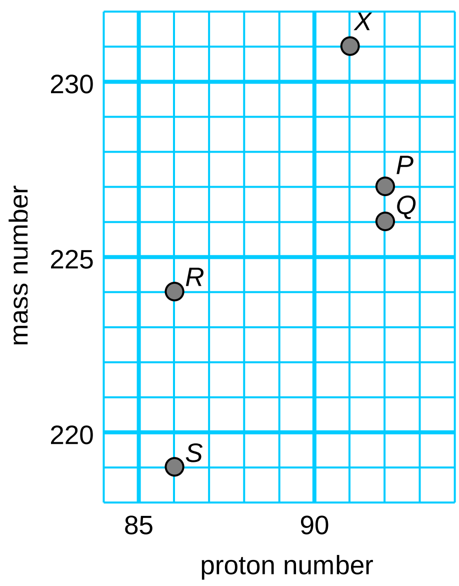


Absorber	Count rate / min^{-1}
–	328
A sheet of paper	*X*
5 mm aluminium	*Y*
25 mm lead	*Z*
50 mm lead	50

If the radioactive source emits only α and γ radiation, which of the following is most likely to be the values of *X*, *Y* and *Z*?

	X	***Y***	***Z***
A.	147	138	85
B.	147	85	53
C.	320	147	53
D.	320	85	71

31. A nuclide X as shown on the right below undergoes a series of α-α-α-β decays. Which of P, Q, R and S is the final product of the decays?



A. P

B. Q

C. R

D. S

32. In which of the following does nuclear fusion take place?

(1) The Sun

(2) An exploding hydrogen bomb

(3) The nuclear reactor in Daya Bay nuclear plant

A. (1) and (2) only

B. (1) and (3) only

C. (2) and (3) only

D. (1), (2) and (3)

*33. In a nuclear reaction, ${}^{15}_{7}\text{N}$ captures a proton and forms ${}^{12}_{6}\text{C}$ by emitting an α particle.

Given: mass of ${}^{15}_{7}\text{N}$ = 15.001 089 u

mass of ${}^{12}_{6}\text{C}$ = 12.000 000 u

mass of ${}^{4}_{2}\text{He}$ = 4.001 505 u

mass of ${}^{1}_{1}\text{p}$ = 1.007 276 u

How much energy is released in this reaction?

A. 1.19×10^{-9} J

B. 8.93×10^{-10} J

C. 1.03×10^{-12} J

D. 1.18×10^{-18} J

END OF SECTION A

List of data, formulae and relationships

Data

molar gas constant	$R = 8.31$ J mol^{-1} K^{-1}
Avogadro constant	$N_A = 6.02 \times 10^{23}$ mol^{-1}
acceleration due to gravity	$g = 9.81$ m s^{-2} (close to the Earth)
universal gravitational constant	$G = 6.67 \times 10^{-11}$ N m^2 kg^{-2}
speed of light in vacuum	$c = 3.00 \times 10^8$ m s^{-1}
charge of electron	$e = 1.60 \times 10^{-19}$ C
electron rest mass	$m_e = 9.11 \times 10^{-31}$ kg
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}$ C^2 N^{-1} m^{-2}
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}$ H m^{-1}
atomic mass unit	u = 1.661×10^{-27} kg (1 u is equivalent to 931 MeV)
astronomical unit	AU = 1.50×10^{11} m
light year	ly = 9.46×10^{15} m
parsec	pc = 3.09×10^{16} m = 3.26 ly = 206 265 AU
Stefan constant	$\sigma = 5.67 \times 10^{-8}$ W m^{-2} K^{-4}
Planck constant	$h = 6.63 \times 10^{-34}$ 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

$\left|\frac{\Delta f}{f_0}\right| \approx \frac{v}{c} \approx \left|\frac{\Delta\lambda}{\lambda_0}\right|$ Doppler effect

Energy and Use of Energy

$E = \frac{\Phi}{A}$ illuminance

$\frac{Q}{t} = k\frac{A(T_H - T_C)}{d}$ rate of energy transfer by conduction

$U = \frac{k}{d}$ thermal transmittance U-value

$P = \frac{1}{2}\rho Av^3$ maximum power by wind turbine

Atomic World

$\frac{1}{2}m_e v_{max}^2 = hf - \phi$ Einstein's photoelectric equation

$E_n = -\frac{1}{n^2}\left\{\frac{m_e e^4}{8h^2\varepsilon_0^2}\right\} = -\frac{13.6}{n^2}$ 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)

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
A2.	$E = l\Delta m$	energy transfer during change of state
A3.	$pV = nRT$	equation of state for an ideal gas
A4.	$pV = \frac{1}{3}Nm\overline{c^2}$	kinetic theory equation
A5.	$E_K = \frac{3RT}{2N_A}$	molecular kinetic energy
B1.	$F = m\frac{\Delta v}{\Delta t} = \frac{\Delta p}{\Delta t}$	force
B2.	moment = $F \times d$	moment of a force
B3.	$E_P = mgh$	gravitational potential energy
B4.	$E_K = \frac{1}{2}mv^2$	kinetic energy
B5.	$P = Fv$	mechanical power
B6.	$a = \frac{v^2}{r} = \omega^2 r$	centripetal acceleration
B7.	$F = \frac{Gm_1m_2}{r^2}$	Newton's law of gravitation
C1.	$\Delta y = \frac{\lambda D}{a}$	fringe width in double-slit interference
C2.	$d\sin\theta = n\lambda$	diffraction grating equation
C3.	$\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$	equation for a single lens

D1.	$F = \frac{Q_1Q_2}{4\pi\varepsilon_0 r^2}$	Coulomb's law
D2.	$E = \frac{Q}{4\pi\varepsilon_0 r^2}$	electric field strength due to a point charge
D3.	$E = \frac{V}{d}$	electric field between parallel plates (numerically)
D4.	$R = \frac{\rho l}{A}$	resistance and resistivity
D5.	$R = R_1 + R_2$	resistors in series
D6.	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$	resistors in parallel
D7.	$P = IV = I^2R$	power in a circuit
D8.	$F = BQv\sin\theta$	force on a moving charge in a magnetic field
D9.	$F = BIl\sin\theta$	force on a current-carrying conductor in a magnetic field
D10.	$B = \frac{\mu_0 I}{2\pi r}$	magnetic field due to a long straight wire
D11.	$B = \frac{\mu_0 NI}{l}$	magnetic field inside a long solenoid
D12.	$\varepsilon = N\frac{\Delta\Phi}{\Delta t}$	induced e.m.f.
D13.	$\frac{V_s}{V_p} \approx \frac{N_s}{N_p}$	ratio of secondary voltage to primary voltage in a transformer
E1.	$N = N_0 e^{-kt}$	law of radioactive decay
E2.	$t_{\frac{1}{2}} = \frac{\ln 2}{k}$	half-life and decay constant
E3.	$A = kN$	activity and the number of undecayed nuclei
E4.	$\Delta E = \Delta mc^2$	mass-energy relationship