Solution to 1819 S6 Physics Mock Exam

Paper 1

Section A

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
C	D	A	D	C	B	A	C	A	D	B	C	C	D	A

16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
D	D	B	D	C	A	A	C	B	B	D	B	A	D	C

31	32	33
B	B	C

Section B

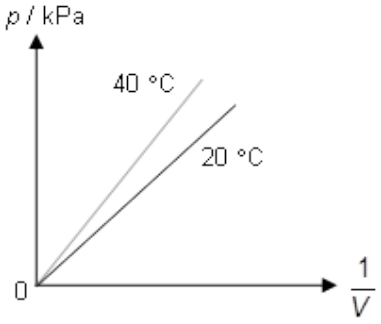
1. (a) By $pV = nRT$, 1M

$n = \frac{pV}{RT} = \frac{150 \times 10^3 \times 50 \times 10^{-6}}{8.31 \times (273+20)} = 3.08 \times 10^{-3}$ mol $\quad (3.0803 \times 10^{-3})$ 1A

3.08×10^{-3} mol of gas is used.

(b) Pressure $= \frac{nRT}{V} = \frac{3.08 \times 10^{-3} \times 8.31 \times (273+40)}{50 \times 10^{-6}} = 160$ kPa $\quad (160240\ Pa)$ 1A

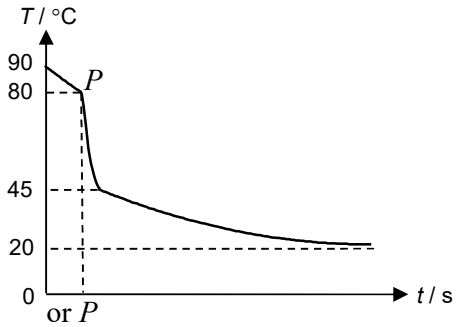
(c)



(Straight lines passing through origin) 1A

(The line for 40 °C having a larger slope) 1A

2. (a)



(Correct position of point P) 1A

(b) 20 °C 1A

(c) Ensure a uniform temperature throughout the water. 1A

(d) Energy gained by ice and cold water = energy lost by hot water

$m\times (3.36\times10^5 + 4200\times45) = 1\times4200\times(80-45)$ 1M

$m = 0.28$ kg 1A

3. (a) by $s=\frac{1}{2}at^2$

$1.5=\frac{1}{2}a(1)^2$ 1A

$a = 3\ \text{m s}^{-2}$

(b) $\begin{cases}2g-T=2a\\T-f=3a\end{cases}$ 2M

$f = 4.62N$ 1A

(c) Block X decelerates uniformly until it comes to a stop. 1A

(d) velocity of X when Y reaches the ground

$v = (3)(1) = 3\ \text{m s}^{-1}$ 1A

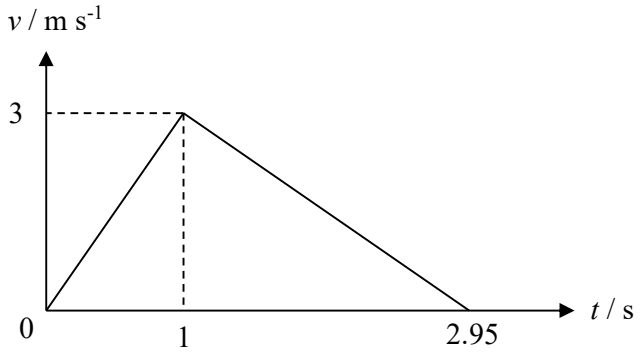
time for X to come to rest

$4.62 = 3a$

$a = 1.54\ \text{m s}^{-1}$

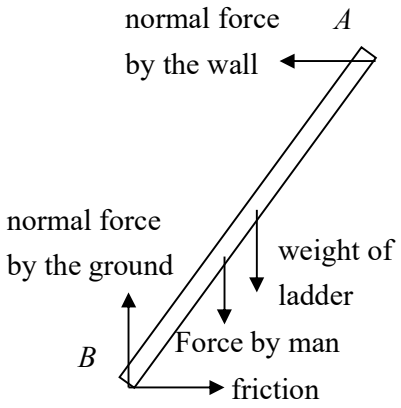
$0 = 3 - 1.54t$

$t = 1.95s$ 1A



1A for correct shape, 1A for all correct numbers

4. (a)



any 2 → 1A, all correct → 2A

(b) Take moment at B

$$500\times\frac{0.75}{\tan 60}+10\times 9.81\times 2\cos 60 = N\times 4\sin 60$$ 1M for LHS , 1M for RHS

$N = 90.8N$ 1A

(c) (i) increase. 1A

The clockwise moment by the weight of the man increases as he climbs up the wall. A larger anticlockwise moment is required to balance. 1A

(ii) unchanged. 1A

As the net force = 0, the vertical force acting on the ladder by the ground is always equals to the sum of the weight of the man and ladder. 1A

5. Measure the radius (r) of the turntable with the plastic ruler. 1A

Put the small metal block of mass (m) at the edge of the turntable. 1A

Switch on the electronic turntable and increase the speed of rotation slowly. 1A

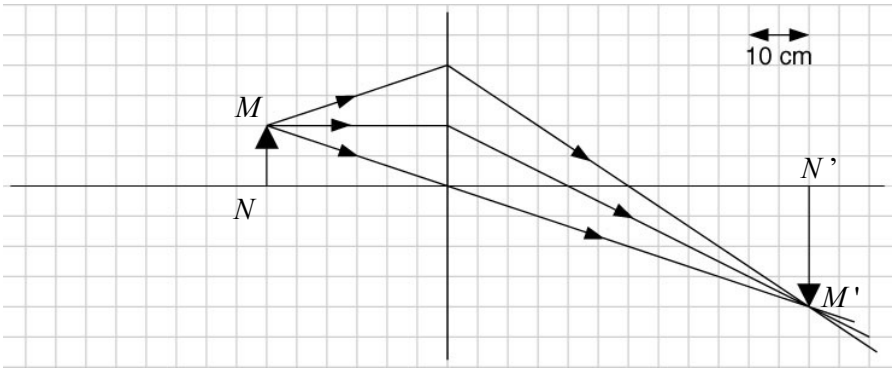
Record the number of revolution per second (n) immediately when the small metal block falls off the turntable. 1A

Friction can be calculated by $(m)(2\pi n)^2(r)$ 1A

6. (a) convex lens. 1A

The light ray bends towards the principal axis. 1A

(b)



1A for correct rays, 1A for the correct position of image

(c) 20 cm 1A

(d) By $\frac{1}{u}-\frac{1}{v}=\frac{1}{f}$

$\frac{1}{80}+\frac{1}{v}=\frac{1}{20}$ 1M

$v = 26.7$ cm 1A

Linear magnification = $\frac{v}{u}=\frac{26.7}{80}=0.333$ 1A

7. (a) refraction 1A

(b) A 1A

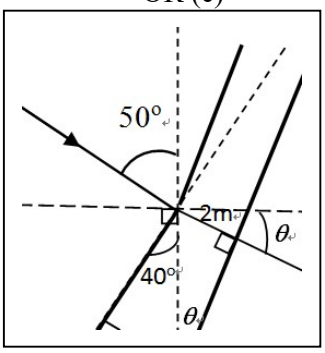
(c) $\frac{n_1}{n_2}=\frac{v_2}{v_1}=\frac{\lambda_2}{\lambda_1}$ 1M

By $n_1 \sin i = n_2 \sin r$ 1M

$\sin r = \frac{n_1}{n_2}\sin 40° = \frac{\lambda_2}{\lambda_1}\sin 40°$

$r = 25.4°$ 1A

OR (c)



8. (a) Light from S_1 and S_2 forms interference pattern on the screen. 1A

The path difference changes along PQ resulting in alternate bright and dark fringes. 1A

(b) $\lambda = \frac{a\Delta y}{D} = \frac{0.1\times10^{-3}\times1.2\times10^{-2}}{2} = 600nm$ 1M, 1A

(c) The zeroth order bright fringe moves towards Q. 1A

The fringe separation does not change. 1A

The light travels slower in the glass block and the wavelength is shorter.

The fringe separation is determined by slit screen separation, wavelength and slit separation which are all constant. 1A

9. (a) Electric field strength E

$= \frac{V}{d}$ 1M

$= \frac{220}{0.02} = 11\ 000$ N C^{-1} (upwards) 1A

(b) Since Y travels horizontally between the parallel plates, the electrostatic force acting on it points upwards and balances its weight.

By $qE = mg$ 1M

$q = \frac{mg}{E} = \frac{0.008 \times 9.81}{11\ 000} = 7.13$ μC 1M

Y carries a charge of +7.13 μC $(7.1345 \times 10^{-6} C)$ 1A

(c) Take the downward and rightward directions as positive. By conservation of momentum,

$0 = m_X v_X + m_Y v_Y$ 1M

$0 = 0.005 v_X + 0.008 \times 2$

$v_X = -3.2$ m s^{-1} 1A

The speed of X is 3.2 m s^{-1}.

(d) (i) Consider all the forces acting on X.

By $F = ma$, 1M

$a = \frac{F}{m} = \frac{mg + qE}{m} = \frac{0.005 \times 9.81 + (7.13 \times 10^{-6})(11\ 000)}{0.005} = 25.5$ m s^{-2} 1A

The acceleration of X is 25.5 m s^{-2} downwards. $(25.506 ms^{-1})$

(ii) Consider the vertical motion.

By $s_y = u_y t + \frac{1}{2} a_y t^2$

$0.01 = 0 + \frac{1}{2}(25.5) t^2$ 1M

$t = 0.0280$s 1A

10. (a) Total amount of charge

= 1800 mA h

= (1800 × 10^{-3} A) × (60 × 60 s) 1M

= 6480 C 1A

(b) Energy stored

= VQ 1M

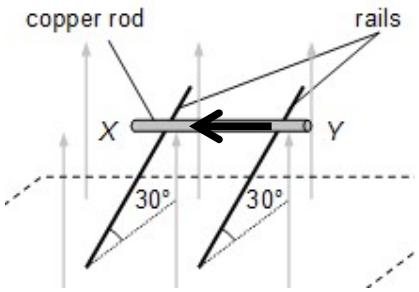
= 3.8 × 6480 = 24 600 J 1A

(c) Current

$= \frac{Q}{t}$ 1M

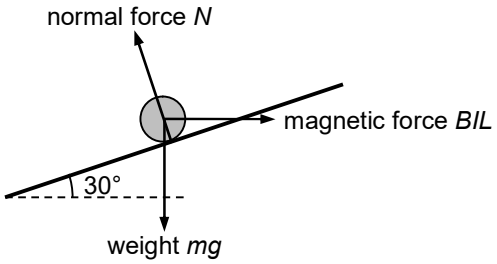
$= \frac{1800 \text{ mA h}}{50 \text{ h}} = 36 \text{ mA}$ 1A

11. (a)



1A

(b)



Any two correct 1A, All correct 2A

(c) Consider the vertical direction.

$N \cos 30° = mg$ (1) 1M

Consider the horizontal direction.

$N \sin 30° = BIL$ (2) 1M

$I = \frac{mg}{BL} \tan 30^o = \frac{(0.035)(9.81)}{(0.1)(0.2)} \tan 30^o = 9.91 \ A$ (9.9117 A) 1A

12. (a) Decay constant $= \dfrac{\ln 2}{t_{\frac{1}{2}}} = \dfrac{\ln 2}{8.02 \times 24 \times 3600}$ 1M

$= 1.00 \times 10^{-6}\ \text{s}^{-1}$ $(1.0003 \times 10^{-6}\ s^{-1})$ 1A

(b) ${}^{131}_{53}\text{I} \rightarrow {}^{131}_{54}\text{X}e + {}^{0}_{-1}\beta + \gamma$ (γ can be omitted.) (1A for ${}^{131}_{54}\text{X}e$) 2A

(c) (i) The γ radiation emitted by xenon can penetrate the body and reach the detector. 1A

(ii) By $A = A_0 e^{-kt}$,
initial activity
$= Ae^{kt} = 37 \times 10^3 \times e^{(1.00 \times 10^{-6})(95 \times 24 \times 3600)}$ 1M
$= 1.36 \times 10^8$ Bq $(1.3613 \times 10^8\ Bq)$ 1A
Assume that all iodine-131 atoms stay in the body within that period of time. 1A

(iii) By $A = kN$,

number of nuclei $= \dfrac{A}{k} = \dfrac{1.36 \times 10^8}{1.00 \times 10^{-6}} = 1.36 \times 10^{14}$ (1.3609×10^{14}) 1A

Paper 2

Section B: Atomic World

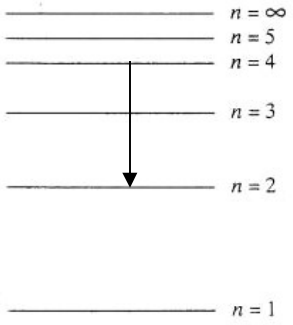
M.C. 1C 2B 3A 4C 5D 6A 7C 8D (2A 1B 3C 2D)

Structured question (10 marks)

(a) $\frac{hc}{\lambda}\times 1.6\times 10^{-19} = \frac{(6.63\times 10^{-34})(3\times 10^{8})}{(486\times 10^{-9})}\times 1.6\times 10^{-19} = 2.56 \text{ eV}$ 1A

(b) $\frac{hc}{\lambda} = -13.6\text{eV}\left(\frac{1}{n^2}-\frac{1}{2^2}\right)$ 1M

$n = 4.02$ 1A



1A for (4→2) pointing downwards

(c) $r = 4\times 5.29\times 10^{-11} = 2.116\times 10^{-10}\text{m}$ 1M, 1A

(d) $\frac{hc}{\lambda} = -13.6\text{eV}\left(0-\frac{1}{2^2}\right)$ 1M

$\lambda = 366$ nm 1A

It will be ionized. 1A

(e) The energy gaps between two consecutive energy levels are smaller at higher excited state. 1A

Section C: Uses of Energy

M.C. 1A 2D 3B 4A 5C 6B 7D 8D (2A 2B 1C 3D)

Structured question (10 marks)

(a) Energy removed in an hour $E = Pt = (2.53 \times 10^3)(60 \times 60) = 9.108MJ$

(1M 1A)

(b) Input electrical power $P_{in} = \frac{1087kWh}{12000h} = 0.9058kW$ (1A)

Coefficient of performance $COP = \frac{2.51}{0.9058} = 2.79$ (1M+1A)

(c) (i) Efficiency of the micro-wind turbine

$$= \frac{\text{electrical power ouput}}{\text{maximum power provided by the wind}} \times 100\%$$

$$= \frac{P_{out}}{200 \times \frac{1}{2}\rho A v^3} \times 100\% = \frac{150}{200 \times \frac{1}{2} \times 1.225 \times \left[\pi \times \left(\frac{0.26}{2}\right)^2\right] \times 5^3} \times 100\% = 18.5\%$$

(1M 1A)

(ii) In a day, amount of electrical energy fed in the grid = 0.150×24=3.6 kW h

Feed-in tariff collected = 3.6×4 = $14.40 (1A)

cost of electrical energy used by the air-conditioner = 0.9058×10×1.2=$10.87 Both correct (1A)

Since the Feed-in tariff collected is greater than cost of electricity used by air conditioner. Therefore, Tommy is right. (1M)

PAPER 1A

SACRED HEART CANOSSIAN COLLEGE

18 – 19 S6 MOCK EXAMINATION

PHYSICS PAPER 1 (Explanation)

Time allowed: 2 hours 30 minutes

This paper must be answered in English

Solution to 1819 S6 Physics Mock Exam

Paper 1

Section A

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
C	D	A	D	C	B	A	C	A	D	B	C	C	D	A

16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
D	D	B	D	C	A	A	C	B	B	D	B	A	D	C

31	32	33
B	B	C

Section A

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

1. A microwave oven is used to heat up 0.2 kg of water at 20 °C. Energy is transferred to the water at a constant rate of 800 W. How long does it take to boil away all the water in the glass?
(The specific latent heat of vaporization of water is 2260 kJ kg^{-1}. The specific heat capacity of water is 4200 J kg^{-1} $°C^{-1}$.)

A. 84 s
B. 565 s
C. 649 s
D. 724 s

$Pt = mc\Delta T + ml$

$800\ t = 0.2 \times 4200 \times 80 + 0.2 \times 2260 \times 10^3$

$t = 649$

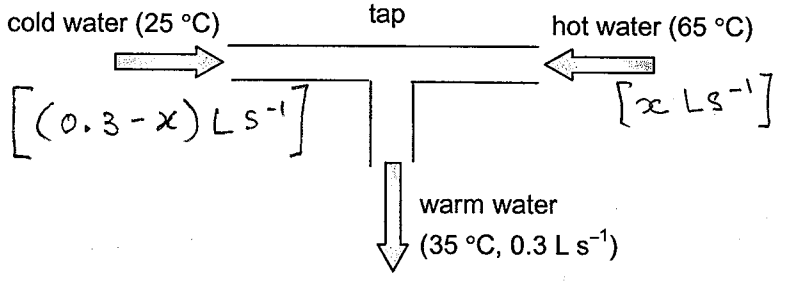
2. The separation between the −10 °C and 110 °C marks on a mercury-in-glass thermometer is 20 cm. When the thermometer is put in a liquid of temperature T, the mercury thread is 10 cm above the 0 °C mark. The temperature T is

A. 50 °C.
B. 55 °C.
C. 58 °C.
D. 60 °C.

$\frac{120}{20} = \frac{T}{10}$

$T = 60$

3. As shown below, hot water at 65 °C and cold water at 25 °C are mixed before leaving the tap. Suppose the water leaving the tap is at 35 °C and flows at a rate of 0.3 L s^{-1}. What is the rate at which the hot water flows into the tap?



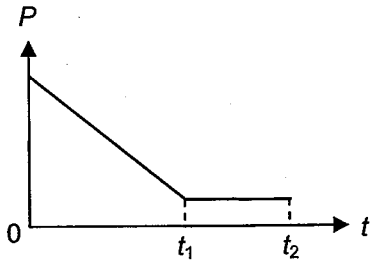
A. 0.075 L s^{-1}
B. 0.092 L s^{-1}
C. 0.138 L s^{-1}
D. 0.150 L s^{-1}

Heat gained = Heat lost

$(0.3 - x)\ c\ (35 - 25) = x \cdot c \cdot (65 - 35)$

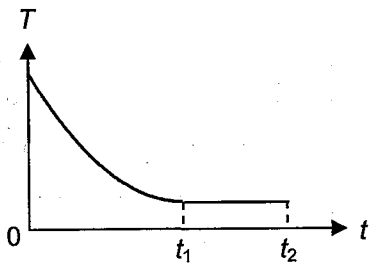
$x = 0.075$

4. A liquid is heated at power P which changes with time t as shown.

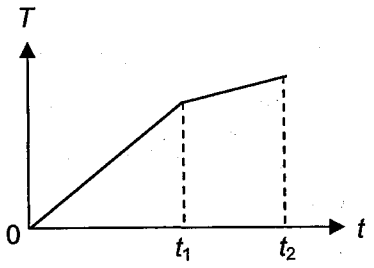


Assume that the liquid does not change to gas until $t = t_2$. Which of the following graphs best shows the variation of the temperature T of the liquid with time t?

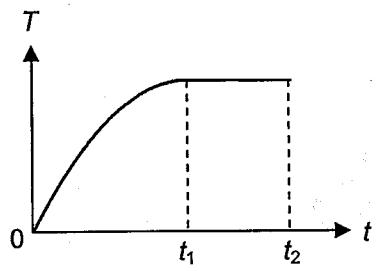
A.



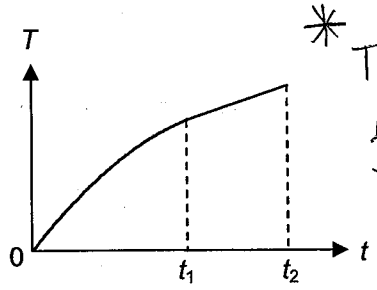
B.



C.



D.



✳ T increases linearly if P is constant

*5. Two vessels X and Y, which contain the same kind of ideal gas at the same temperature, are connected by a tap which is initially closed. The volume and pressure of the gas in the vessels are listed as follows:

Vessel	Pressure / Pa	Volume / m^3
X	4×10^5	1.3×10^{-2}
Y	3×10^5	7×10^{-3}

When the tap is opened, what will be the final pressure in the vessels if the volumes of the vessels and the temperature of the gas are constant throughout the process?

A. 3.42×10^5 Pa
B. 3.50×10^5 Pa
C. 3.65×10^5 Pa
D. 3.83×10^5 Pa

$n_x + n_y = n \quad n = \frac{PV}{RT}$

$\frac{4 \times 13}{RT} + \frac{3 \times 7}{RT} = \frac{P(13+7)}{RT}$

$P = 3.65 \quad (\times 10^5)$

6. Which of the following about a uniformly accelerating object MUST be correct?

(1) The object is speeding up.

(2) The velocity of the object is changing.

(3) The object is moving in the same direction.

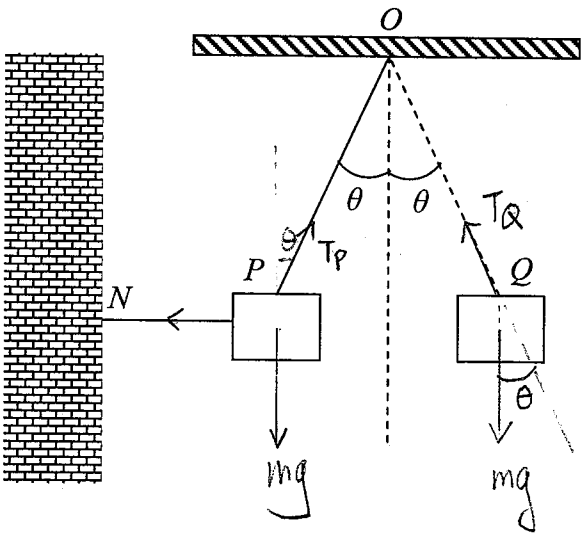
A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

7. A block of mass m is held at rest at P by a string OP making an angle θ with the vertical and a horizontal string NP as shown in the figure below. The tension in OP is T_P. When the string NP is cut, the block will swing to position Q where OQ also makes an angle θ with the vertical. The tension in OP is T_Q. Which of the following gives the values of T_P and T_Q.

For T_P, Vertically, $T_P \cos\theta = mg$, $T_P = \frac{mg}{\cos\theta}$

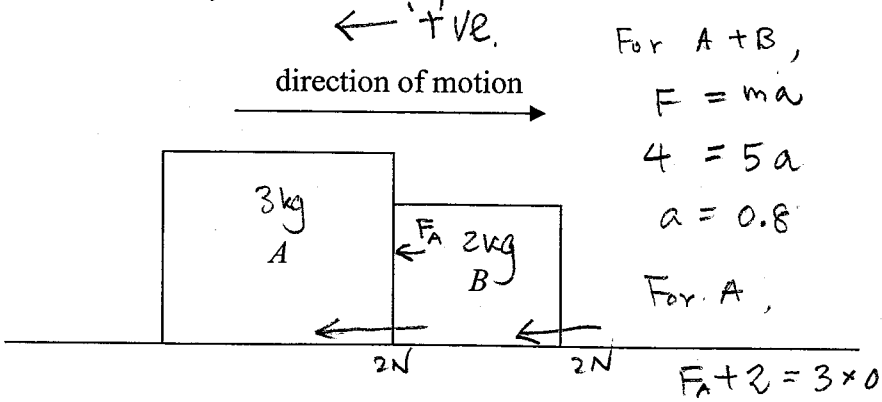
For T_Q, no net force along OQ direction, $T_Q = mg\cos\theta$.

	T_P	T_Q
A.	$\frac{mg}{\cos\theta}$	$mg\cos\theta$
B.	$\frac{mg}{\cos\theta}$	$\frac{mg}{\cos\theta}$
C.	$mg\cos\theta$	$\frac{mg}{\cos\theta}$
D.	$mg\cos\theta$	$mg\cos\theta$



8. Two blocks, A and B, of mass 3 kg and 2 kg respectively, are moving together on a rough horizontal surface as shown in the figure below. The friction acting on each block is 2 N. Find the force acting on A by B.

A. 2 N
B. 0.8 N
C. 0.4 N
D. 0 N



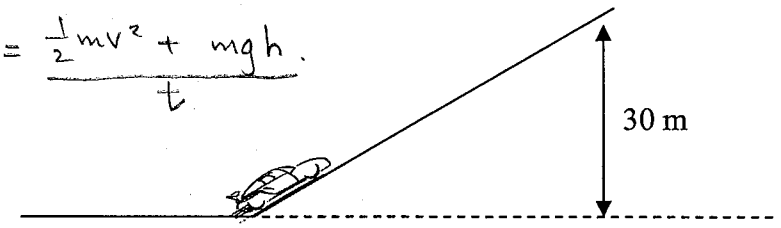
For A + B, $F = ma$, $4 = 5a$, $a = 0.8$

For A, $F_A + 2 = 3 \times 0.8$, $F_A = 0.4$

9. A car of mass 1000 kg is moving up a slope from rest. The car arrives at the top of the slope, which is 30 m from the ground level, with a speed of 10 m s^{-1} in 40 s. Find the average power output of the car. Neglect air resistance and friction.

A. 8610 W
B. 7360 W
C. 6349 W
D. 1250 W

$\frac{E}{t} = \frac{\frac{1}{2}mv^2 + mgh}{t}$.



$= \frac{\frac{1}{2} \times 1000 \times 10^2 + 1000 \times 9.81 \times 30}{40} = 8608$ W

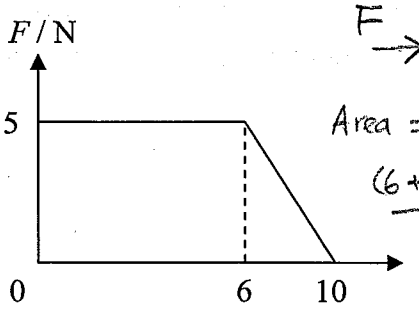
10. A bob of mass 4 kg is originally moving at 6 m s^{-1} towards the *left*. It experiences a force F pushing it towards the *right* for 10 s. The variation of the force F and time t is shown in the graph below. What is the speed of the bob after 10 s?

A. 16 m s^{-1}
B. 12 m s^{-1}
C. 8 m s^{-1}
D. 4 m s^{-1}

'+' →

$u = -6$ m s^{-1} ←

F →



Area = change in momentum.

$\frac{(6+10) \times 5}{2} = 4v - 4(-6)$

$v = +4$ m s^{-1}

*11. A ball is projected horizontally from the top of a building at 20 m s^{-1}. Assume that there is no air resistance. What is its vertical speed 5 s later?

A. 20 m s^{-1}
B. 49.1 m s^{-1}
C. 100 m s^{-1}
D 223 m s^{-1}

Vertically, $u_y = 0$, $a = 9.81$, $t = 5$

$v_y = u_y + at$.

$= 0 + 9.81 \times 5$

$= 49.05$ m s^{-1}

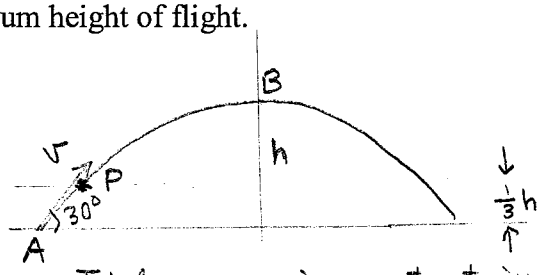
*12. A projectile is projected with speed v at an angle 30° above the horizontal, and its kinetic energy is E. Express the kinetic energy of the projectile in terms of E when it is at one-third of its maximum height of flight.

A. $\frac{5}{6}E$

B. $\frac{25}{36}E$

C. $\frac{11}{12}E$

D. $\frac{121}{144}E$



Total energy is constant in the air.

$E = \frac{1}{2}mv^2$

At B, $E = mgh + \frac{1}{2}m(v\cos 30°)^2$

$mgh = (1 - \cos^2 30°)E$

$= \frac{1}{4}E$

At P,

$E = mg\times\frac{h}{3} + E_K$

$E_K = E - \frac{1}{3}\times\frac{1}{4}E$

$= \frac{11}{12}E$

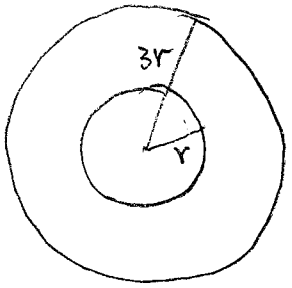
*13. A satellite turns around a planet in a circular orbit with period T. If the distance between the satellite and the centre of the planet is three times its original value, the period will become

A. T

B. $3T$

C. $5.20T$

D. $9T$



$\frac{GMm}{R^2} = mR\omega^2 = mR\left(\frac{2\pi}{T}\right)^2$

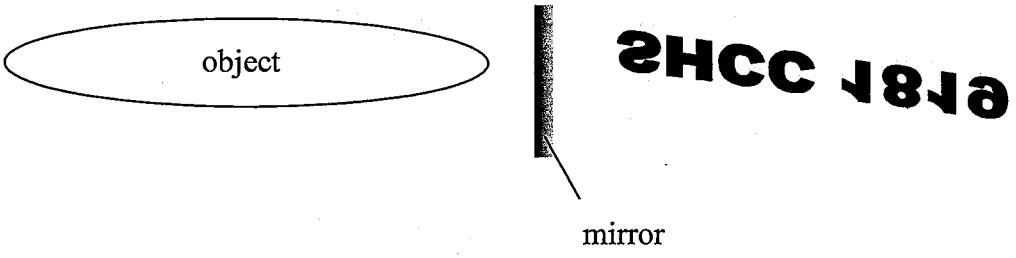
$\therefore T^2 \propto R^3$

$\left(\frac{T}{T'}\right)^2 = \left(\frac{r}{3r}\right)^3$

$T' = \sqrt{27}\,T$

$= 5.196T$

14. The figure below shows the image formed in a plane mirror.



Which of the following correctly shows the object?

A. SHCC 1819

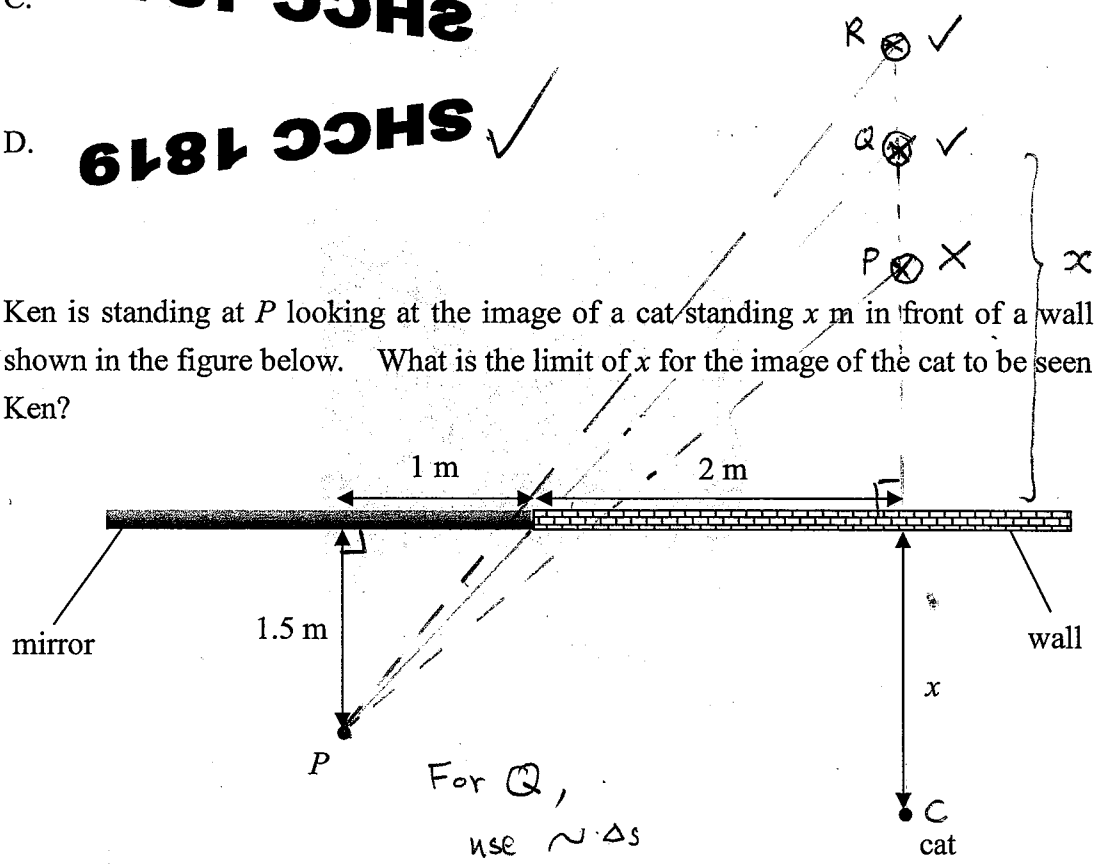
B. SHCC 1819

C. SHCC 1819

D. SHCC 1819 ✓

look at the back of this page !

15. Ken is standing at P looking at the image of a cat standing x m in front of a wall as shown in the figure below. What is the limit of x for the image of the cat to be seen by Ken?



A. at least 3 m
B. at most 3 m
C. at least 1.5 m
D. at most 1.5 m

For Q, use ∼ Δs

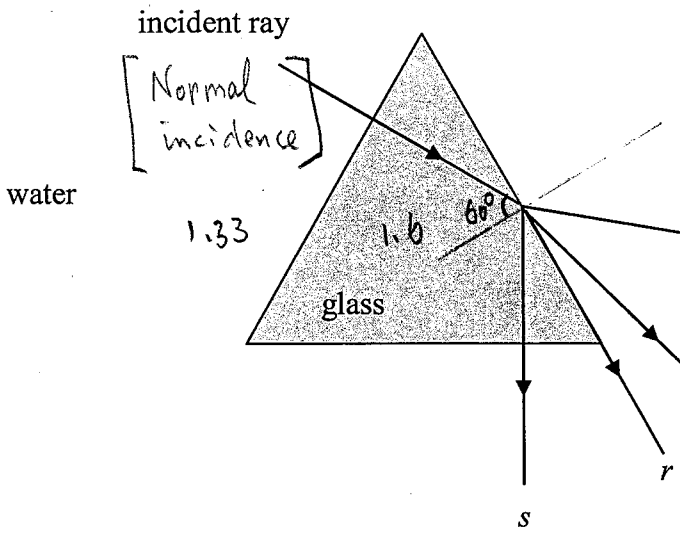
$\frac{x}{1.5} = \frac{2}{1}$

$x = 3$

For R, $x > 3$

$\therefore x \geq 3$

16. A light ray is incident on a equilateral triangular glass prism (refractive index 1.6) immersed in water (refractive index 1.33) as shown in the figure below. Which light ray best represents the emergent ray?



$n_1 \sin\theta_1 = n_2 \sin\theta_2$

$1.6 \sin c = 1.33 \sin 90°$

$c = 56.23°$

$i = 60° > c$

∴ under total internal reflection.

A. *p*
B. *q*
C. *r*
D. *s*

17. The figure below shows an image when viewing through a spherical lens.

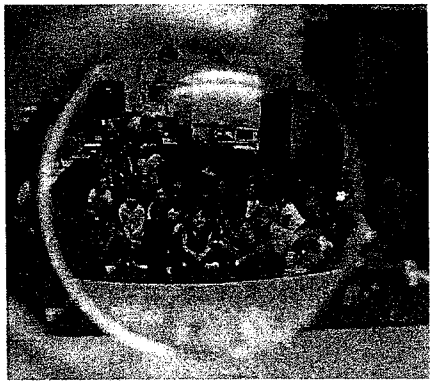


image is virtual, smaller. which can only be formed by concave lens.

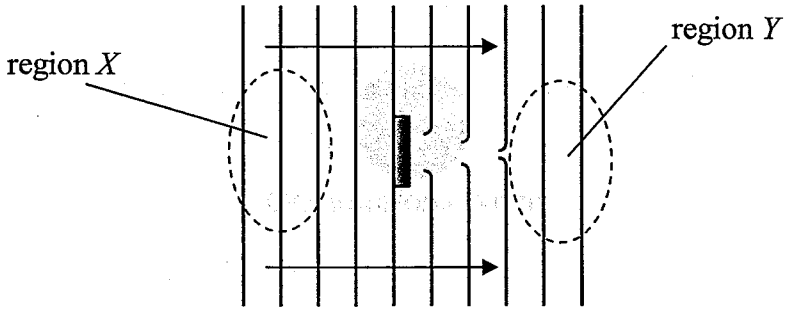
Which of the following statements are INCORRECT?

(1) The lens used is convex lens.
(2) The image is real, upright and diminished.
(3) The image can be formed on a screen.

} ALL incorrect.

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

18. The figure below shows a water wave travelling to the right in a water tank of uniform depth. It is diffracted when it passes an obstacle.

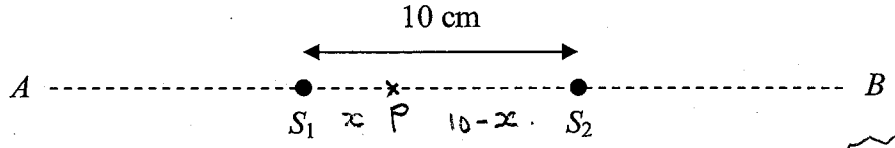


Which of the following physical quantities of the water waves in regions *X* and *Y* are the same?

(1) wave speed ✓
(2) amplitude ✗ There is energy loss. Therefore, amplitude ↓.
(3) frequency ✓

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

19. The figure below shows two coherent sources, S_1 and S_2, separated by 10 cm. They are vibrating at 2.5 Hz and producing water wave of speed 5 cm s^{-1}. *AB* is a line joining S_1 and S_2. How many points of zero displacement can be found along *AB*?



A. 4
B. 6
C. 8
D. 10

$\lambda = \frac{v}{f} = \frac{0.05}{2.5} = 0.02\ m = 2\ cm$

OR ($\Delta = \frac{1}{2}\lambda$)
Count from $x = 0.5$ cm
$x = 1.5$ cm ↙ $\Delta = \frac{3}{2}\lambda$
⋮
$x = 9.5$ cm

point of zero displacement locates between S_1 and S_2 only.
(For points outside, $\Delta = 10\ cm = 5\lambda$)

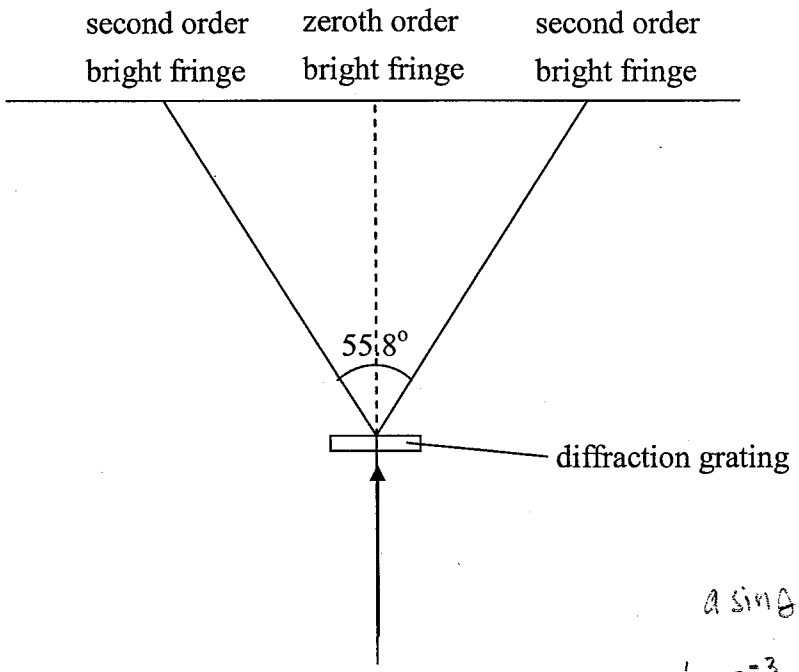
At P, (zero displacement).
$\Delta = |10 - x - x| = \frac{2n+1}{2} \times 2$ where $n = 0, 1, 2, \ldots$

ie $10 - 2x = 2n+1$ or $2x - 10 = 2n+1$

$x = \frac{9-2n}{2}$ or $x = \frac{9+2n}{2}$

10 locations ⟶ $n = 0, 1, 2, 3, 4$. $n = 1, 2, 3, 4, 5$.

20. A monochromatic light of wavelength 520 nm is incident normally on a diffraction grating of y lines per mm as shown in the figure below. The angle subtended by the two second order bright fringes is 55.8°. Find the value of y.



$a \sin\theta = n\lambda$

$\frac{1\times10^{-3}}{y} \sin 27.9^\circ = 2 \times 520 \times 10^{-9}$

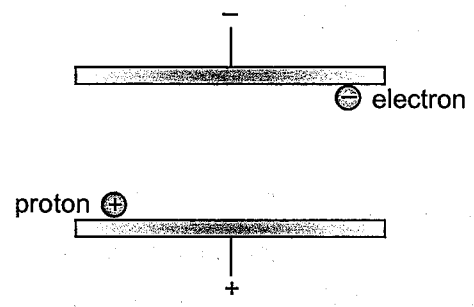
$y = 449.93$

A. 225
B. 398
C. 450
D. 795

21. Which of the following about audible sound and ultrasound MUST be correct?
(1) Both ultrasound and audible sound are longitudinal waves. ✓
(2) Ultrasound has higher frequency than audible sound. ✓
(3) Ultrasound carries more energy than audible sound. ✗

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

22. A proton and an electron are placed between two parallel charged plates as shown. Initially, the proton is at rest at the positive plate (lower plate) and the electron is at rest at the negative plate (upper plate). Neglect the effect of gravity and the electrostatic forces between the proton and the electron. Which of the following statements is/are correct when the proton and the electron reach the opposite plates?



K.E gained = QV

$\frac{1}{2}m_e v_e^2 = \frac{1}{2}m_p v_p^2$

$\frac{1}{2}\frac{p_e^2}{m_e} = \frac{1}{2}\frac{p_p^2}{m_p}$

$\frac{p_e^2}{p_p^2} = \frac{m_e}{m_p}$

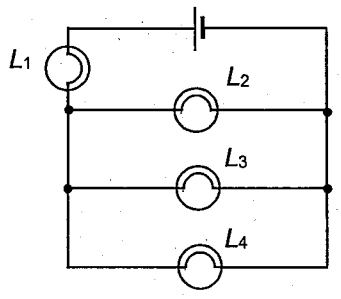
(1) The momentum of the electron is larger in magnitude than that of the proton.

(2) The electron has a smaller speed than the proton. $\frac{v_e^2}{v_p^2} = \frac{m_p}{m_e}$

(3) The electron and the proton have equal kinetic energy.

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

23. Four identical lamps are connected as shown. Assume the internal resistance of the dry cell is negligible.



If the filament in L_3 is burnt, which of the following will happen?

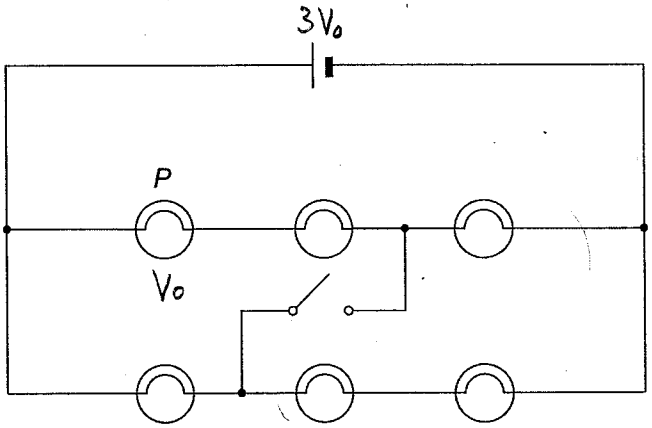
(1) L_1 becomes dimmer. total R ↑ ⇒ main I ↓ ⇒ V_{L_1} ↓

(2) L_2 becomes dimmer.

(3) L_4 becomes brighter. ⇕ V_{L_2}, V_{L_4} ↑

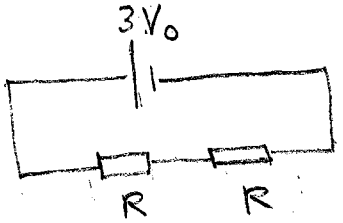
A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

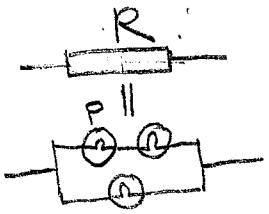
24. Six identical light bulbs are connected as shown. The internal resistance of the dry cell is negligible.



When the switch is open, the potential difference across bulb P is V_o. What is the potential difference across bulb P when the switch is closed?

A. $0.5V_o$
B. $0.75V_o$
C. V_o
D. $1.5V_o$

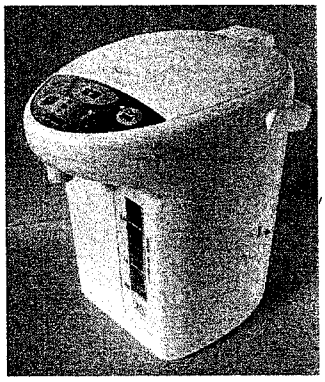




$V_P = \frac{1}{2} V_R = \frac{1.5}{2}$

1.2kW $\frac{15}{60}$ h

25. A kettle operating at 1200 W takes 15 minutes to boil 3 kg of water.



Suppose electrical energy costs \$1.1 per kW h. Estimate the cost of boiling 1-kg water by this kettle.

$\frac{1}{3} \times 1.2 \times \frac{15}{60} \times \$1.1$

$= \$0.11$

A. \$ 0.09
B. \$ 0.11
C. \$ 0.33
D. \$ 0.99

26. A kettle of rated value '220V, 1500W' is connected to a sinusoidal a.c. power supply. If the average power consumption of the kettle is 1000 W, find the peak value of the voltage across the kettle.

A. 127 V
B. 180 V
C. 194 V
D. 254 V

$\bar{P} = \frac{\bar{V}^2}{R}$

$1500 = \frac{220^2}{R}$

$R = \frac{220^2}{1500}$

$1000 = \frac{\bar{V}'^2}{R}$

$\bar{V}'^2 = 1000 \times \frac{220^2}{1500}$

$\bar{V}' = 179.63$

$V'_{peak} = \sqrt{2}\,\bar{V}' = 254$

*27. A transformer works at an efficiency of 80%. The primary voltage is 100 V and the turns ratio is 20 : 1. If the resistance of the secondary circuit is 50 Ω, what is the primary current?

A. 5 mA
B. 6.25 mA
C. 10 mA
D. 2 A

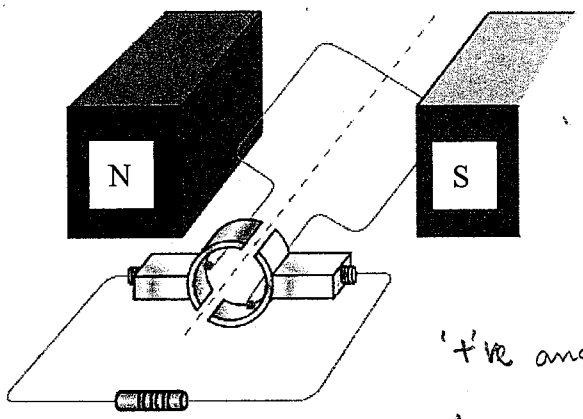
$\frac{V_p}{V_s} = \frac{20}{1}$, $V_s = \frac{100}{20} = 5$

$V_p I_p \times 80\% = V_s I_s = \frac{V_s^2}{R}$

$100 \times I_p \times 0.8 = \frac{5^2}{50}$

$I_p = 6.25 \times 10^{-3}$

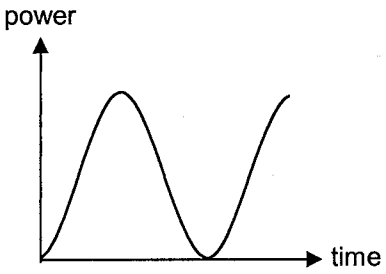
28. In the generator shown below, the coil rotates at a constant speed. A resistor is connected to the generator.



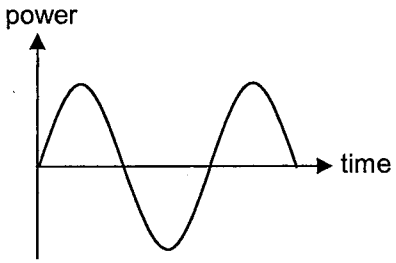
't' is and not constant.

Which of the following graphs best shows the power dissipated in the resistor?

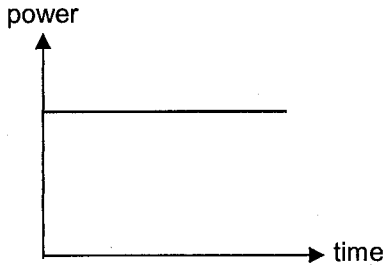
A.



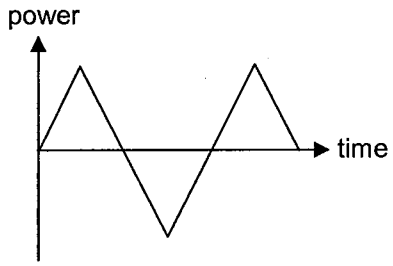
B.



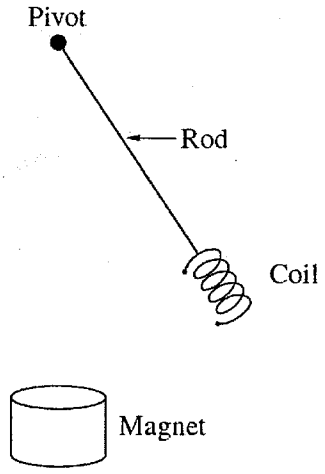
C.



D.



29. A light rod has a coil of insulated copper wire fixed at one end and is pivoted at the other end. The result is a pendulum which is free to swing back and forth. A magnet is placed underneath this pendulum. The arrangement is shown in the diagram. The pendulum is pulled back and then allowed to swing. If air resistance is negligible, which of the following would cause the pendulum to come to rest most quickly?



A. Replacing the magnet with a stronger one
B. Shortening the pendulum
C. Replacing the rod with a heavier one
D. Connecting the ends of the coil by a piece of copper wire

induced current in the coil flows in a direction so as to oppose the change (oppose the motion)

30. Two straight metal rods, P and Q, have the same length. They are each pivoted at one end and rotated with the same angular velocity so that they sweep out horizontal circular paths as shown in diagrams X and Y. A constant current I is flowing along each rod as shown. In diagram X, a constant magnetic field is applied perpendicular to the plane of the circular path. In diagram Y, a uniform magnetic field of the same magnitude is applied in the plane of the circular path.

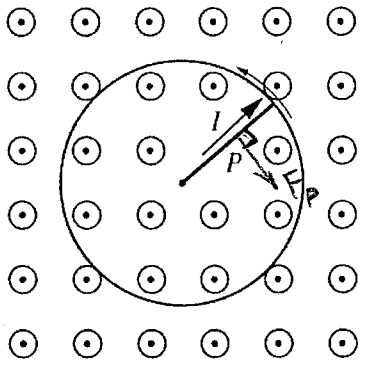


Diagram X

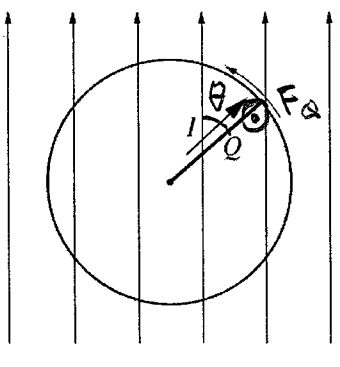


Diagram Y

$F_P = IBl$

$F_Q = IBl \sin\theta$

θ changes ⇕ F_Q changes

Which of the following statements about the forces acting on rod P and rod Q is correct?

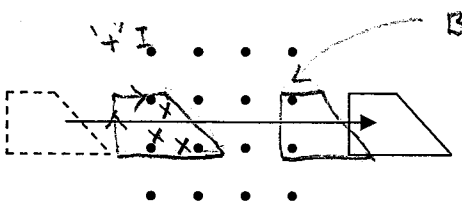
A. The magnitude of the magnetic force on P is exactly the same as the magnitude of the force on Q at all times.

B. The magnitude of the force on P is constant and the magnitude of the force on Q is zero.

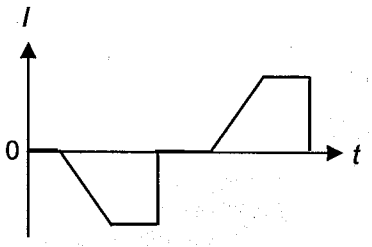
C. The magnitude of the force on P is constant and the magnitude of the force on Q varies with time.

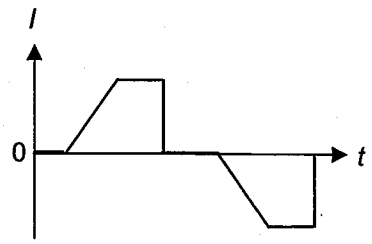
D. The magnitude of the force on P varies with time and the magnitude of the force on Q is constant.

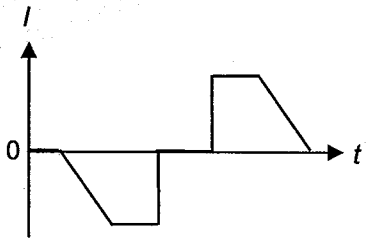
31. In the following figure, a trapezium-shaped metal coil moves at a constant velocity across a uniform magnetic field pointing out of page.

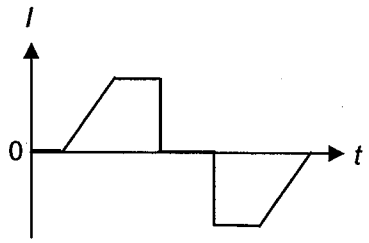


Which of the following graphs best shows the variation of the induced current I in the coil with time t? The clockwise direction is taken as positive.

A.


B.


C.


D.


*32. The fission of one atom of uranium-235 (U-235) generates 202.5 MeV of energy. Suppose that a power plant consumes 0.5 kg of U-235 each hour and its efficiency in converting the nuclear energy into electrical energy is 30%. Estimate its power output. Given: molar mass of U-235 = 235 g

A. 1.24 GW
B. 3.46 GW
C. 6.92 GW
D. 11.5 GW

no. of moles of U-235 in 0.5kg = $\frac{0.5}{0.235}$

no. of U-235 atom = $\frac{0.5}{0.235} \times N_A$

$P = \frac{E}{t}$

$= \frac{0.5}{0.235} \times 6.02 \times 10^{23} \times 202.5 \times 10^{6} \times 1.6 \times 10^{-19} \times 0.3 / 3600$

$= 3.458 \times 10^{9}$ W

*33. The decay constant of a radioactive sample is $3 \times 10^{-4}\ s^{-1}$. The sample initially consists of 99% of undecayed nuclides. How long does it take for the percentage of the undecayed nuclides in the sample to decrease to 1%?

A. 38.5 minutes
B. 4.17 hours
C. 4.25 hours
D. 62.9 hours

$1 = 99 e^{-3\times10^{-4} t}$

$\ln \frac{1}{99} = \ln(e^{-3\times10^{-4} t})$

$\ln \frac{1}{99} = -3\times10^{-4} \times t$

$t = 15317\ s \simeq 4.25\ h.$

END OF SECTION A

SECTION B: Atomic World

eVs

$K_{max} = hf - \Phi$

$1.53 \times 1.6 \times 10^{-19} = \frac{hc}{\lambda} - 0.8 \times 1.6 \times 10^{-19}$

$\lambda = 5.34 \times 10^{-7}$

Q.2: Multiple choice questions.

2.1. In the photoelectric effect experiment, a monochromatic light is directed to the metal plate. The stopping potential is 1.53 eV and the work function of the metal plate is 0.8 eV. Find the wavelength of the monochromatic light used.

A. 497 nm
B. 509 nm
C. 534 nm
D. 570 nm

A	B	C	D
○	○	○	○

2.2. A green monochromatic light is directed to the metal plate. Only a small amount of photoelectrons are emitted. Which of the following MUST increase the amount of photoelectrons emitted?

no. of photon remains unchanged.

(1) Replace the metal plate with another one of smaller work function.
(2) Replace the green monochromatic light with violet monochromatic light of the same intensity. no. of violet photon decreases as each violet photon carries more energy (hf)
(3) Increase the intensity of the green monochromatic light. no. of green photon increases

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

A	B	C	D
○	○	○	○

2.3. In Rutherford's scattering experiment, a thin gold foil is bombarded by α particles. Which of the following cannot be explained by the result of this experiment?

A. Atoms do not continuously emit electromagnetic waves.
B. The nucleus of an atom is much smaller than the atom itself.
C. The density of charge in an atom is not uniform.
D. There is a large empty space in an atom.

A	B	C	D
○	○	○	○

can be explained.

2.4. What is the ratio of angular momentum of an electron in the 3rd excited state to that in the 4th excited state of a hydrogen atom?

n = 5 n = 4

ang. momentum $= \frac{nh}{2\pi}$

A. 16 : 25
B. 9 : 16
C. 4 : 5
D. 3 : 4

A	B	C	D
○	○	○	○

2.5. Which of the following are physical properties of nano materials?

(1) The colour of gold nano particles depends on its size.
(2) The electrical conductivity of copper drops drastically when it is reduced to nano size.
(3) Carbon nanotubes are harder and stronger than most metals.

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

A	B	C	D
○	○	○	○

2.6. Felix is on a plane 9100 m above the ground. Find the minimum distance between two people on the ground that he is able to resolve. Assume the people's hair reflects yellow light of wavelength 500 nm and the pupil of Felix's eye has a diameter of 3.5 mm.

A. 1.586 m
B. 1.796 m
C. 1.902 m
D. 2.003 m

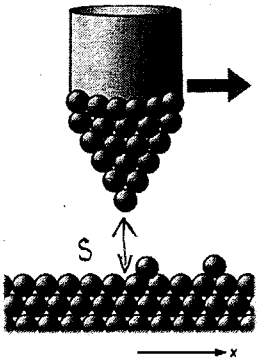
$\theta \simeq \frac{1.22\lambda}{d}$ & $s = r\theta$

$\frac{s}{9100} \simeq \frac{1.22 \times 500 \times 10^{-9}}{3.5 \times 10^{-3}}$

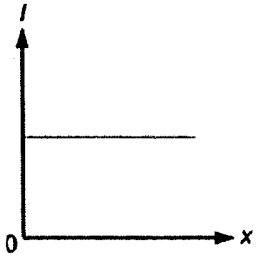
$s = 1.586$

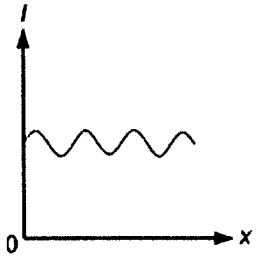
A	B	C	D
○	○	○	○

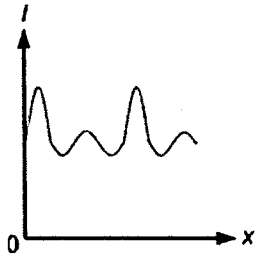
2.7. Which of the following best shows the tunnelling current I registered by a transmission electron microscope (TEM) against the displacement x of the tip?

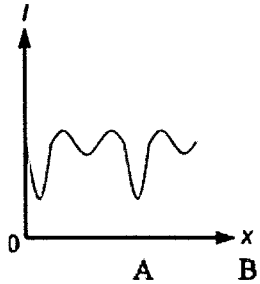


$s \downarrow, I \uparrow$

A.


B.


C.


D.


A	B	C	D
○	○	○	○

2.8. The resolution of an optical microscope is much lower than a transmission electron microscope (TEM) because

A. the aperture of TEM is too small.
B. the aperture of the pupil of human eye is too small.
C. visible wavelength is shorter than the de Broglie wavelength of high energy electron.
D. the de Broglie wavelength of high energy electron is shorter than visible wavelength.

A	B	C	D
○	○	○	○

$\theta \simeq \frac{1.22\lambda}{d}$, $\lambda = \frac{h}{mv}$: de Broglie wavelength.

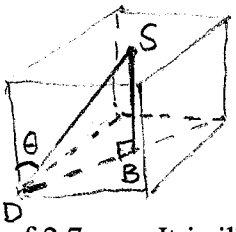
smaller θ, higher resolution.

high e⁻ speed $\rightsquigarrow$ $\lambda \downarrow$, $\theta \downarrow$

(less than λ of visible light)

SECTION C: Energy and Use of Energy

Q.3: Multiple choice questions.



$SB = 2.7$

$DB = \frac{5\sqrt{2}}{2}$

$SD^2 = 2.7^2 + \left(\frac{5\sqrt{2}}{2}\right)^2 = 19.79$

$SD = 4.4486$

3.1. A room with an area of 5 m × 5 m has a height of 2.7 m. It is illuminated by one single lamp of luminous flux 2000 lm mounted at the centre of the ceiling. Find the ratio of the illuminance between the darkest and the brightest spots on the floor.

$\cos\theta = \frac{SB}{SD} = 0.60693$

(A) 1 : 4.5
B. 1 : 2.7
C. 1 : 2.5
D. 1 : 1.6

$\frac{\Phi \cos\theta}{4\pi(SD)^2} : \frac{\Phi}{4\pi(SB)^2}$

$\frac{0.60693}{4.4486^2} : \frac{1}{2.7^2}$

$1 : 4.473$

A	B	C	D
○	○	○	○

3.2. Which of the following features is/are essential for an induction cooker to work properly?

(1) A magnetic field alternating at a high frequency is produced.
(2) A heat-conducting surface for a cooking utensil to sit on. ← not necessary
(3) A utensil with a metal bottom is used.

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

A	B	C	D
○	○	○	○

3.3. A cubic refrigerator has side lengths of 0.6 m. All its surfaces are 1 cm thick and are made of an insulating material of conductivity 0.02 W m^{-1} K^{-1}. Suppose heat enters the interior of the refrigerator via all its surfaces at a rate of 40 W. Estimate the temperature difference between the inside and the outside of the surfaces of the refrigerator.

A. 5.56 °C
(B) 9.26 °C
C. 18.5 °C
D. 55.6 °C

$\frac{Q}{t} = 40$

$\frac{0.02 \times 0.6^2 \times 6}{0.01} \times \Delta T = 40$

$\Delta T = 9.26$

A	B	C	D
○	○	○	○

3.4. Using double-glazing glass can reduce the OTTV of a building. Which of the following is/are the major reason(s)?

(1) The U-value of double glazing glass is low.
(2) The heat gained by the building via radiation is reduced. ← insignificant
(3) Heat is lost from a building through a double-glazing glass window easily.

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

A	B	C	D
○	○	○	○

3.5. Arrange the following lighting devices in increasing order of end-use energy efficiency.

efficacy = flux / power

(1) A 57 W halogen lamp giving out 1370 lm. (1) 24.04
(2) A 12 W LED giving out 456 lm. (2) 38
(3) A 13 W compact fluorescent lamp giving out 780 lm. 60 (3)
(4) A 100 W light bulb giving out 1700 lm. 17 (4)

A. (2), (3), (1), (4)
B. (3), (2), (1), (4)
C. (4), (1), (2), (3)
D. (4), (1), (3), (2)

A	B	C	D
○	○	○	○

3.6. Identify the components that can be found in hybrid vehicles but **NOT** in electric vehicles.

(1) Internal combustion engine
(2) Fuel tank
(3) Battery

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

A	B	C	D
○	○	○	○

3.7. Which of the following statements about a nuclear reactor are correct?

(1) The nuclear fission in a nuclear reactor is under control.
(2) The coolant in a nuclear reactor is used for decreasing the rate of nuclear fission. ↖ water in primary loop.
(3) The moderator in a nuclear reactor is used to slow down neutrons.

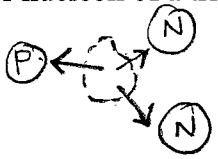
A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

A	B	C	D
○	○	○	○

3.8. Given that: mass of proton = 1.0073 u, mass of neutron = 1.0087 u,
mass of tritium ($^{3}_{1}H$) nucleus = 3.0155 u

What is the binding energy per nucleon of a tritium nucleus?

A. 2.3×10^{-3} MeV
B. 3.1×10^{-3} MeV
C. 2.1 MeV
D. 2.9 MeV



A	B	C	D
○	○	○	○

$\Delta m = 1.0073 + 2 \times 1.0087 - 3.0155$
$= 9.2 \times 10^{-3}$ u
$E_{/3} = 9.2 \times 10^{-3} \times 931$ MeV/3
$= 2.855$ MeV

Section A

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

1. A microwave oven is used to heat up 0.2 kg of water at 20 °C. Energy is transferred to the water at a constant rate of 800 W. How long does it take to boil away all the water in the glass?
(The specific latent heat of vaporization of water is 2260 kJ kg^{-1}. The specific heat capacity of water is 4200 J kg^{-1} °C^{-1}.)

$800\,t = (0.2)(4200)(100-20) + (0.2)(2.26\times10^{6})$

$t = 649\,s$

A. 84 s
B. 565 s
C. 649 s
D. 724 s

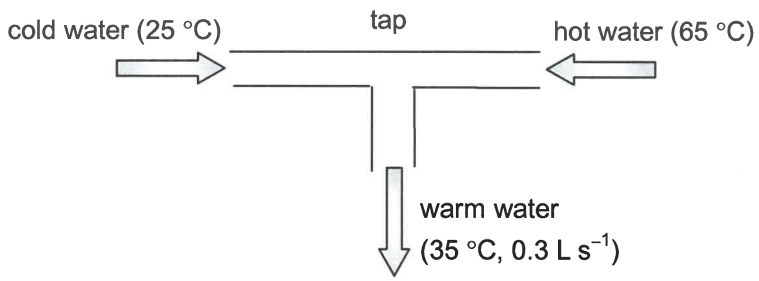
2. The separation between the –10 °C and 110 °C marks on a mercury-in-glass thermometer is 20 cm. When the thermometer is put in a liquid of temperature T, the mercury thread is 10 cm above the 0 °C mark. The temperature T is

$\text{graduation} = \frac{120}{20} = 6\ ^{\circ}C\ cm^{-1}$

$T = 60\ ^{\circ}C$

A. 50 °C.
B. 55 °C.
C. 58 °C.
D. 60 °C.

3. As shown below, hot water at 65 °C and cold water at 25 °C are mixed before leaving the tap. Suppose the water leaving the tap is at 35 °C and flows at a rate of 0.3 L s^{-1}. What is the rate at which the hot water flows into the tap?



$m_C\,c\,(35-25) = m_H\,c\,(65-35)$

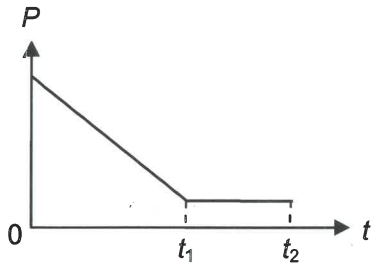
$\frac{m_C}{m_H} = 3$

$\text{rate of hot water} = \frac{0.3}{4}$

$= 0.075\ L\,s^{-1}$

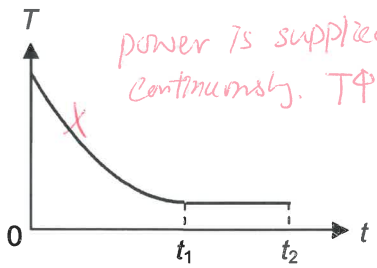
A. 0.075 L s^{-1}
B. 0.092 L s^{-1}
C. 0.138 L s^{-1}
D. 0.150 L s^{-1}

4. A liquid is heated at power P which changes with time t as shown.



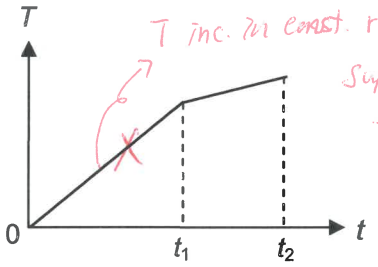
Assume that the liquid does not change to gas until $t = t_2$. Which of the following graphs best shows the variation of the temperature T of the liquid with time t?

A.



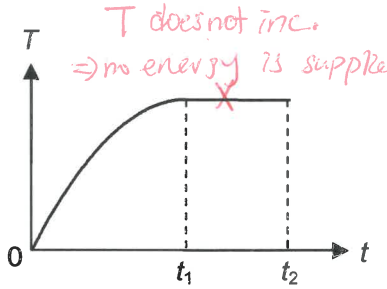
power is supplied continuously. T↑

B.



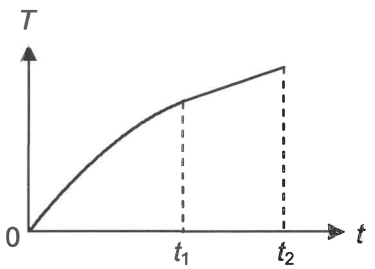
T inc. in const. rate ⇒ energy is supplied in const. rate. ⇒ power is const.

C.



T does not inc. ⇒ no energy is supplied

D.



*5. Two vessels X and Y, which contain the same kind of ideal gas at the same temperature, are connected by a tap which is initially closed. The volume and pressure of the gas in the vessels are listed as follows:

Vessel	Pressure / Pa	Volume / m^3
X	4×10^5	1.3×10^{-2}
Y	3×10^5	7×10^{-3}

When the tap is opened, what will be the final pressure in the vessels if the volumes of the vessels and the temperature of the gas are constant throughout the process?

A. 3.42×10^5 Pa
B. 3.50×10^5 Pa
C. 3.65×10^5 Pa
D. 3.83×10^5 Pa

Before the tap opens

X: $(4\times10^5)(1.3\times10^{-2}) = n_X RT$

Y: $(3\times10^5)(7\times10^{-3}) = n_Y RT$

After the tap opens

$p'(1.3\times10^{-2} + 7\times10^{-3}) = (n_X + n_Y)RT$

$p'(0.02) = \left[\frac{(4\times10^5)(1.3\times10^{-2}) + (3\times10^5)(7\times10^{-3})}{RT}\right]RT$

$p = 365000$ Pa

6. Which of the following about a uniformly accelerating object MUST be correct?

(1) The object is speeding up.
(2) The velocity of the object is changing.
(3) The object is moving in the same direction.

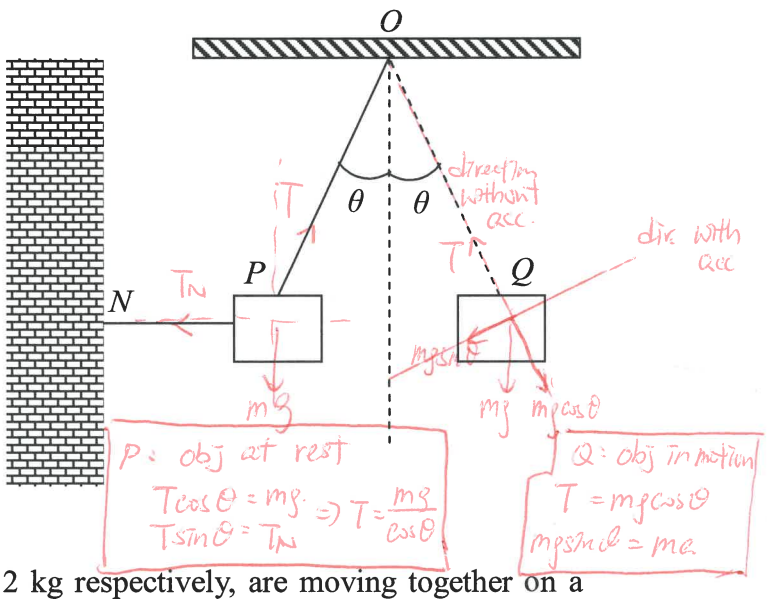
when v and a are of opp direction, the obj. slows down
the definition of acc. is the rate of change in vel.

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

when v and a are of opp. direction, the obj. will decelerates, eventually stops momentarily and accelerates towards the opposite direction

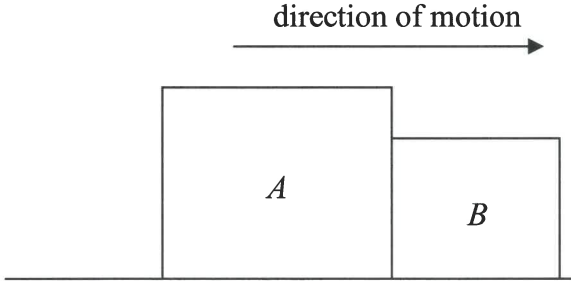
7. A block of mass m is held at rest at P by a string OP making an angle θ with the vertical and a horizontal string NP as shown in the figure below. The tension in OP is T_P. When the string NP is cut, the block will swing to position Q where OQ also makes an angle θ with the vertical. The tension in OP is T_Q. Which of the following gives the values of T_P and T_Q.

	T_P	T_Q
A.	$\frac{mg}{\cos\theta}$	$mg\cos\theta$
B.	$\frac{mg}{\cos\theta}$	$\frac{mg}{\cos\theta}$
C.	$mg\cos\theta$	$\frac{mg}{\cos\theta}$
D.	$mg\cos\theta$	$mg\cos\theta$



8. Two blocks, A and B, of mass 3 kg and 2 kg respectively, are moving together on a rough horizontal surface as shown in the figure below. The friction acting on each block is 2 N. Find the force acting on A by B.

A. 2 N
B. 0.8 N
C. 0.4 N
D. 0 N

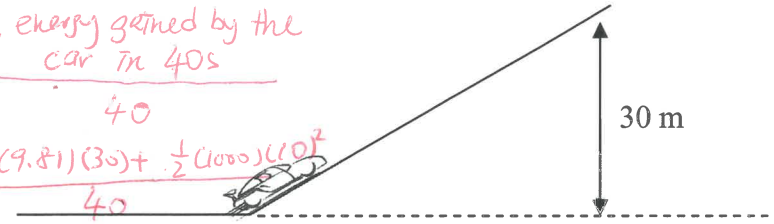


A+B ← 4N
F = ma
4 = 5a
a = 0.8 ms⁻²
∴ deceleration of both blocks are 0.8 ms⁻²

A ← F_AB
2N
F_AB + 2 = 3(0.8)
F_AB = 0.4N

9. A car of mass 1000 kg is moving up a slope from rest. The car arrives at the top of the slope, which is 30 m from the ground level, with a speed of 10 m s^{-1} in 40 s. Find the average power output of the car. Neglect air resistance and friction.

A. 8610 W
B. 7360 W
C. 6349 W
D. 1250 W



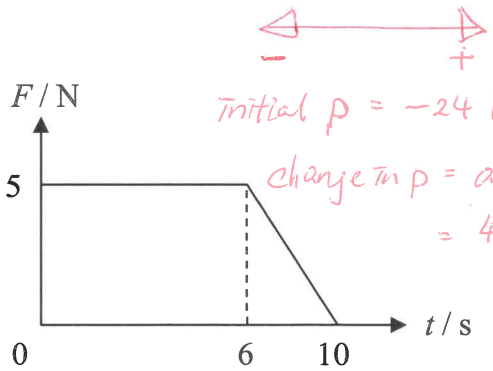
↳ P = total energy gained by the car in 40s / 40

$= \frac{(1000)(9.81)(30) + \frac{1}{2}(1000)(10)^2}{40}$

$= 8607.5\ W$

10. A bob of mass 4 kg is originally moving at 6 m s^{-1} towards the *left*. It experiences a force F pushing it towards the *right* for 10 s. The variation of the force F and time t is shown in the graph below. What is the speed of the bob after 10 s?

A. 16 m s^{-1}
B. 12 m s^{-1}
C. 8 m s^{-1}
D. 4 m s^{-1}



− +

Initial p = $-24\ kg\ ms^{-1}$

change in p = area under F-t graph = $40\ kg\ ms^{-1}$

final p = $-24 + 40 = 16\ kg\ ms^{-1}$

final v = $4\ ms^{-1}$ (to the right)

*11. A ball is projected horizontally from the top of a building at 20 m s^{-1}. Assume that there is no air resistance. What is its vertical speed 5 s later?

A. 20 m s^{-1}
B. 49.1 m s^{-1}
C. 100 m s^{-1}
D 223 m s^{-1}

In vertical direction = free fall from rest

$v = u + at$

$v = 0 + (9.81)(5)$

$v = 49.1\ ms^{-1}$

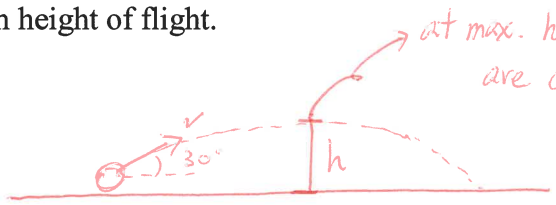
*12. A projectile is projected with speed v at an angle 30° above the horizontal, and its kinetic energy is E. Express the kinetic energy of the projectile in terms of E when it is at one-third of its maximum height of flight.

A. $\frac{5}{6}E$

B. $\frac{25}{36}E$

C. $\frac{11}{12}E$

D. $\frac{121}{144}E$



at max. height, $\frac{1}{2}m(v\sin\theta)^2$ are converted into PE.

total mechanical energy $= \frac{1}{2}mv^2 = E$ ⇒ remains constant throughout the motion since no work is done on the obj.

at $\frac{1}{3}$ of max. height, $\frac{1}{3}\left(\frac{1}{2}m(v\sin\theta)^2\right)$ is converted into PE.

$\therefore$ KE at this moment $= \frac{1}{2}m(v\cos 30^\circ)^2 + \frac{2}{3}\left(\frac{1}{2}m(v\sin 30^\circ)^2\right)$

$= \frac{3}{4}E + \frac{2}{3}\left(\frac{1}{4}\right)E = \frac{11}{12}E$

*13. A satellite turns around a planet in a circular orbit with period T. If the distance between the satellite and the centre of the planet is three times its original value, the period will become

A. T

B. $3T$

C. $5.20T$

D. $9T$

$m\omega^2 r = \frac{GMm}{r^2}$; $\omega = \frac{2\pi}{T}$

$\frac{4\pi^2}{T^2} = \frac{GM}{r^3}$

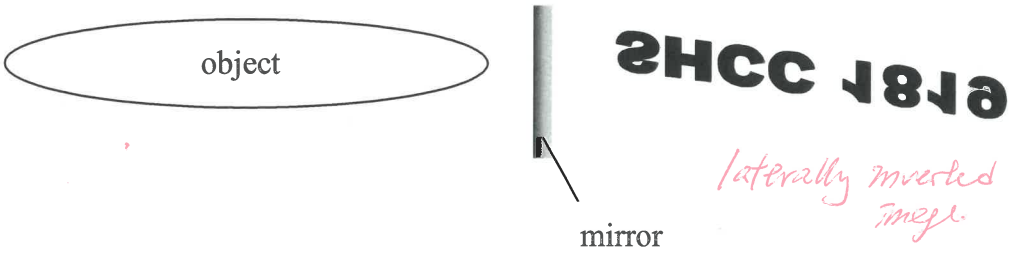
$\therefore T^2 \propto r^3$

$\therefore \frac{T^2}{T'^2} = \frac{r^3}{(3r)^3}$

$27T^2 = T'^2$

$T' = \sqrt{27}\,T$

14. The figure below shows the image formed in a plane mirror.



Which of the following correctly shows the object?

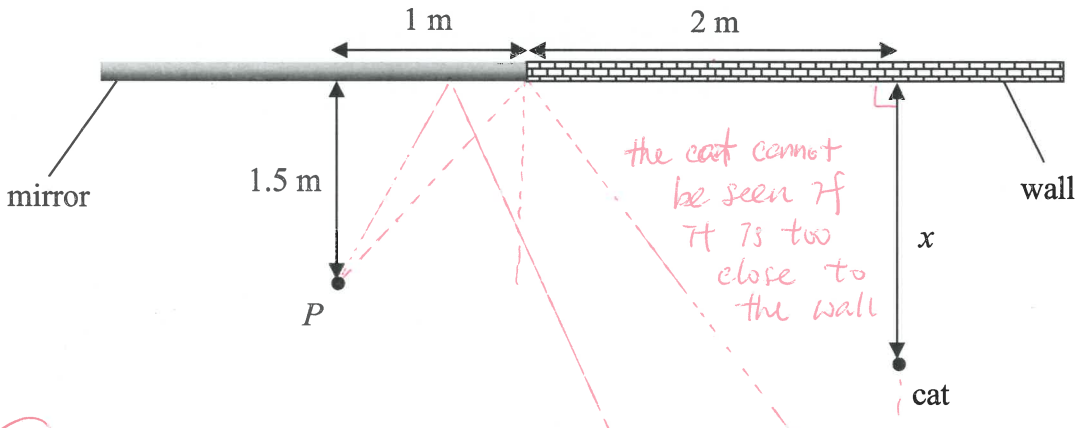
A. SHCC 1819

B. SHCC 1819

C. SHCC 1819

D. SHCC 1819

15. Ken is standing at P looking at the image of a cat standing x m in front of a wall as shown in the figure below. What is the limit of x for the image of the cat to be seen by Ken?



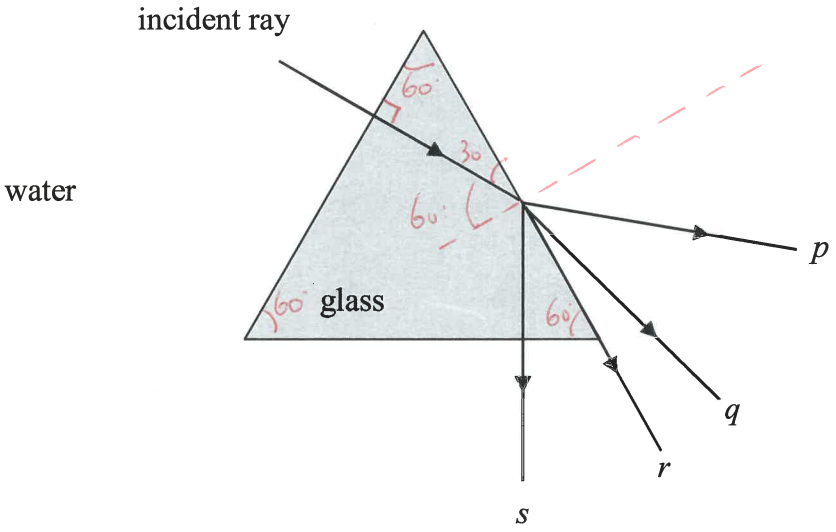
A. at least 3 m

B. at most 3 m

C. at least 1.5 m

D. at most 1.5 m

16. A light ray is incident on a equilateral triangular glass prism (refractive index 1.6) immersed in water (refractive index 1.33) as shown in the figure below. Which light ray best represents the emergent ray?



A. *p*
B. *q*
C. *r*
D. *s*

critical angle = $\sin^{-1}\left(\frac{1.33}{1.6}\right)$
= 56.227°
∴ light travels from optically denser to optically less dense medium and angle of incidence > critical angle ⇒ TIR.

17. The figure below shows an image when viewing through a spherical lens.

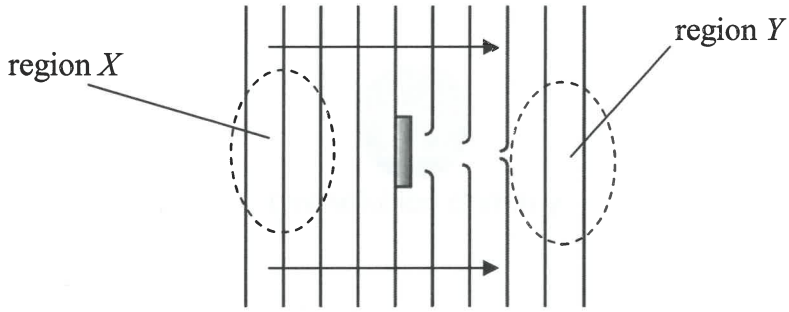
upright, diminished
⇒ Concave lens.

Which of the following statements are INCORRECT?

(1) The lens used is convex lens. should be concave
(2) The image is real, upright and diminished. should be virtual.
(3) The image can be formed on a screen. virtual image cannot be formed on screen

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

18. The figure below shows a water wave travelling to the right in a water tank of uniform depth. It is diffracted when it passes an obstacle.

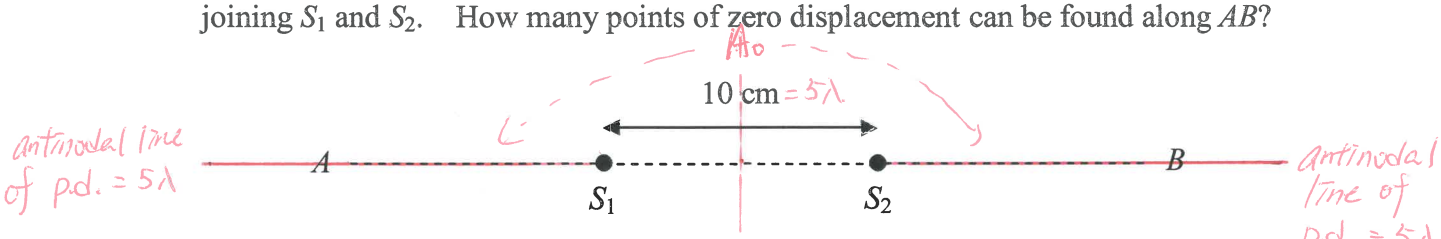


Which of the following physical quantities of the water waves in regions X and Y are the same?

(1) wave speed ✓ speed depends on depth of water
(2) amplitude ✗ part of the wave is reflected / cannot pass through the obstacle. ⇒ some energy is lost.
(3) frequency ✓ freq. depends on the source.

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

19. The figure below shows two coherent sources, S_1 and S_2, separated by 10 cm. They are vibrating at 2.5 Hz and producing water wave of speed 5 cm s^{-1}. AB is a line joining S_1 and S_2. How many points of zero displacement can be found along AB?

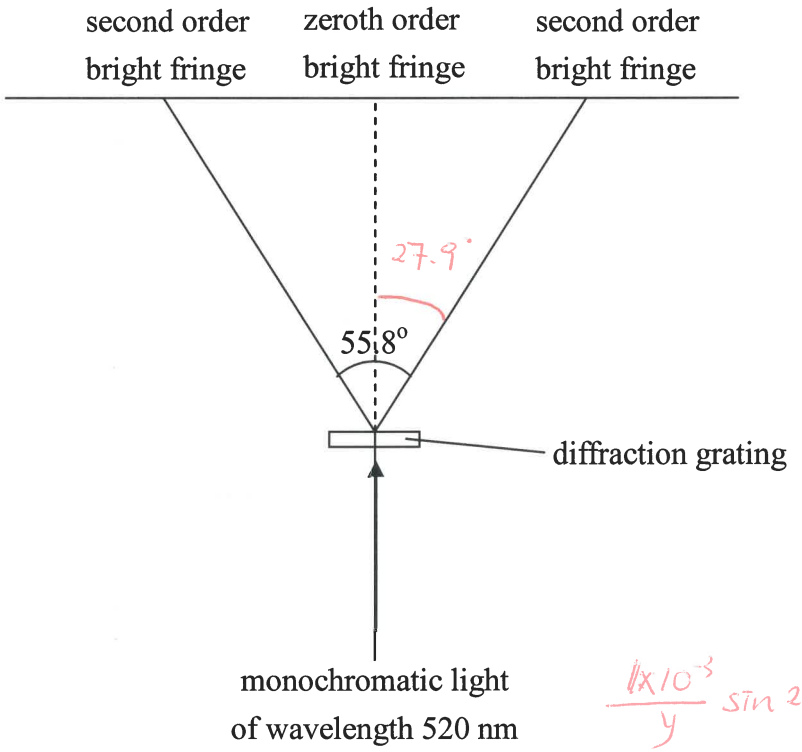


A. 4
B. 6
C. 8
D. 10

$\lambda = \frac{v}{f} = 2\text{cm}$

from A_0 to A_5, there are in total 5 nodal lines on each sides, ie. $N_{0.5}$, $N_{1.5}$, $N_{2.5}$ ... $N_{4.5}$

20. A monochromatic light of wavelength 520 nm is incident normally on a diffraction grating of y lines per mm as shown in the figure below. The angle subtended by the two second order bright fringes is 55.8°. Find the value of y.



$\frac{1 \times 10^{-3}}{y} \sin 27.9° = (2)(520 \times 10^{-9})$

$y = 449.93$

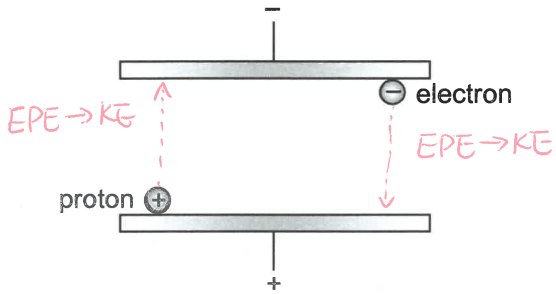
A. 225
B. 398
C. 450
D. 795

21. Which of the following about audible sound and ultrasound MUST be correct?

(1) Both ultrasound and audible sound are longitudinal waves.
(2) Ultrasound has higher frequency than audible sound. ⇒ def. of ultrasound
(3) Ultrasound carries more energy than audible sound. ⇒ depends on the amplitude of sound wave also

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

22. A proton and an electron are placed between two parallel charged plates as shown. Initially, the proton is at rest at the positive plate (lower plate) and the electron is at rest at the negative plate (upper plate). Neglect the effect of gravity and the electrostatic forces between the proton and the electron. Which of the following statements is/are correct when the proton and the electron reach the opposite plates?



(3) $EPE = qV$
⇒ which is the same in proton and electron

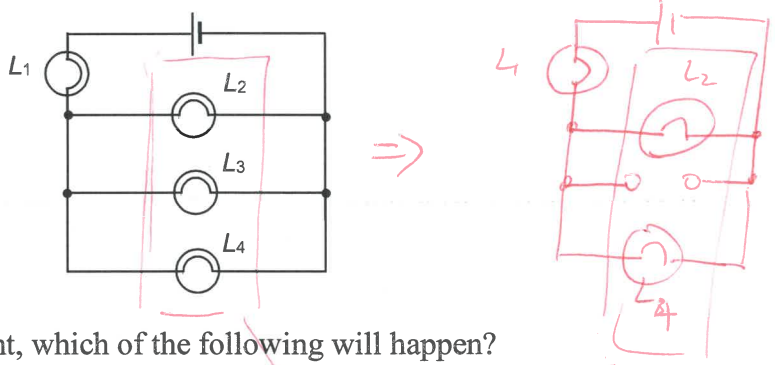
(1) The momentum of the electron is larger in magnitude than that of the proton.
(2) The electron has a smaller speed than the proton.
(3) The electron and the proton have equal kinetic energy.

(2) p and e^- carry the same KE. p has larger mass, hence smaller speed.

(1) change in momentum = $F \cdot t$
⇒ $F = qE$, the same among p and e^-
⇒ proton takes larger time since the acc. of proton is smaller due to the larger mass.
} proton has larger momentum

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

23. Four identical lamps are connected as shown. Assume the internal resistance of the dry cell is negligible.

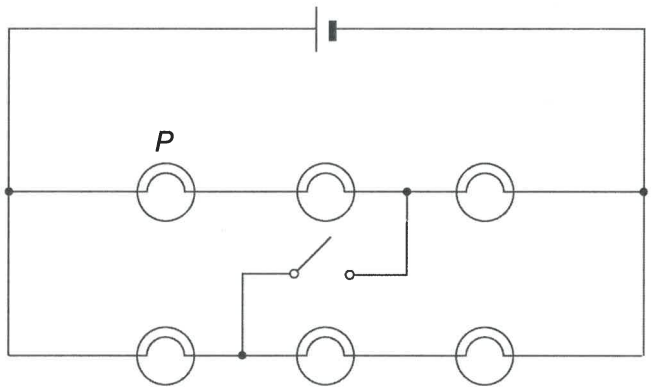


If the filament in L_3 is burnt, which of the following will happen?
(1) L_1 becomes dimmer.
(2) L_2 becomes dimmer.
(3) L_4 becomes brighter.

resistance increases
⇒ more voltage drops across L_2 and L_4.
⇒ less voltage drops across L_1.

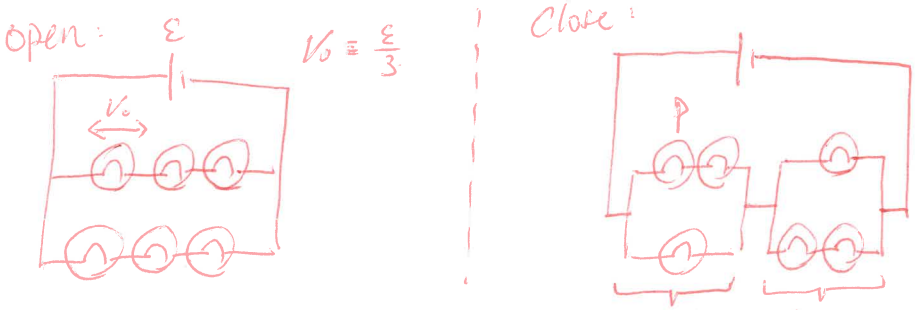
A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

24. Six identical light bulbs are connected as shown. The internal resistance of the dry cell is negligible.



When the switch is open, the potential difference across bulb P is V_o. What is the potential difference across bulb P when the switch is closed?

A. $0.5V_o$
B. $0.75V_o$
C. V_o
D. $1.5V_o$



25. A kettle operating at 1200 W takes 15 minutes to boil 3 kg of water.

Suppose electrical energy costs \$1.1 per kW h. Estimate the cost of boiling 1-kg water by this kettle.

$\frac{\left(\frac{1200}{1000}\right)\left(\frac{15}{60}\right)}{3} \times 1.1 =$

A. \$ 0.09
B. \$ 0.11
C. \$ 0.33
D. \$ 0.99

26. A kettle of rated value '220V, 1500W' is connected to a sinusoidal a.c. power supply. If the average power consumption of the kettle is 1000 W, find the peak value of the voltage across the kettle.

resistance of kettle $= \frac{220^2}{1500} = 32.26667\ \Omega$

If average power consumption, voltage applied:

$\frac{V^2}{32.6667} = 1000$

$V = 179.629\text{V}$

the voltage found is V_{rms}, peak $V = (179.629)(\sqrt{2}) = 254.03\text{V}$

A. 127 V
B. 180 V
C. 194 V
D. 254 V

*27. A transformer works at an efficiency of 80%. The primary voltage is 100 V and the turns ratio is 20 : 1. If the resistance of the secondary circuit is 50 Ω, what is the primary current?

secondary voltage $= \frac{100}{20} = 5\text{V}$

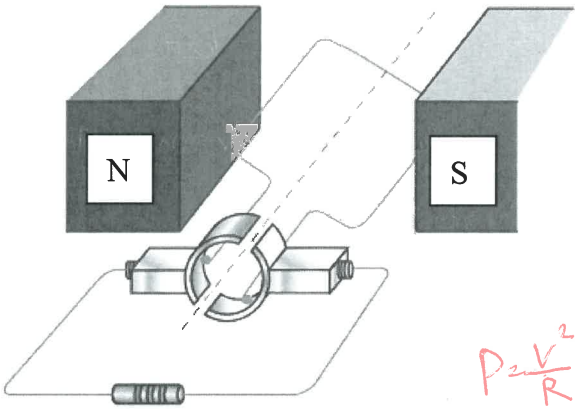
power output $= \frac{V^2}{R} = \frac{5^2}{50} = 0.5\text{W}$

power input $= \frac{0.5}{0.8} = 0.625\text{W}$

primary current $= \frac{P}{V} = \frac{0.625}{100} = 6.25\times10^{-3}\text{A}$

A. 5 mA
B. 6.25 mA
C. 10 mA
D. 2 A

28. In the generator shown below, the coil rotates at a constant speed. A resistor is connected to the generator.

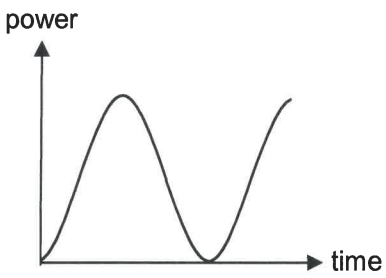


$P = \frac{V^2}{R}$

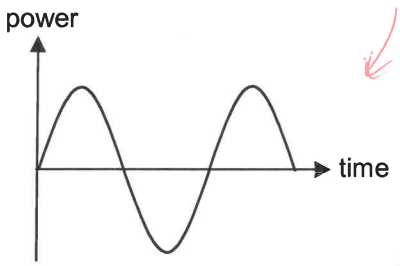
Which of the following graphs best shows the power dissipated in the resistor?

power cannot be negative

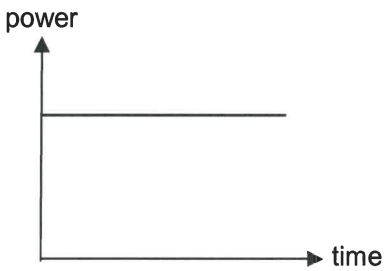
A.



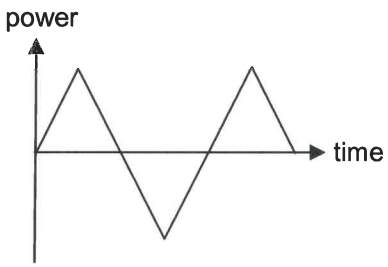
B.



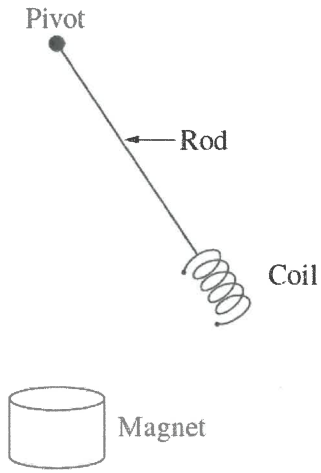
C.



D.



29. A light rod has a coil of insulated copper wire fixed at one end and is pivoted at the other end. The result is a pendulum which is free to swing back and forth. A magnet is placed underneath this pendulum. The arrangement is shown in the diagram. The pendulum is pulled back and then allowed to swing. If air resistance is negligible, which of the following would cause the pendulum to come to rest most quickly?



A. Replacing the magnet with a stronger one
B. Shortening the pendulum
C. Replacing the rod with a heavier one
D. Connecting the ends of the coil by a piece of copper wire

change in magnetic flux
↓
Induced e.m.f.
↓ (complete circuit)
Induced current
↓
magnetic force to oppose motion.

D no magnetic force is present unless the circuit is completed

30. Two straight metal rods, P and Q, have the same length. They are each pivoted at one end and rotated with the same angular velocity so that they sweep out horizontal circular paths as shown in diagrams X and Y. A constant current I is flowing along each rod as shown. In diagram X, a constant magnetic field is applied perpendicular to the plane of the circular path. In diagram Y, a uniform magnetic field of the same magnitude is applied in the plane of the circular path.

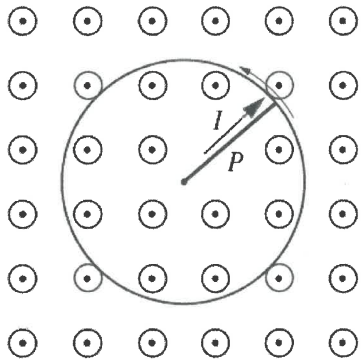


Diagram X

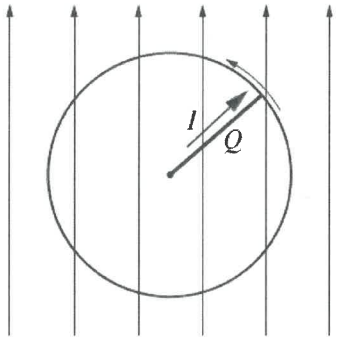


Diagram Y

Which of the following statements about the forces acting on rod P and rod Q is correct?

A. The magnitude of the force on P is exactly the same as the magnitude of the force on Q at all times.

B. The magnitude of the force on P is constant and the magnitude of the force on Q is zero.

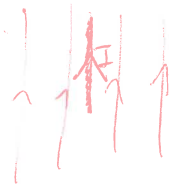
C. The magnitude of the force on P is constant and the magnitude of the force on Q varies with time.

D. The magnitude of the force on P varies with time and the magnitude of the force on Q is constant.

$F = BIl$, with $B \perp I$

for P: $B \perp I$ for all time.

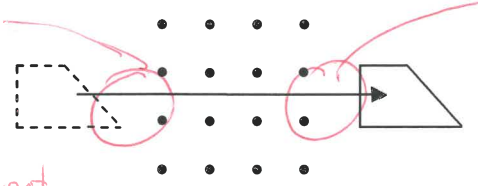
for Q:



$B \parallel I$, $\Rightarrow$ no force

$B \perp I$, $\Rightarrow$ force present

31. In the following figure, a trapezium-shaped metal coil moves at a constant velocity across a uniform magnetic field pointing out of page.

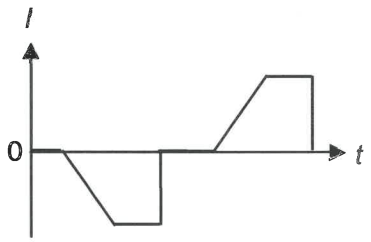


when entering, ↻ I is induced to produce B-field into the paper to resist the increasing flux out of paper

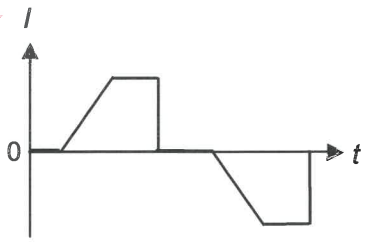
when leaving ↺ I is induced to produce B-field out of paper to resist the decreasing flux out of paper.

Which of the following graphs best shows the variation of the induced current I in the coil with time t? The clockwise direction is taken as positive.

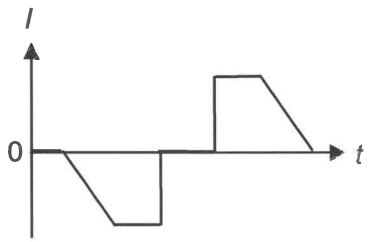
A.



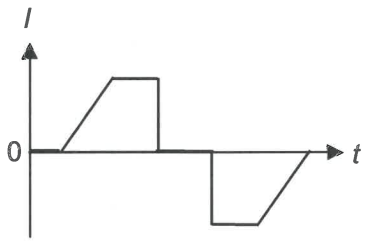
B.



C.



D.



*32. The fission of one atom of unranium-235 (U-235) generates 202.5 MeV of energy. Suppose that a power plant consumes 0.5 kg of U-235 each hour and its efficiency in converting the nuclear energy into electrical energy is 30%. Estimate its power output.
Given: molar mass of U-235 = 235 g

A. 1.24 GW
B. 3.46 GW
C. 6.92 GW
D. 11.5 GW

no. of U-235 atoms in 0.5kg $= \frac{500}{235} \times 6.02 \times 10^{23}$
$= 1.28085 \times 10^{24}$

power output in one hour $= (1.28085 \times 10^{24}) \times (202.5 \times 10^{6} \times 1.6 \times 10^{-19})$ (202.5 MeV convert to J)
$\times 0.3$
$= 1.244987 \times 10^{13}\ J\ hr^{-1}$

$P = \frac{1.244987 \times 10^{13}}{3600} = 3.458 \times 10^{9}\ W$

*33. The decay constant of a radioactive sample is $3 \times 10^{-4}\ s^{-1}$. The sample initially consists of 99% of undecayed nuclides. How long does it take for the percentage of the undecayed nuclides in the sample to decrease to 1%?

A. 38.5 minutes
B. 4.17 hours
C. 4.25 hours
D. 62.9 hours

No. of nuclides = N

$0.01N = 0.99N\, e^{-(3\times10^{-4})t}$

$\ln \frac{0.01}{0.99} = -(3\times10^{-4})\, t$

$t = 15317\,s = 4.25\,hr$

END OF SECTION A

Section A

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

1. A microwave oven is used to heat up 0.2 kg of water at 20 °C. Energy is transferred to the water at a constant rate of 800 W. How long does it take to boil away all the water in the glass?
(The specific latent heat of vaporization of water is 2260 kJ kg^{-1}. The specific heat capacity of water is 4200 J kg^{-1} °C^{-1}.)

$800\,t = (0.2)(4200)(100-20) + (0.2)(2.26\times10^{6})$

$t = 649\,s$

A. 84 s
B. 565 s
C. 649 s
D. 724 s

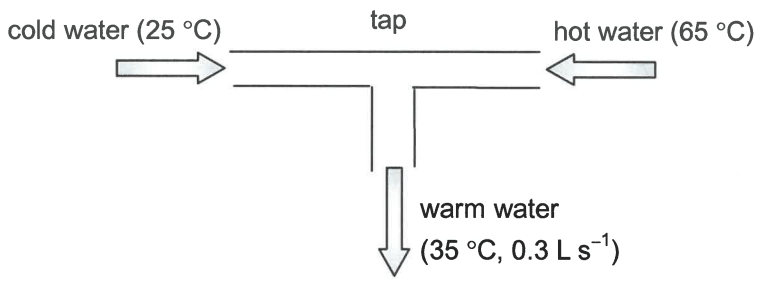
2. The separation between the –10 °C and 110 °C marks on a mercury-in-glass thermometer is 20 cm. When the thermometer is put in a liquid of temperature T, the mercury thread is 10 cm above the 0 °C mark. The temperature T is

$\text{graduation} = \frac{120}{20} = 6\ ^{\circ}C\ cm^{-1}$

$T = 60\ ^{\circ}C$

A. 50 °C.
B. 55 °C.
C. 58 °C.
D. 60 °C.

3. As shown below, hot water at 65 °C and cold water at 25 °C are mixed before leaving the tap. Suppose the water leaving the tap is at 35 °C and flows at a rate of 0.3 L s^{-1}. What is the rate at which the hot water flows into the tap?



$m_C\,c\,(35-25) = m_H\,c\,(65-35)$

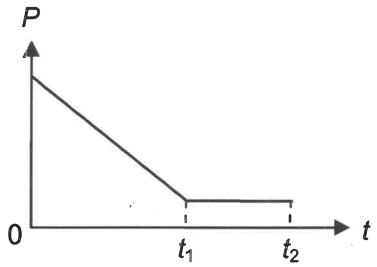
$\frac{m_C}{m_H} = 3$

$\text{rate of hot water} = \frac{0.3}{4}$

$= 0.075\ L\,s^{-1}$

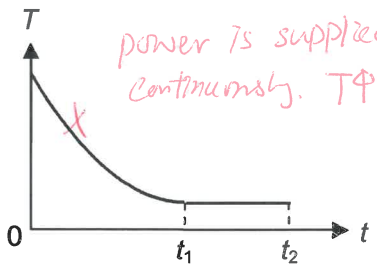
A. 0.075 L s^{-1}
B. 0.092 L s^{-1}
C. 0.138 L s^{-1}
D. 0.150 L s^{-1}

4. A liquid is heated at power P which changes with time t as shown.



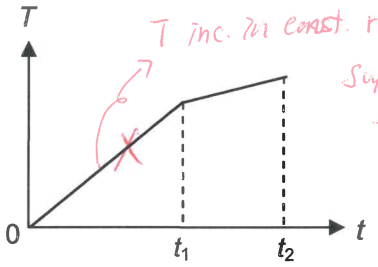
Assume that the liquid does not change to gas until $t = t_2$. Which of the following graphs best shows the variation of the temperature T of the liquid with time t?

A.



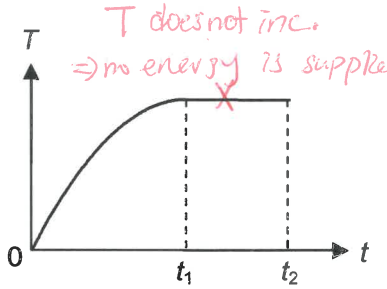
power is supplied continuously. T↑

B.



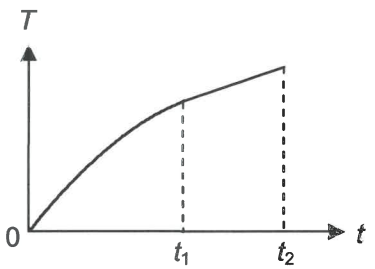
T inc. in const. rate ⇒ energy is supplied in const. rate. ⇒ power is const.

C.



T does not inc. ⇒ no energy is supplied

D.



*5. Two vessels X and Y, which contain the same kind of ideal gas at the same temperature, are connected by a tap which is initially closed. The volume and pressure of the gas in the vessels are listed as follows:

Vessel	Pressure / Pa	Volume / m^3
X	4×10^5	1.3×10^{-2}
Y	3×10^5	7×10^{-3}

When the tap is opened, what will be the final pressure in the vessels if the volumes of the vessels and the temperature of the gas are constant throughout the process?

A. 3.42×10^5 Pa
B. 3.50×10^5 Pa
C. 3.65×10^5 Pa
D. 3.83×10^5 Pa

Before the tap opens

X: $(4\times10^5)(1.3\times10^{-2}) = n_X RT$

Y: $(3\times10^5)(7\times10^{-3}) = n_Y RT$

After the tap opens

$p'(1.3\times10^{-2} + 7\times10^{-3}) = (n_X + n_Y)RT$

$p'(0.02) = \left[\frac{(4\times10^5)(1.3\times10^{-2}) + (3\times10^5)(7\times10^{-3})}{RT}\right]RT$

$p = 365000$ Pa

6. Which of the following about a uniformly accelerating object MUST be correct?

(1) The object is speeding up.
(2) The velocity of the object is changing.
(3) The object is moving in the same direction.

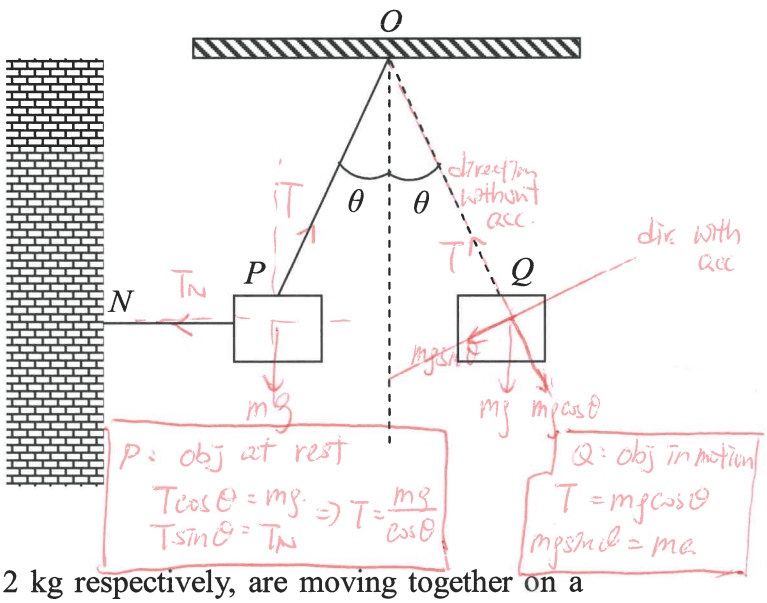
when v and a are of opp direction, the obj. slows down
the definition of acc. is the rate of change in vel.

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

when v and a are of opp. direction, the obj. will decelerates, eventually stops momentarily and accelerates towards the opposite direction

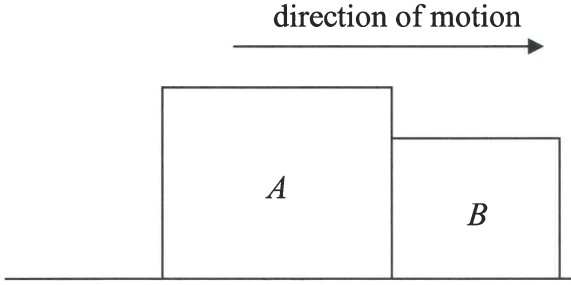
7. A block of mass m is held at rest at P by a string OP making an angle θ with the vertical and a horizontal string NP as shown in the figure below. The tension in OP is T_P. When the string NP is cut, the block will swing to position Q where OQ also makes an angle θ with the vertical. The tension in OP is T_Q. Which of the following gives the values of T_P and T_Q.

	T_P	T_Q
A.	$\frac{mg}{\cos\theta}$	$mg\cos\theta$
B.	$\frac{mg}{\cos\theta}$	$\frac{mg}{\cos\theta}$
C.	$mg\cos\theta$	$\frac{mg}{\cos\theta}$
D.	$mg\cos\theta$	$mg\cos\theta$



8. Two blocks, A and B, of mass 3 kg and 2 kg respectively, are moving together on a rough horizontal surface as shown in the figure below. The friction acting on each block is 2 N. Find the force acting on A by B.

A. 2 N
B. 0.8 N
C. 0.4 N
D. 0 N

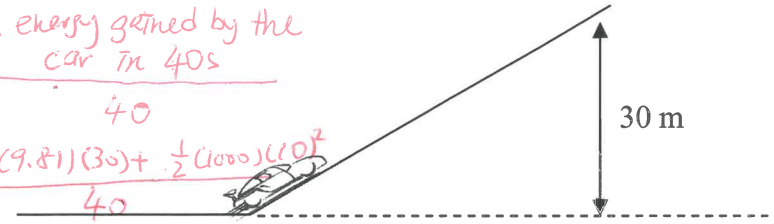


A+B ← 4N
F = ma
4 = 5a
a = 0.8 ms⁻²
∴ deceleration of both blocks are 0.8 ms⁻²

A ← F_AB
2N
F_AB + 2 = 3(0.8)
F_AB = 0.4N

9. A car of mass 1000 kg is moving up a slope from rest. The car arrives at the top of the slope, which is 30 m from the ground level, with a speed of 10 m s^{-1} in 40 s. Find the average power output of the car. Neglect air resistance and friction.

A. 8610 W
B. 7360 W
C. 6349 W
D. 1250 W



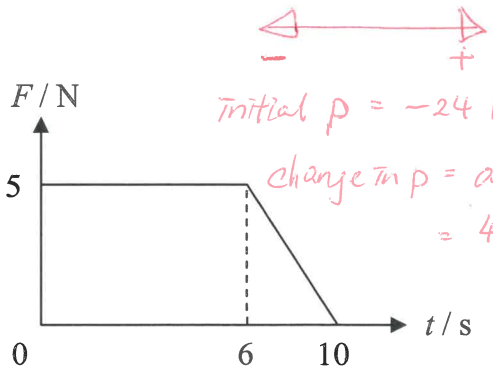
↳ P = total energy gained by the car in 40s / 40

$= \frac{(1000)(9.81)(30) + \frac{1}{2}(1000)(10)^2}{40}$

$= 8607.5\ W$

10. A bob of mass 4 kg is originally moving at 6 m s^{-1} towards the *left*. It experiences a force F pushing it towards the *right* for 10 s. The variation of the force F and time t is shown in the graph below. What is the speed of the bob after 10 s?

A. 16 m s^{-1}
B. 12 m s^{-1}
C. 8 m s^{-1}
D. 4 m s^{-1}



− +

Initial p = $-24\ kg\ ms^{-1}$

change in p = area under F-t graph = $40\ kg\ ms^{-1}$

final p = $-24 + 40 = 16\ kg\ ms^{-1}$

final v = $4\ ms^{-1}$ (to the right)

*11. A ball is projected horizontally from the top of a building at 20 m s^{-1}. Assume that there is no air resistance. What is its vertical speed 5 s later?

A. 20 m s^{-1}
B. 49.1 m s^{-1}
C. 100 m s^{-1}
D 223 m s^{-1}

In vertical direction = free fall from rest

$v = u + at$

$v = 0 + (9.81)(5)$

$v = 49.1\ ms^{-1}$

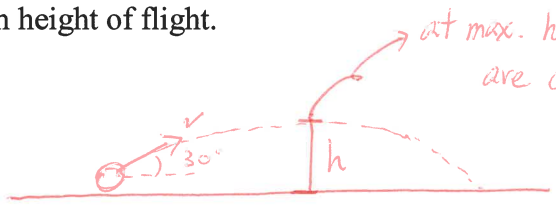
*12. A projectile is projected with speed v at an angle 30° above the horizontal, and its kinetic energy is E. Express the kinetic energy of the projectile in terms of E when it is at one-third of its maximum height of flight.

A. $\frac{5}{6}E$

B. $\frac{25}{36}E$

C. $\frac{11}{12}E$

D. $\frac{121}{144}E$



at max. height, $\frac{1}{2}m(v\sin\theta)^2$ are converted into PE.

total mechanical energy $= \frac{1}{2}mv^2 = E$ ⇒ remains constant throughout the motion since no work is done on the obj.

at $\frac{1}{3}$ of max. height, $\frac{1}{3}\left(\frac{1}{2}m(v\sin\theta)^2\right)$ is converted into PE.

$\therefore$ KE at this moment $= \frac{1}{2}m(v\cos 30^\circ)^2 + \frac{2}{3}\left(\frac{1}{2}m(v\sin 30^\circ)^2\right)$

$= \frac{3}{4}E + \frac{2}{3}\left(\frac{1}{4}\right)E = \frac{11}{12}E$

*13. A satellite turns around a planet in a circular orbit with period T. If the distance between the satellite and the centre of the planet is three times its original value, the period will become

A. T

B. $3T$

C. $5.20T$

D. $9T$

$m\omega^2 r = \frac{GMm}{r^2}$; $\omega = \frac{2\pi}{T}$

$\frac{4\pi^2}{T^2} = \frac{GM}{r^3}$

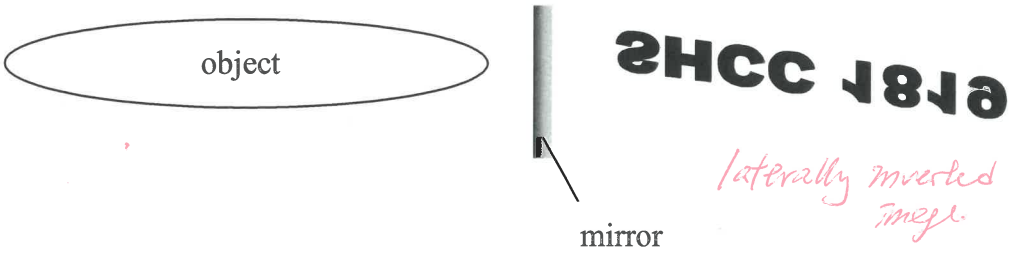
$\therefore T^2 \propto r^3$

$\therefore \frac{T^2}{T'^2} = \frac{r^3}{(3r)^3}$

$27T^2 = T'^2$

$T' = \sqrt{27}\,T$

14. The figure below shows the image formed in a plane mirror.



Which of the following correctly shows the object?

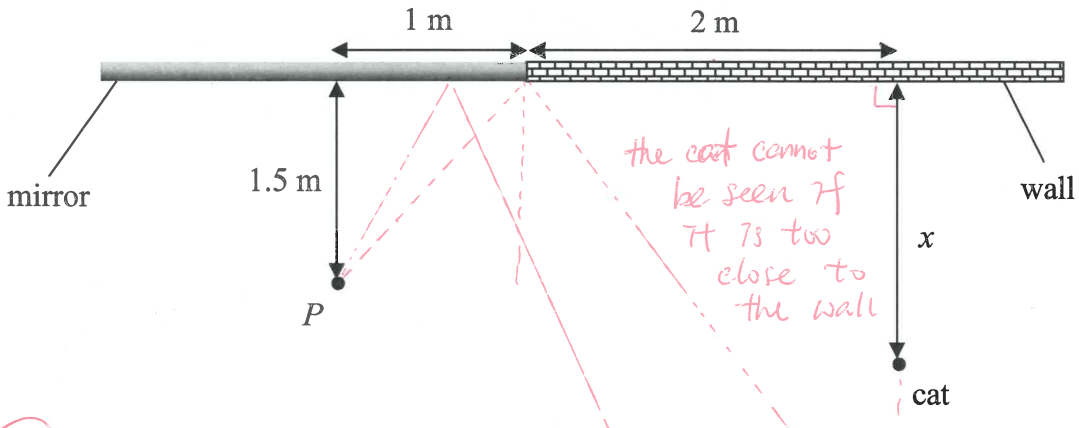
A. SHCC 1819

B. SHCC 1819

C. SHCC 1819

D. SHCC 1819

15. Ken is standing at P looking at the image of a cat standing x m in front of a wall as shown in the figure below. What is the limit of x for the image of the cat to be seen by Ken?



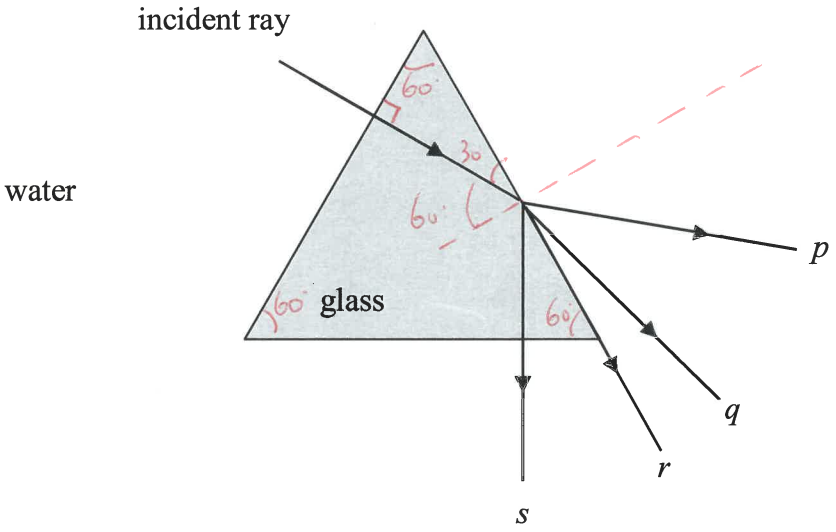
A. at least 3 m

B. at most 3 m

C. at least 1.5 m

D. at most 1.5 m

16. A light ray is incident on a equilateral triangular glass prism (refractive index 1.6) immersed in water (refractive index 1.33) as shown in the figure below. Which light ray best represents the emergent ray?



A. *p*
B. *q*
C. *r*
D. *s*

critical angle = $\sin^{-1}\left(\frac{1.33}{1.6}\right)$
= 56.227°
∴ light travels from optically denser to optically less dense medium and angle of incidence > critical angle ⇒ TIR.

17. The figure below shows an image when viewing through a spherical lens.

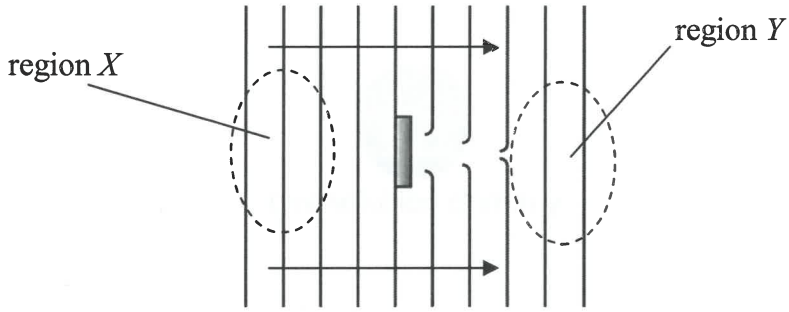
upright, diminished
⇒ Concave lens.

Which of the following statements are INCORRECT?

(1) The lens used is convex lens. should be concave
(2) The image is real, upright and diminished. should be virtual.
(3) The image can be formed on a screen. virtual image cannot be formed on screen

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

18. The figure below shows a water wave travelling to the right in a water tank of uniform depth. It is diffracted when it passes an obstacle.

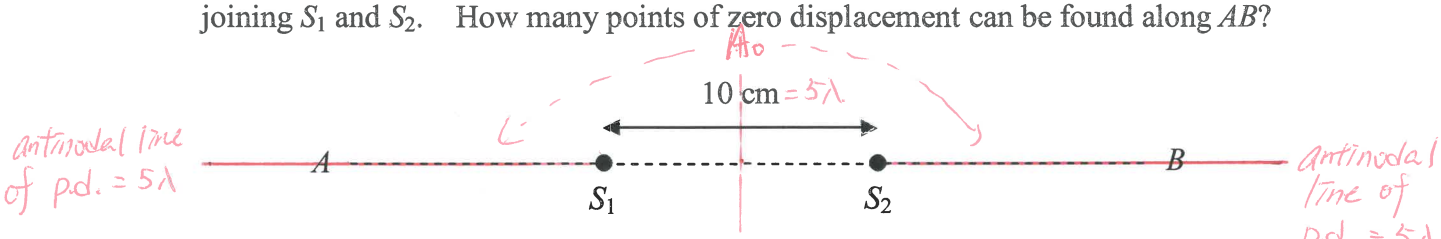


Which of the following physical quantities of the water waves in regions X and Y are the same?

(1) wave speed ✓ speed depends on depth of water
(2) amplitude ✗ part of the wave is reflected / cannot pass through the obstacle. ⇒ some energy is lost.
(3) frequency ✓ freq. depends on the source.

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

19. The figure below shows two coherent sources, S_1 and S_2, separated by 10 cm. They are vibrating at 2.5 Hz and producing water wave of speed 5 cm s^{-1}. AB is a line joining S_1 and S_2. How many points of zero displacement can be found along AB?

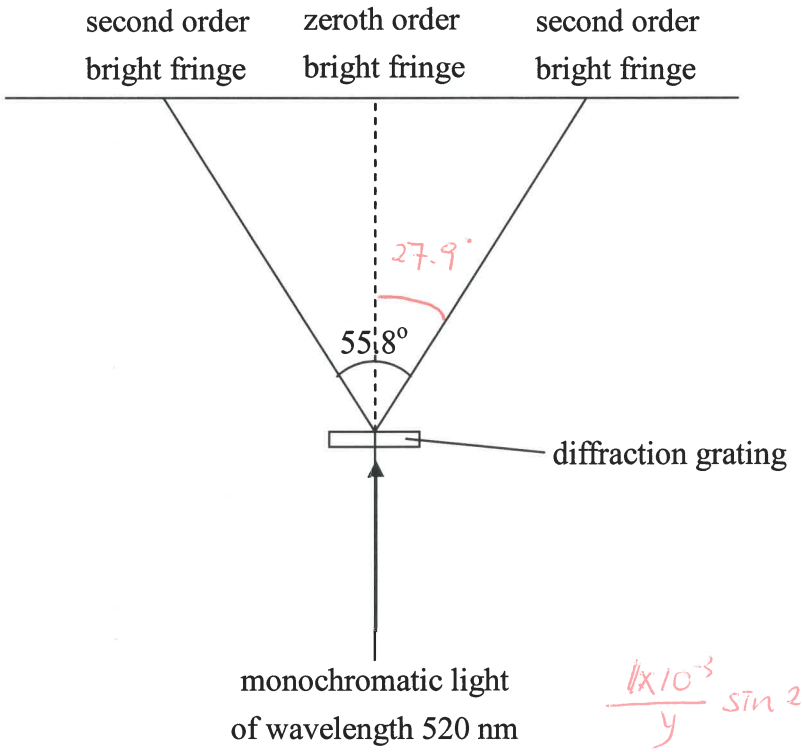


A. 4
B. 6
C. 8
D. 10

$\lambda = \frac{v}{f} = 2\text{cm}$

from A_0 to A_5, there are in total 5 nodal lines on each sides, ie. $N_{0.5}$, $N_{1.5}$, $N_{2.5}$ ... $N_{4.5}$

20. A monochromatic light of wavelength 520 nm is incident normally on a diffraction grating of y lines per mm as shown in the figure below. The angle subtended by the two second order bright fringes is 55.8°. Find the value of y.



$\frac{1 \times 10^{-3}}{y} \sin 27.9° = (2)(520 \times 10^{-9})$

$y = 449.93$

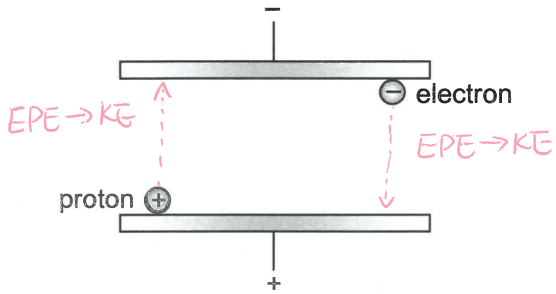
A. 225
B. 398
C. 450
D. 795

21. Which of the following about audible sound and ultrasound MUST be correct?

(1) Both ultrasound and audible sound are longitudinal waves.
(2) Ultrasound has higher frequency than audible sound. ⇒ def. of ultrasound
(3) Ultrasound carries more energy than audible sound. ⇒ depends on the amplitude of sound wave also

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

22. A proton and an electron are placed between two parallel charged plates as shown. Initially, the proton is at rest at the positive plate (lower plate) and the electron is at rest at the negative plate (upper plate). Neglect the effect of gravity and the electrostatic forces between the proton and the electron. Which of the following statements is/are correct when the proton and the electron reach the opposite plates?



(3) $EPE = qV$
⇒ which is the same in proton and electron

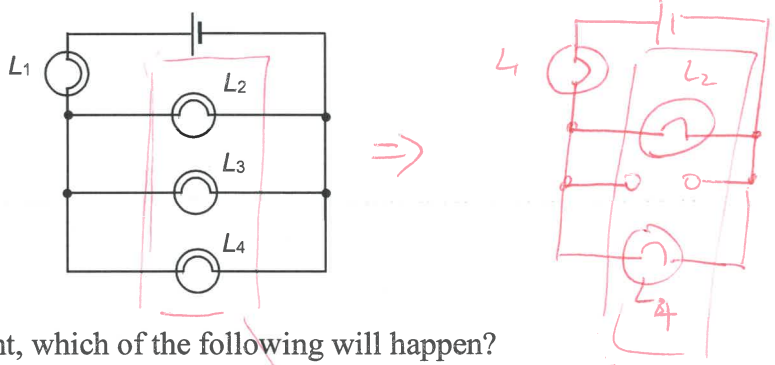
(1) The momentum of the electron is larger in magnitude than that of the proton.
(2) The electron has a smaller speed than the proton.
(3) The electron and the proton have equal kinetic energy.

(2) p and e^- carry the same KE. p has larger mass, hence smaller speed.

(1) change in momentum = $F \cdot t$
⇒ $F = qE$, the same among p and e^-
⇒ proton takes larger time since the acc. of proton is smaller due to the larger mass.
} proton has larger momentum

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

23. Four identical lamps are connected as shown. Assume the internal resistance of the dry cell is negligible.

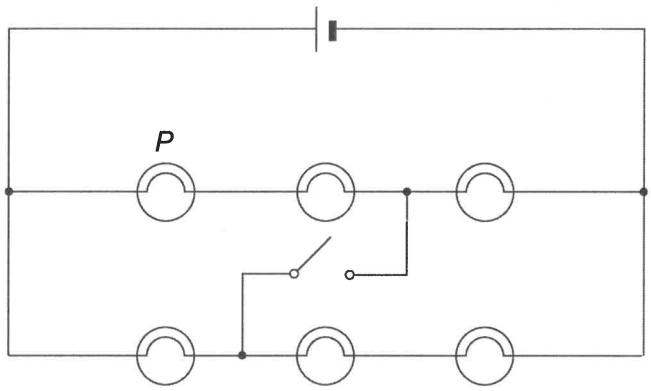


If the filament in L_3 is burnt, which of the following will happen?
(1) L_1 becomes dimmer.
(2) L_2 becomes dimmer.
(3) L_4 becomes brighter.

resistance increases
⇒ more voltage drops across L_2 and L_4.
⇒ less voltage drops across L_1.

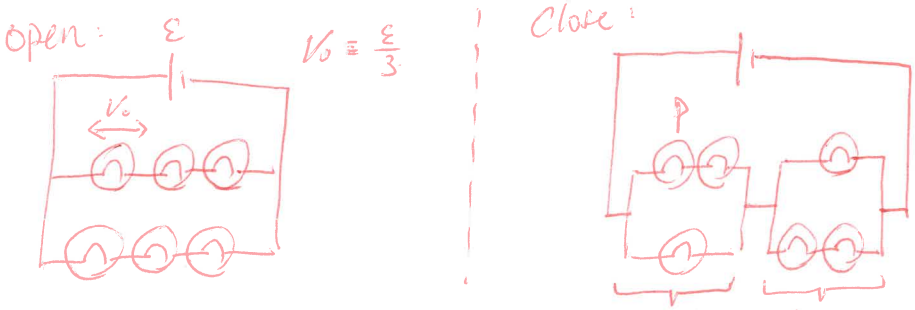
A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

24. Six identical light bulbs are connected as shown. The internal resistance of the dry cell is negligible.



When the switch is open, the potential difference across bulb P is V_o. What is the potential difference across bulb P when the switch is closed?

A. $0.5V_o$
B. $0.75V_o$
C. V_o
D. $1.5V_o$



25. A kettle operating at 1200 W takes 15 minutes to boil 3 kg of water.

Suppose electrical energy costs \$1.1 per kW h. Estimate the cost of boiling 1-kg water by this kettle.

$\frac{\left(\frac{1200}{1000}\right)\left(\frac{15}{60}\right)}{3} \times 1.1 =$

A. \$ 0.09
B. \$ 0.11
C. \$ 0.33
D. \$ 0.99

26. A kettle of rated value '220V, 1500W' is connected to a sinusoidal a.c. power supply. If the average power consumption of the kettle is 1000 W, find the peak value of the voltage across the kettle.

resistance of kettle $= \frac{220^2}{1500} = 32.26667\ \Omega$

If average power consumption, voltage applied:

$\frac{V^2}{32.6667} = 1000$

$V = 179.629\text{V}$

the voltage found is V_{rms}, peak $V = (179.629)(\sqrt{2}) = 254.03\text{V}$

A. 127 V
B. 180 V
C. 194 V
D. 254 V

*27. A transformer works at an efficiency of 80%. The primary voltage is 100 V and the turns ratio is 20 : 1. If the resistance of the secondary circuit is 50 Ω, what is the primary current?

secondary voltage $= \frac{100}{20} = 5\text{V}$

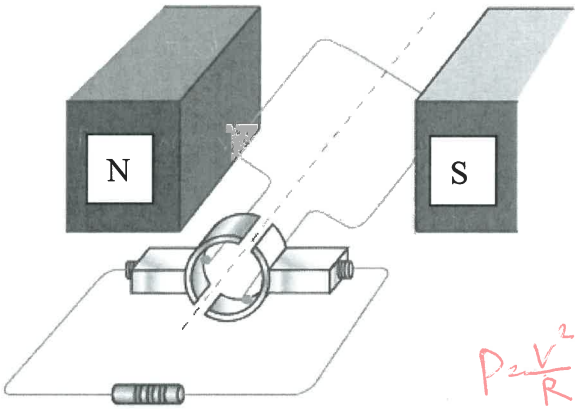
power output $= \frac{V^2}{R} = \frac{5^2}{50} = 0.5\text{W}$

power input $= \frac{0.5}{0.8} = 0.625\text{W}$

primary current $= \frac{P}{V} = \frac{0.625}{100} = 6.25\times10^{-3}\text{A}$

A. 5 mA
B. 6.25 mA
C. 10 mA
D. 2 A

28. In the generator shown below, the coil rotates at a constant speed. A resistor is connected to the generator.

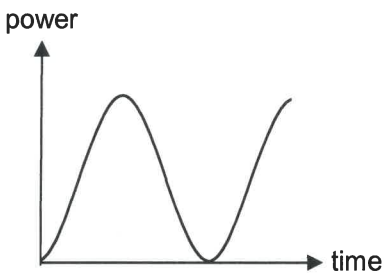


$P = \frac{V^2}{R}$

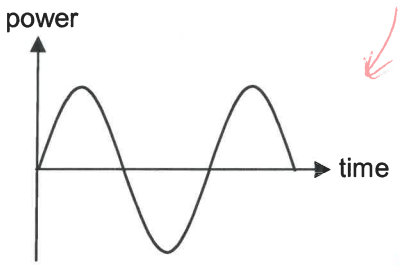
Which of the following graphs best shows the power dissipated in the resistor?

power cannot be negative

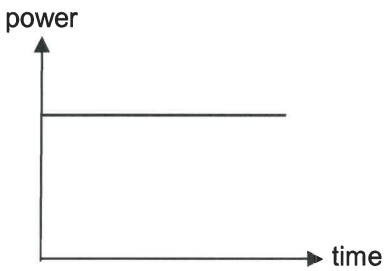
A.



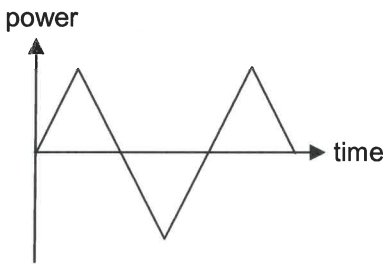
B.



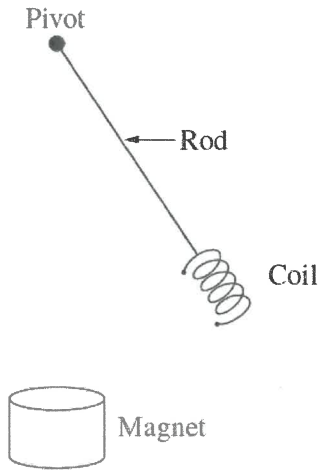
C.



D.



29. A light rod has a coil of insulated copper wire fixed at one end and is pivoted at the other end. The result is a pendulum which is free to swing back and forth. A magnet is placed underneath this pendulum. The arrangement is shown in the diagram. The pendulum is pulled back and then allowed to swing. If air resistance is negligible, which of the following would cause the pendulum to come to rest most quickly?



A. Replacing the magnet with a stronger one
B. Shortening the pendulum
C. Replacing the rod with a heavier one
D. Connecting the ends of the coil by a piece of copper wire

change in magnetic flux
↓
Induced e.m.f.
↓ (complete circuit)
Induced current
↓
magnetic force to oppose motion.

D no magnetic force is present unless the circuit is completed

30. Two straight metal rods, P and Q, have the same length. They are each pivoted at one end and rotated with the same angular velocity so that they sweep out horizontal circular paths as shown in diagrams X and Y. A constant current I is flowing along each rod as shown. In diagram X, a constant magnetic field is applied perpendicular to the plane of the circular path. In diagram Y, a uniform magnetic field of the same magnitude is applied in the plane of the circular path.

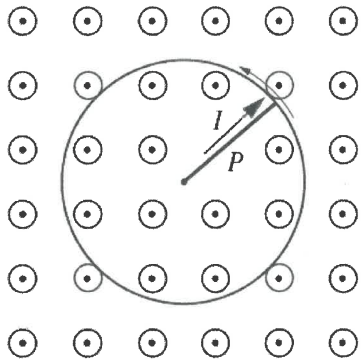


Diagram X

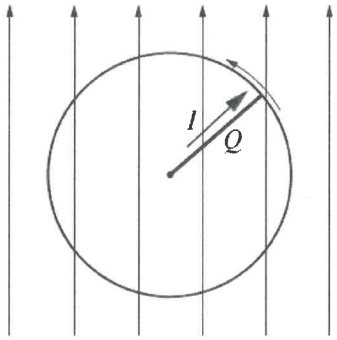


Diagram Y

Which of the following statements about the forces acting on rod P and rod Q is correct?

A. The magnitude of the force on P is exactly the same as the magnitude of the force on Q at all times.

B. The magnitude of the force on P is constant and the magnitude of the force on Q is zero.

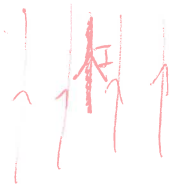
C. The magnitude of the force on P is constant and the magnitude of the force on Q varies with time.

D. The magnitude of the force on P varies with time and the magnitude of the force on Q is constant.

$F = BIl$, with $B \perp I$

for P: $B \perp I$ for all time.

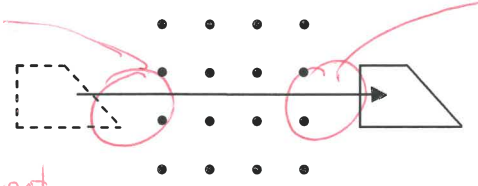
for Q:



$B \parallel I$, $\Rightarrow$ no force

$B \perp I$, $\Rightarrow$ force present

31. In the following figure, a trapezium-shaped metal coil moves at a constant velocity across a uniform magnetic field pointing out of page.

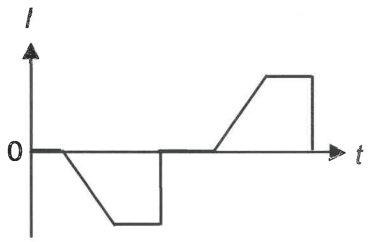


when entering, ↻ I is induced to produce B-field into the paper to resist the increasing flux out of paper

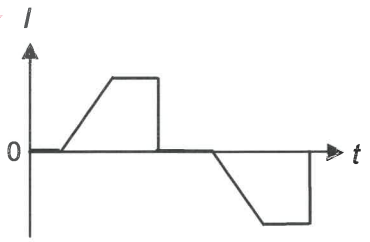
when leaving ↺ I is induced to produce B-field out of paper to resist the decreasing flux out of paper.

Which of the following graphs best shows the variation of the induced current I in the coil with time t? The clockwise direction is taken as positive.

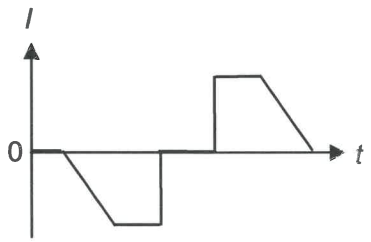
A.



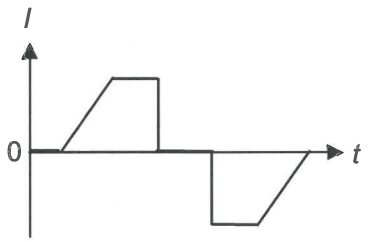
B.



C.



D.



*32. The fission of one atom of unranium-235 (U-235) generates 202.5 MeV of energy. Suppose that a power plant consumes 0.5 kg of U-235 each hour and its efficiency in converting the nuclear energy into electrical energy is 30%. Estimate its power output.
Given: molar mass of U-235 = 235 g

A. 1.24 GW
B. 3.46 GW
C. 6.92 GW
D. 11.5 GW

no. of U-235 atoms in 0.5kg $= \frac{500}{235} \times 6.02 \times 10^{23}$
$= 1.28085 \times 10^{24}$

power output in one hour $= (1.28085 \times 10^{24}) \times (202.5 \times 10^{6} \times 1.6 \times 10^{-19})$ (202.5 MeV convert to J)
$\times 0.3$
$= 1.244987 \times 10^{13}\ J\ hr^{-1}$

$P = \frac{1.244987 \times 10^{13}}{3600} = 3.458 \times 10^{9}\ W$

*33. The decay constant of a radioactive sample is $3 \times 10^{-4}\ s^{-1}$. The sample initially consists of 99% of undecayed nuclides. How long does it take for the percentage of the undecayed nuclides in the sample to decrease to 1%?

A. 38.5 minutes
B. 4.17 hours
C. 4.25 hours
D. 62.9 hours

No. of nuclides = N

$0.01N = 0.99N\, e^{-(3\times10^{-4})t}$

$\ln \frac{0.01}{0.99} = -(3\times10^{-4})\, t$

$t = 15317\,s = 4.25\,hr$

END OF SECTION A