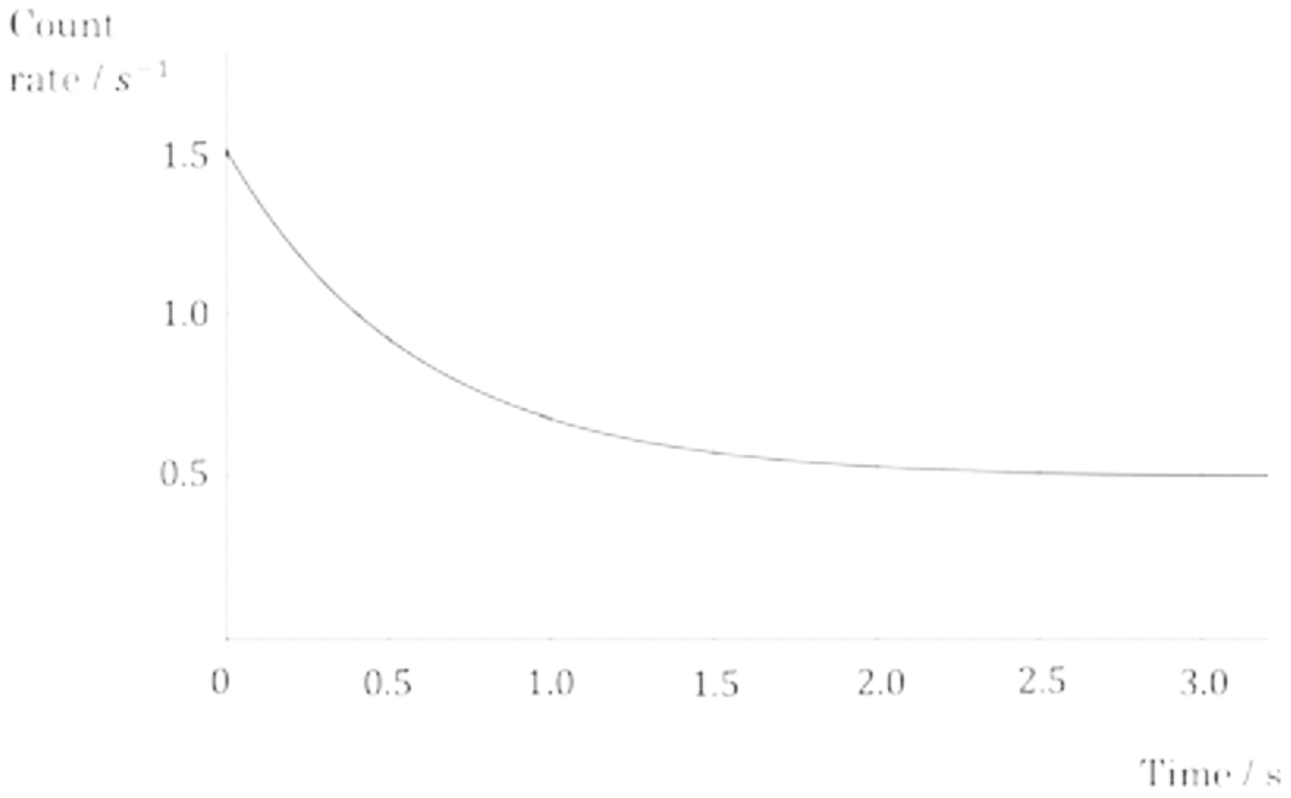
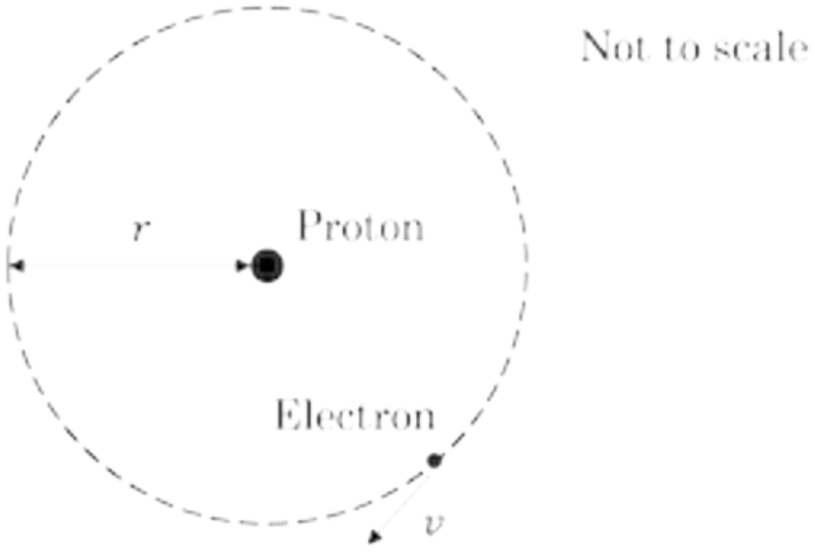
The count rate is measured at a point near a radioactive sample. The average background count rate is constant throughout. The graph below shows how the count rate varies with time.



Which row correctly shows the half-life of the radioactive sample and the background count rate?

	Half-life of sample / s	**Background count rate / s^{-1}**
A.	0.4	0.5
B.	0.4	0.75
C.	0.8	0.5
D.	0.8	0.75

An electron in a certain energy state orbits a proton with a radius r and speed v as shown in the diagram below.



According to the Bohr model of the hydrogen atom, which of the following is a correct expression, for the energy state of the electron in eV?

A. $-13.6\left(\dfrac{h}{2\pi m_e vr}\right)^2$

B. $-13.6\left(\dfrac{2\pi m_e vr}{h}\right)^2$

C. $-13.6\left(\dfrac{h}{2\pi m_p vr}\right)^2$

D. $-13.6\left(\dfrac{2\pi m_p vr}{h}\right)^2$

Below are three physical phenomena:

I. Electron diffraction
II. The photoelectric effect
III. Beta decay

Which of the physical phenomena combine to give evidence for wave-particle duality?

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

Two capacitors, **A** and **B** are connected in parallel to a voltage supply and allowed to charge fully. Capacitor **A** has three times the capacitance of capacitor **B**.

What is the ratio $\frac{Charge\ stored\ on\ capacitor\ A}{Charge\ stored\ on\ capacitor\ B}$?

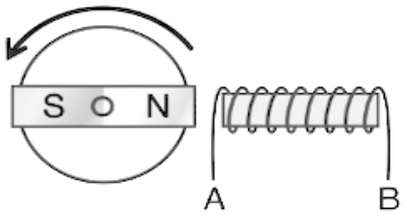
A. $\frac{1}{9}$

B. $\frac{1}{3}$

C. 1

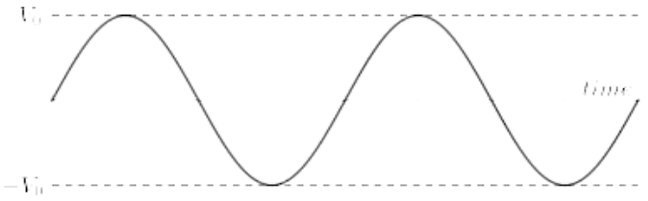
D. 3

A permanent magnet is attached circular platform which rotates about its centre with a frequency f. A solenoid is placed next to the rotating platform so that there is an induced electromotive force in the solenoid.



Created with Chemix (https://chemix.org)

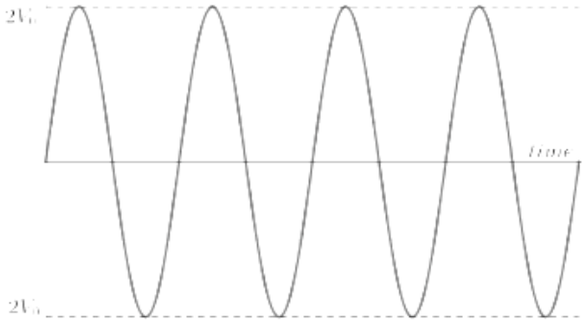
The graph below shows the potential difference across the terminals of the solenoid **A** and **B**. The peak voltage induced in the solenoid is V_0.



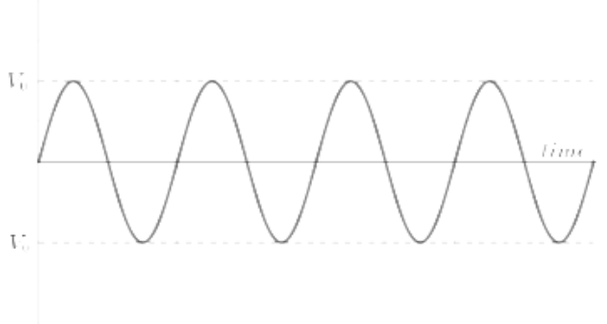
The number of turns in the solenoid is then halved and the frequency at which the platform rotates is increased to $2f$.

Which of the following graphs best describes the potential difference from **A** to **B**?

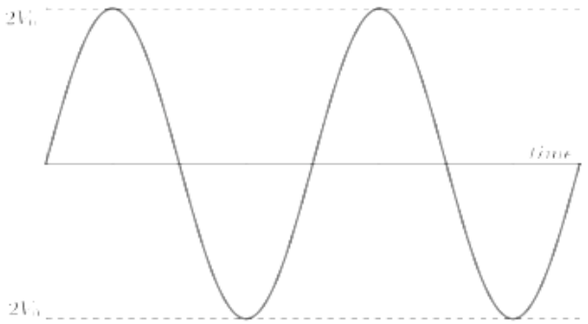
A.



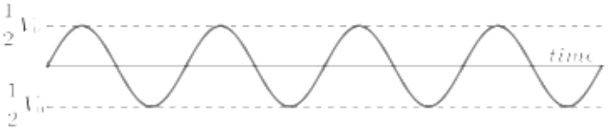
B.



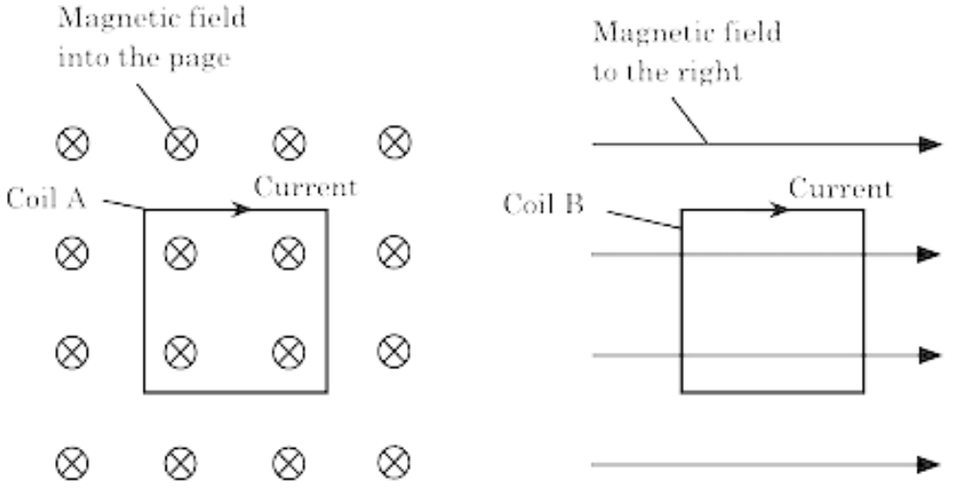
C.



D.



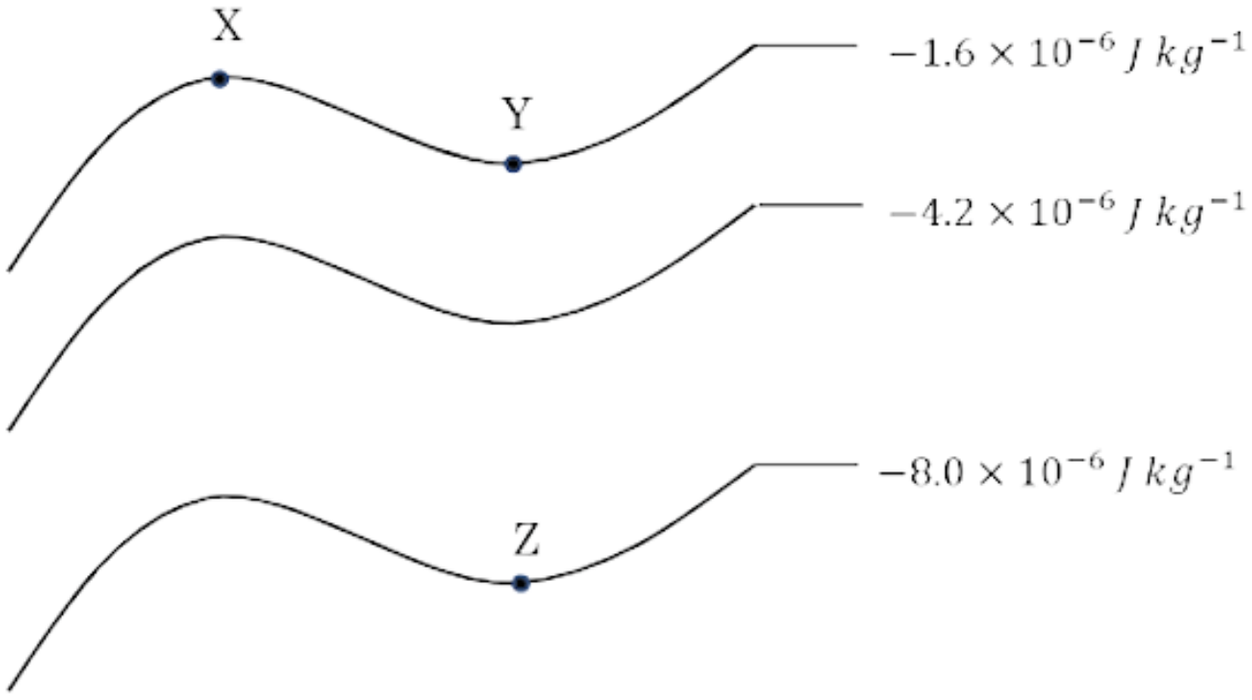
Two square coils, coil **A** and coil **B** are placed in a magnetic field. Both coils carry a current. The plane of coil **A** is perpendicular to the magnetic field and the plane of coil **B** is parallel to the magnetic field as shown in the diagram below.



Which row correctly describes the motion of each of the coils due to their interaction with the magnetic field?

	Coil A	**Coil B**
A.	Rotation	Linear acceleration
B.	Linear acceleration	Rotation
C.	No acceleration	Linear acceleration
D.	No acceleration	Rotation

The diagram below shows a series of equipotential lines in a gravitational field, along with the potentials of the lines. Points **X**, **Y** and **Z** lie on these equipotential lines.



Three statements about **X**, **Y** and **Z** are:

I. No work is done transporting a particle from point **X** to point **Y**
II. Work is done by the field when a mass is transported from point **Z** to point **X**.
III. A mass placed at point **Y** will accelerate towards **Z**.

Which of the statements are correct?

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

An observer is moving at 10% of the speed of sound away from a sound source generating a frequency f_0. What is the correct expression for the perceived frequency in terms of f_0?

A. $\frac{10}{11} f_0$

B. $\frac{11}{10} f_0$

C. $\frac{10}{9} f_0$

D. $\frac{9}{10} f_0$

White light from two distant objects passes through a narrow slit and is received by an observer. The image of the two objects is just resolved.

Which change would **NOT** assist in fully resolving the image?

A. Using a circular aperture of the same size.

B. Increasing the slit width.

C. Filtering out red light.

D. Moving the objects further apart from each other.

In a Young's double-slit experiment, the fringes are just resolved. What change can improve the resolution so that the fringes can be better observed?

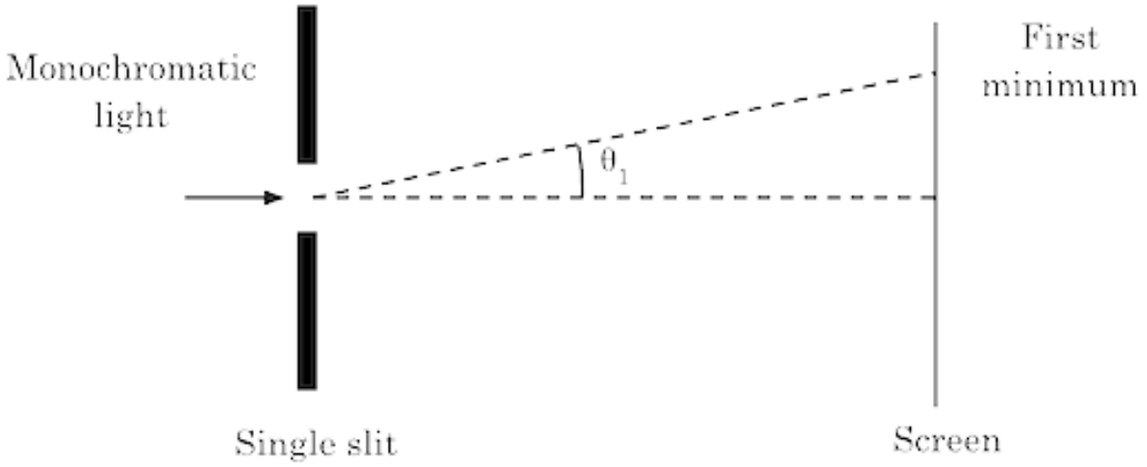
A. Bringing the screen closer to the double-slit.

B. Decreasing the distance between slits.

C. Bringing the light source closer to the double-slit.

D. Decreasing the wavelength of light.

A beam of monochromatic light is incident on a single slit and a diffraction pattern forms on the screen. The angle θ_1 represents the angle at which the first minimum occurs.



What change will increase θ_1?

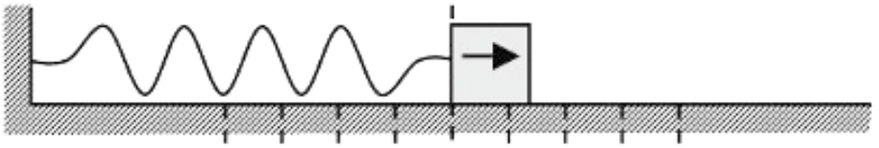
A. Increasing the width of the slit.

B. Decreasing the width of the slit.

C. Increasing the distance between the slit and the screen.

D. Decreasing the distance between the slit and the screen.

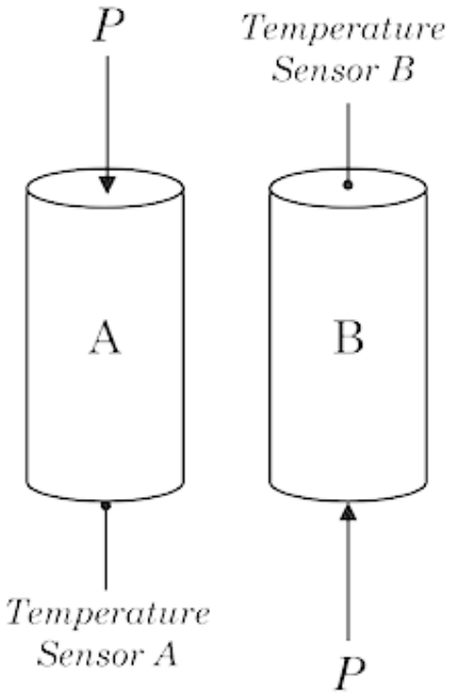
A mass (M) is attached to a spring of constant (k) and is oscillating in SHM across a frictionless surface.



Which of the following, when done together, will reduce the time period (T) of oscillation?

	Mass (M)	**Spring constant (k)**
A.	Decrease by 50%	Decrease by 50%
B.	Increase by 50%	Increase by 50%
C.	Increase by 50%	Decrease by 50%
D.	Decrease by 50%	Increase by 50%

Two vertical cylinders are filled with water. The cylinders are identical and do not lose heat to their surroundings. Heat is supplied to the top face of Cylinder **A** at a rate P, and the temperature change of the bottom face is measured by Temperature Sensor **A**. The bottom face of Cylinder **B** is also heated at a rate P, and Temperature Sensor **B** measures the temperature change of the top face.



Which temperature sensor measures the higher rate of temperature change?

A. Temperature Sensor **A**

B. Temperature Sensor **B**

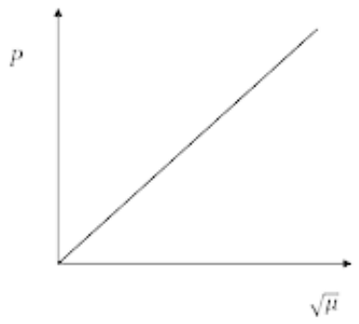
C. The rates are equal

D. The relative rates depend on the value of P

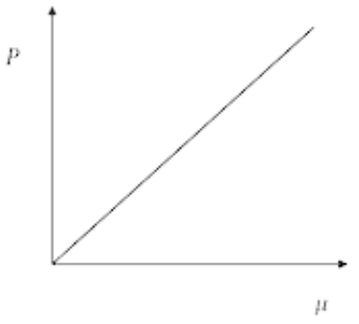
A particular wind turbine is powered by air on a windy day.

Which of the following graphs correctly shows the relation between the power output of the wind turbine P and the mass of air hitting the blades per unit time μ. Assume that air hitting the blades has a constant density.

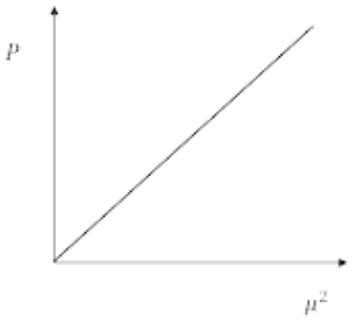
A.



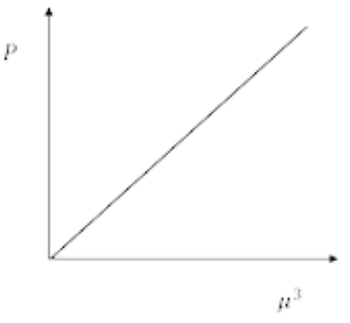
B.



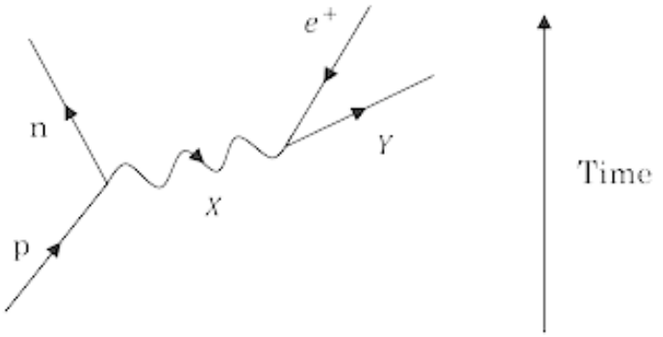
C.



D.



Below shows a Feynman diagram representing the decay of a proton.



Which row correctly identifies particles X and Y?

	Particle X	**Particle Y**
A.	π^-	ν_e
B.	π^-	$\bar{\nu}_e$
C.	W^-	ν_e
D.	W^-	$\bar{\nu}_e$

The mass of a nucleus of ${}^{12}_{6}\mathrm{C}$ in g is m_c. N_A is Avogadro's constant in mol^{-1}.

Which of the following is equivalent to 1 g?

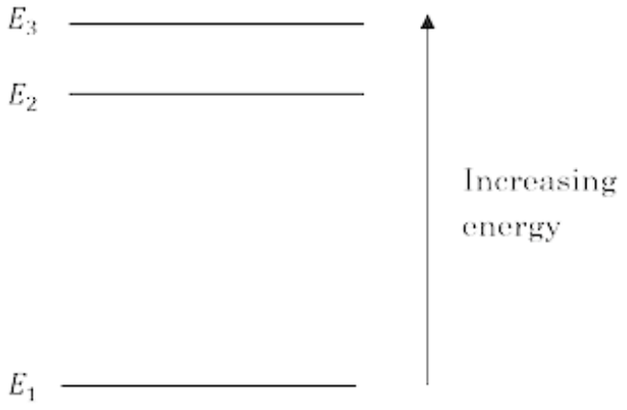
A. $\dfrac{N_A m_c}{12}$

B. $N_A m_c$

C. $\dfrac{N_A}{12 m_c}$

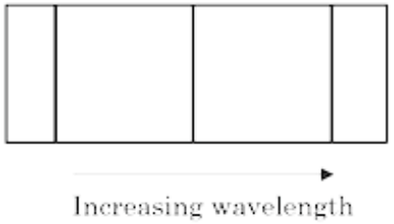
D. $\dfrac{N_A}{m_c}$

The diagram below shows three energy levels for atoms inside a gas.

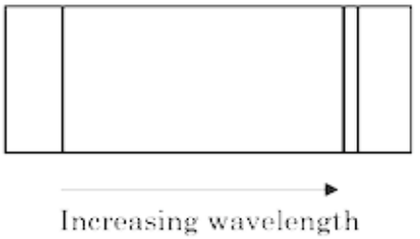


The diagram is drawn to scale and all transitions between energy levels are possible. Which of the following could represent the absorption spectrum of this gas. Assume that only three transitions take place.

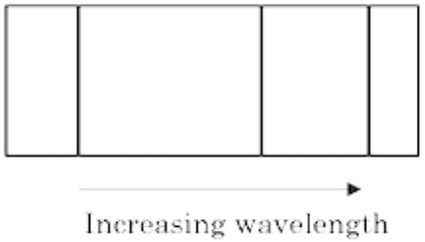
A.



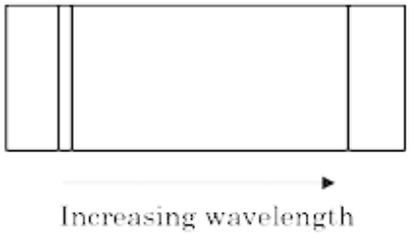
B.



C.



D.



Nuclide X decays with a half-life of T and nuclide Y decays with a half-life of $3T$. At $t = 0$ a sample of nuclide X has eight times the activity of a sample of nuclide Y.

When $t = 6T$, the activity of the sample of nuclide X is A. What is the activity of the sample of nuclide Y at this time?

A. $\frac{1}{16}A$

B. $\frac{1}{2}A$

C. $2A$

D. $16A$

Planet X has five times the mass and eight times the volume of Earth.

What is the gravitational field strength on the surface of planet X?

Assume that both the Earth and planet X are spherical.

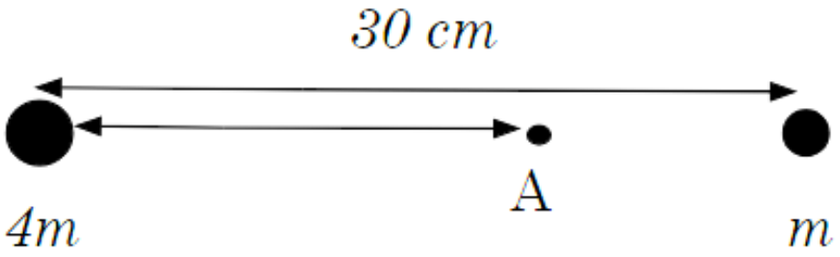
A. $\frac{5}{8}\,g$

B. $\frac{5}{4}\,g$

C. $\frac{5}{2}\,g$

D. $5\,g$

Two point masses 4 m and m separated by 30 cm as shown.



At point **A**, the net gravitational field due to the point masses is zero.

What is the distance between 4 m and **A**?

A. 10 cm

B. 15 cm

C. 20 cm

D. 30 cm

A wire and a region of uniform magnetic field lie in the same plane. The wire is positioned in two distinct ways, as illustrated in Figure **A** and Figure **B**, resulting in different angles between the direction of the magnetic field and the direction of the current in the wire

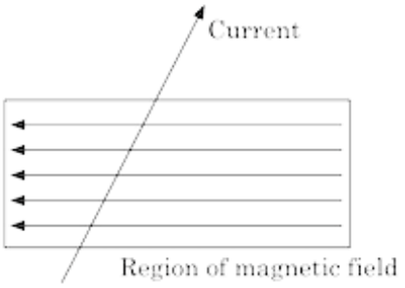


Figure A

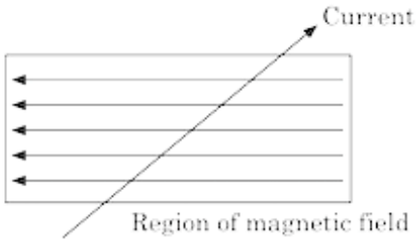
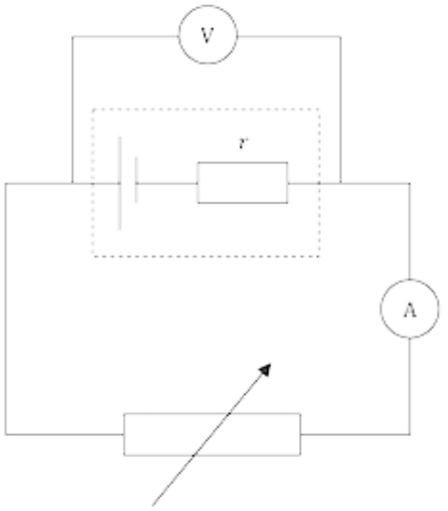


Figure B

Which of the following is correct in terms of the magnitude of the force and the direction of the force acting on the wire?

	Magnitude of the force	**The direction of the force**
A.	Same	Same
B.	Same	Opposite
C.	Greater in **A**	Same
D.	Greater in **A**	Opposite

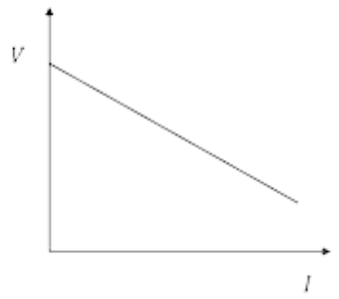
The diagram below shows a variable resistor connected in series with a cell of internal resistance r.



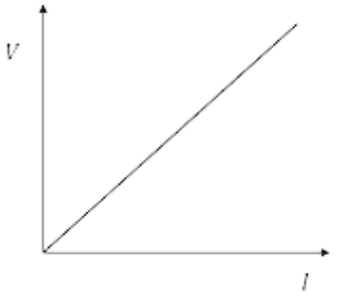
The resistance of the variable resistor is initially much higher than the internal resistance of the cell. The resistance of the variable resistor is then decreased.

Which of following graphs shows how the current measured in the ammeter I varies with the potential difference measured in the voltmeter V?

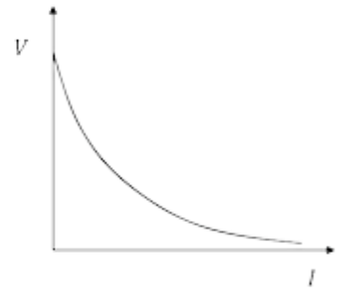
A.



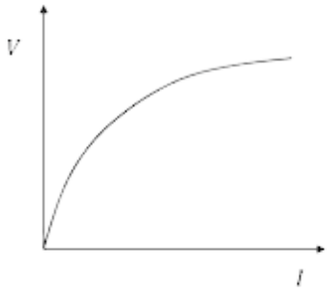
B.



C.



D.

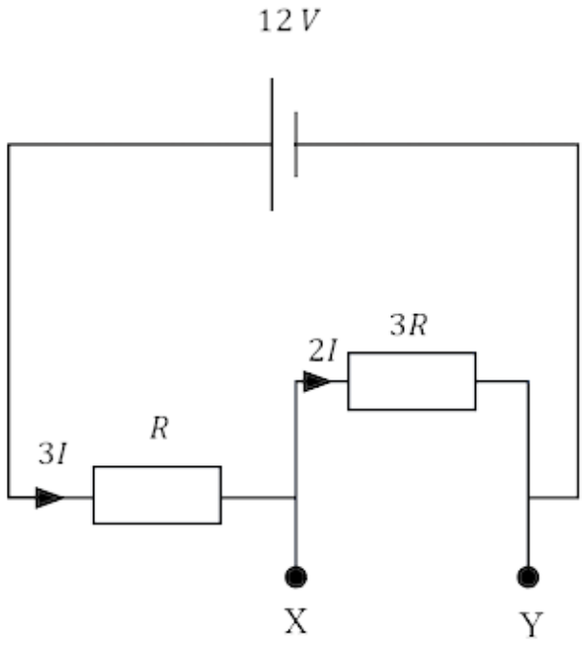


Two cylindrical resistors **A** and **B** are made from the same material and have the same length. Resistor **A** has twice the cross-sectional area of resistor **B**.

What is the ratio $\frac{Power\ dissipated\ across\ resistor\ A}{Power\ dissipated\ across\ resistor\ B}$ when they are connected in series and parallel?

	Series	**Parallel**
A.	$\frac{1}{2}$	$\frac{1}{2}$
B.	$\frac{1}{2}$	2
C.	2	$\frac{1}{2}$
D.	2	2

The diagram below shows part of a circuit connected to a $12\,V$ battery. The circuit contains two resistors of resistance R and $3R$ with currents $3I$ and $2I$ flowing through them respectively. Terminals **X** and **Y** are connected via an external circuit.



What is the potential difference between **X** and **Y**?

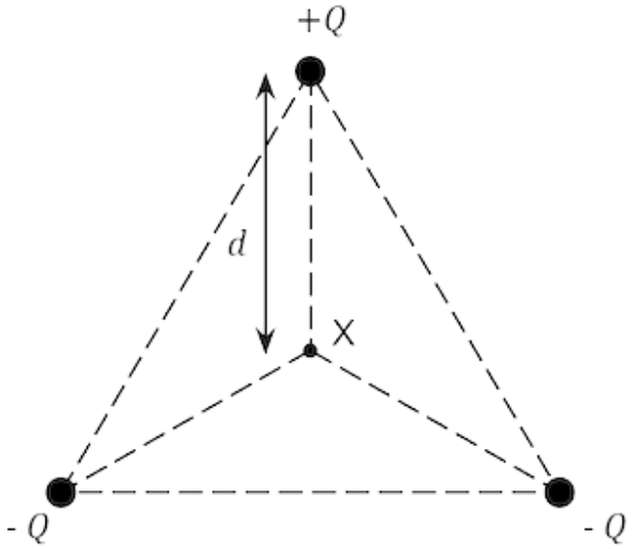
A. $3\,V$

B. $4\,V$

C. $8\,V$

D. $9\,V$

Three charges $-Q$, $-Q$ and $+Q$ form an equilateral triangle. Point **X** lies at the center of the triangle. The distance between **X** and the center of each of the charges is d as shown in the diagram below.



What is the magnitude of the electric field strength at **X**?

Note that $cos(60^\circ) = \frac{1}{2}$ and $sin(60^\circ) = \frac{\sqrt{3}}{2}$

A. 0

B. $\frac{kQ}{d^2}$

C. $\frac{2kQ}{d^2}$

D. $\frac{9kQ}{4d^2}$

A string of length L is free at both ends. The string vibrates with a frequency f and a standing wave of the third harmonic is formed.

One end of the string is then fixed, and the string is shortened with the speed of waves in the string remaining unchanged. The string vibrates with the same frequency f and a standing wave is formed.

Which of the following could not be the new length of the string?

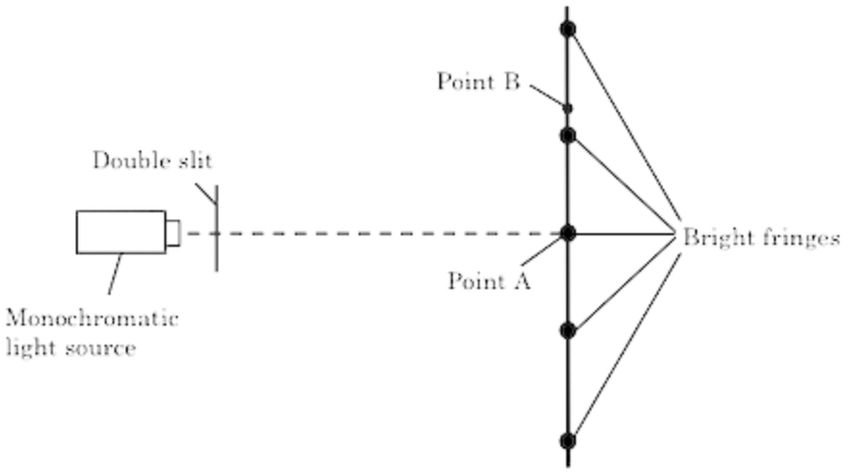
A. $\frac{L}{6}$

B. $\frac{L}{3}$

C. $\frac{L}{2}$

D. $\frac{5L}{6}$

Light is incident on a double slit and a fringe pattern is observed on a screen. Point **A** is equidistant from both slits and point **B** lies in between a dark and light fringe as shown in the diagram below.



Below are three statements about the fringe pattern.

I. The path difference of light arriving from each of the slits at B is between 0 and $\frac{\lambda}{2}$.

II. If only the distance between the double slit and the screen is increased, then the distance between adjacent bright fringes will increase

III. If only the frequency of the light is increased , then the distance between adjacent bright fringes will decrease.

Which of the statements are correct?

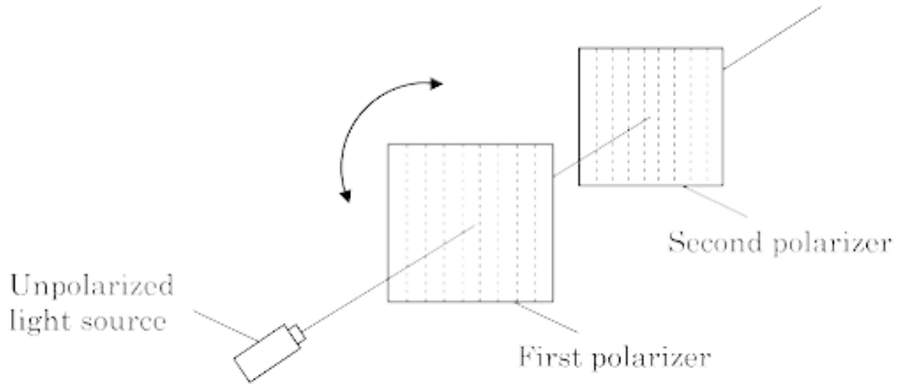
A. I and II only

B. I and III only

C. II and III only

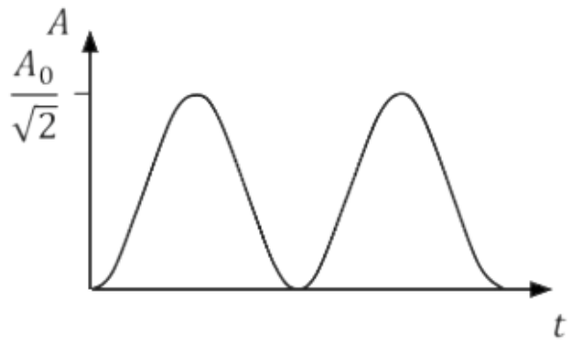
D. I, II and III

Initially unpolarized light of amplitude A_0 is passed through two identical polarizers. Initially the polarizers are at 90° to each other. The first polarizer is then rotated through an angle of 360° at a constant speed as shown in the diagram below.

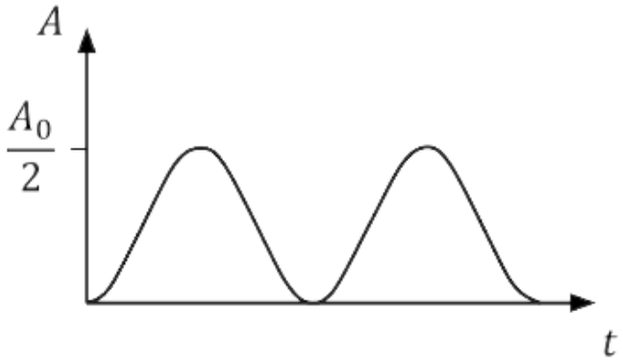


Which graph correctly shows how the amplitude of the light after passing through both polarizers A varies with time t?

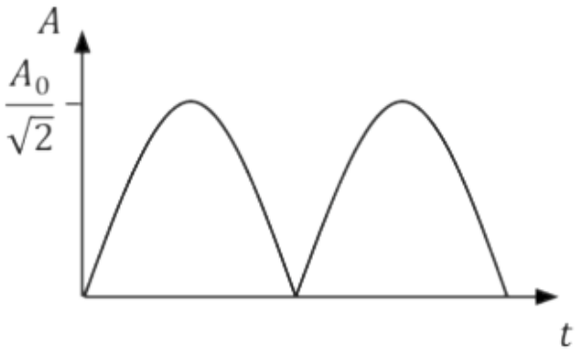
A.



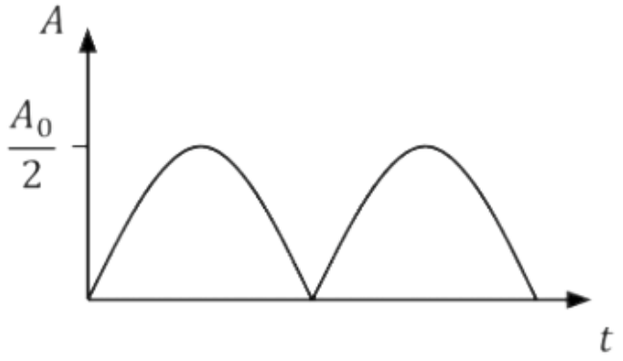
B.



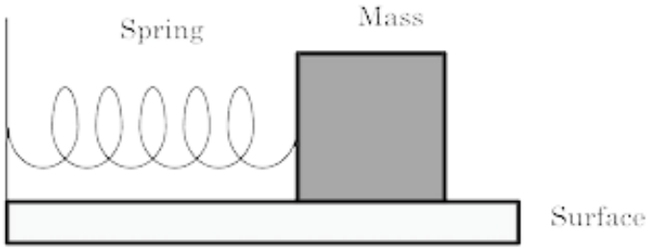
C.



D.



A mass of 400 g is connected to a spring on a frictionless surface.



The spring constant is 0.06 $N\ cm^{-1}$. What is the magnitude of the acceleration when the mass is 20 cm from equilibrium?

A. $0.03\ m\ s^{-2}$

B. $0.06\ m\ s^{-2}$

C. $0.6\ m\ s^{-2}$

D. $3\ m\ s^{-2}$

Two containers **A** and **B** contain the same ideal gas at the same temperature. The volumes of **A** and **B** are $3\,cm^3$ and $1.5\,cm^3$ respectively.

The pressures in **A** and **B** are $\frac{p}{2}$ and p respectively.

The two containers are connected together and the gases are mixed together at constant temperature.

What is the change in pressure of container **B**?

A. $\frac{-2}{3}p$

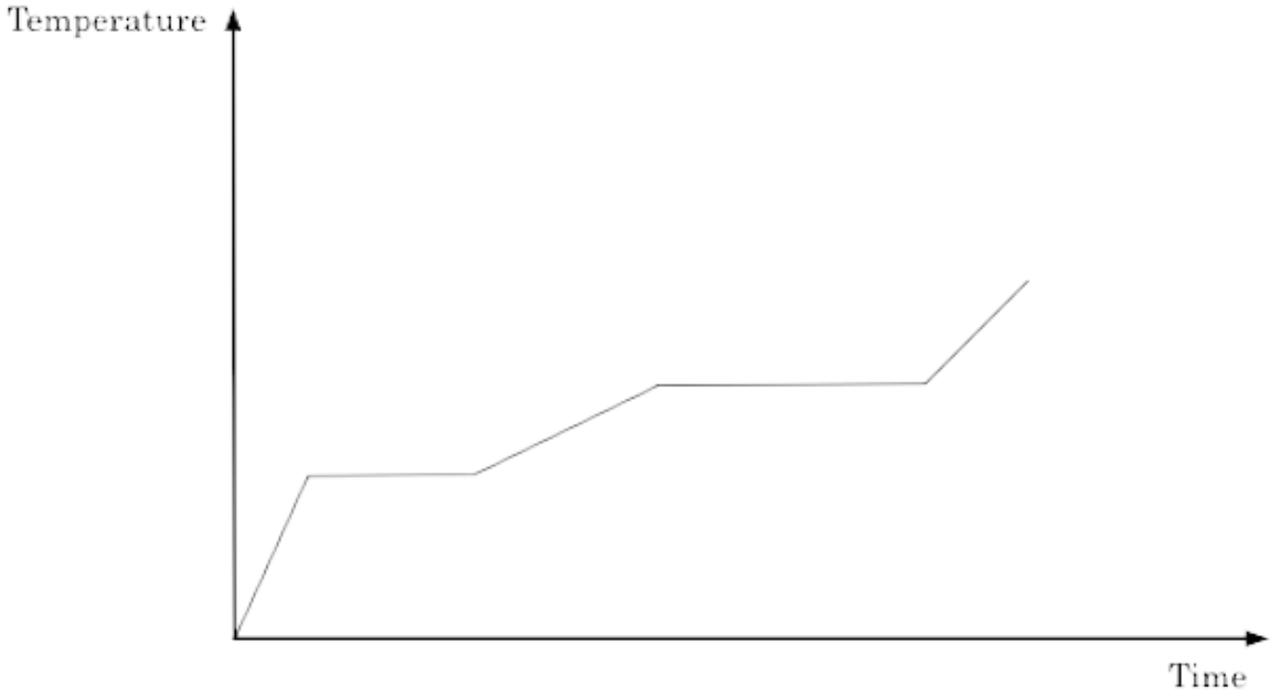
B. $\frac{-1}{3}p$

C. $\frac{1}{3}p$

D. $\frac{2}{3}p$

A solid material is heated at a constant rate.

The graph shows the variation of its temperature with time.



Three statements are given about this material

I. The solid state has the highest specific heat capacity
II. The specific latent heat of vaporisation L_v is greater than the specific latent heat of fusion L_f
III. The liquid state has the highest specific heat capacity

Which of these statements is correct?

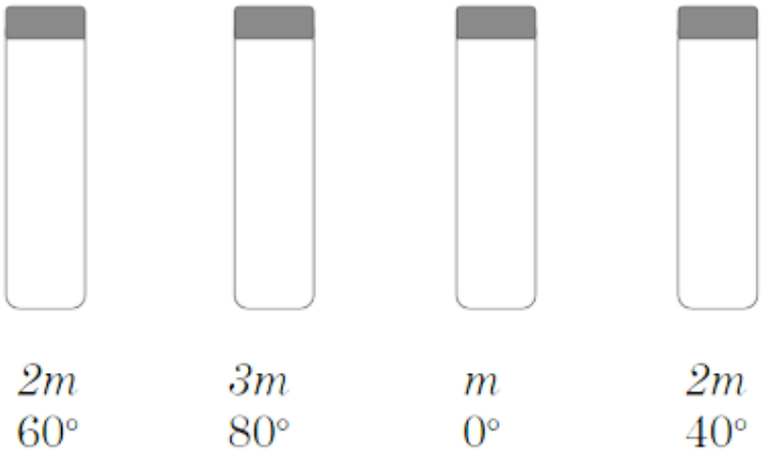
A. I only

B. I and II

C. II only

D. II and III

Four insulated containers contain the same liquid with different masses and at different temperatures as shown in the diagram.



The four are then mixed in another insulated container.

What is the final temperature of the mixture?

A. 45°

B. 55°

C. 60°

D. 180°

A tennis ball with mass $60\,g$ travels horizontally with constant speed u. The ball hits a stationary racket and rebounds in the opposite direction with a horizontal speed v. The time for the collision is $5.0\,ms$.

What is the magnitude of the force on the ball?

A. $0.06(u - v)$

B. $0.06(u + v)$

C. $12(u - v)$

D. $12(u + v)$

A spring that obeys Hooke's Law is stretched a distance x and stores energy E.

What is the work done by the spring when it returns to the point where x is reduced to half of its original value?

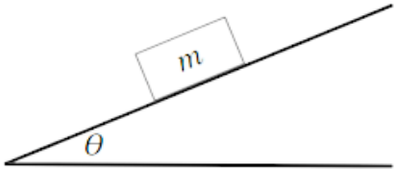
A. $\frac{E}{4}$

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

C. $\frac{3E}{4}$

D. $2E$

An inclined plane makes an angle θ with the horizontal. An object with mass m is just about to slide on the inclined plane.



Which of the following is correct about the coefficient of static friction μ_s and the free body diagram of the mass?

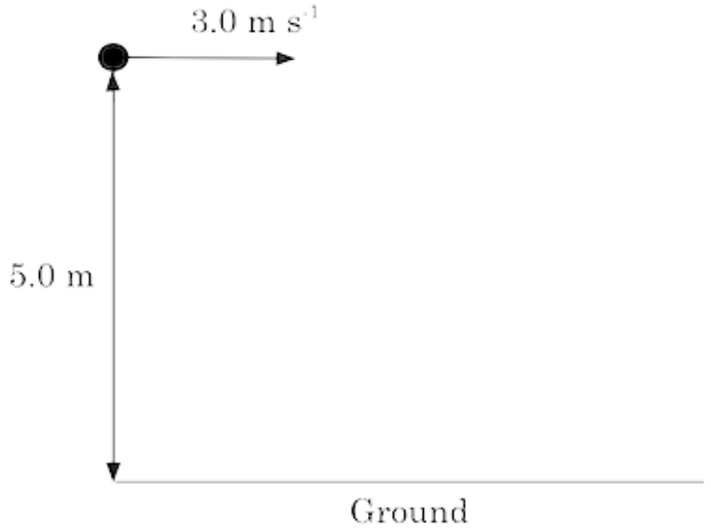
	μ_s	**Free body diagram**
A.	$sin\theta$	
B.	$sin\theta$	
C.	$tan\theta$	
D.	$tan\theta$	

A box of weight $400\,N$ is placed on a scale in an elevator. The scale reads $300\,N$.

Which of the following is correct about the magnitude and direction of the acceleration of the elevator?

	Magnitude	Direction
A.	$0.25\,m\,s^{-2}$	Upwards
B.	$0.25\,m\,s^{-2}$	Downwards
C.	$2.5\,m\,s^{-2}$	Upwards
D.	$2.5\,m\,s^{-2}$	Downwards

A projectile is launched horizontally on Earth with initial speed of $3.0\ m\ s^{-1}$ from a height of $5.0\ m$ above the ground.



What is the magnitude of the displacement of the stone when it reaches the ground?

A. $5.0\ m$

B. $8.0\ m$

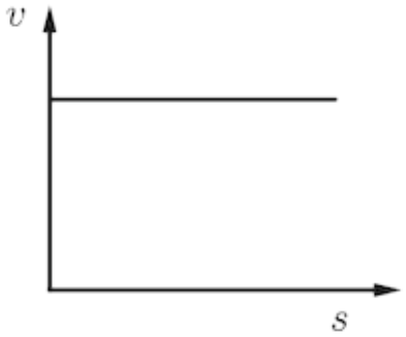
C. $\sqrt{34}\ m$

D. $\sqrt{51}\ m$

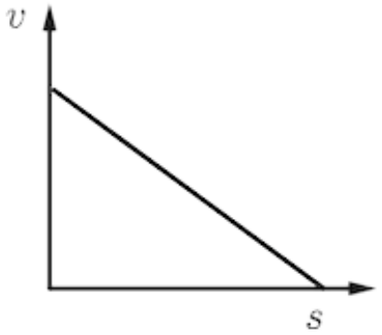
A car decelerates with a constant rate until it stops.

Which graph shows the variation of speed of the car with the distance travelled?

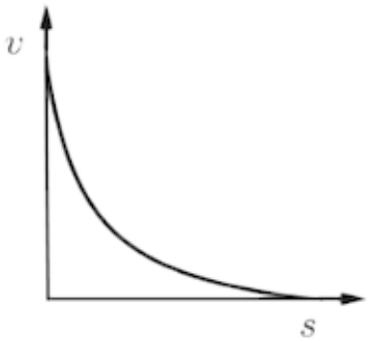
A.



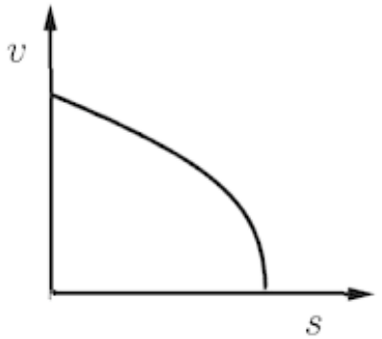
B.



C.



D.



The absolute uncertainty in the radius r of a sphere is Δr.

What is the fractional uncertainty in the volume of the sphere?

A. $\left(\frac{\Delta r}{r}\right)^3$

B. $3\frac{\Delta r}{r}$

C. $\frac{4}{3}\pi\left(\frac{\Delta r}{r}\right)^3$

D. $4\pi\frac{\Delta r}{r}$

A box moves a distance of $(5.0 \pm 0.5)\ m$ due to a horizontal force of $(20 \pm 1)\ N$.

What is the percentage uncertainty in the work done on the box?

A. 0.15%

B. 1.5%

C. 9%

D. 15%

The nucleon numbers of elements X and Y are A and $8A$ respectively. Their radii are R_X and R_Y, and their densities are ρ_X and ρ_Y.

Which of the following shows the correct values of the ratios $\frac{R_Y}{R_X}$ and $\frac{\rho_Y}{\rho_X}$?

	$\frac{R_Y}{R_X}$	$\frac{\rho_Y}{\rho_X}$
A.	2	1
B.	8	2
C.	2	2
D.	8	1

The uncertainty in the position of a proton is $10^{-10}\,m$, and its speed is $7 \times 10^{5}\,m\,s^{-1}$. What is the fractional uncertainty in its speed?

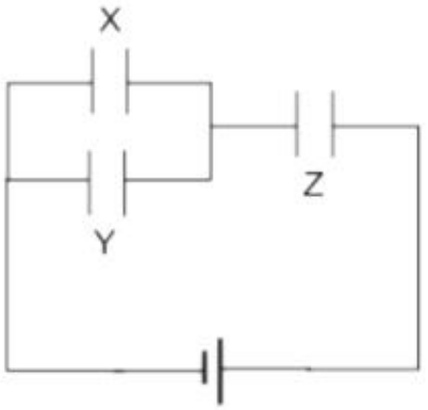
A. 5×10^{-4}

B. 5×10^{2}

C. 5×10^{-8}

D. 2×10^{-4}

Three identical capacitors, X, Y, and Z are connected to a direct current power supply as shown. When there is no dielectric between the plates of the capacitors, the effective capacitance of the circuit is C_1.



The region between parallel plates of capacitor Z is then filled with a dielectric whose electric permittivity constant is $2\varepsilon_0$.

The new effective capacitance of the circuit is C_2. What is the ratio of $\frac{C_1}{C_2}$?

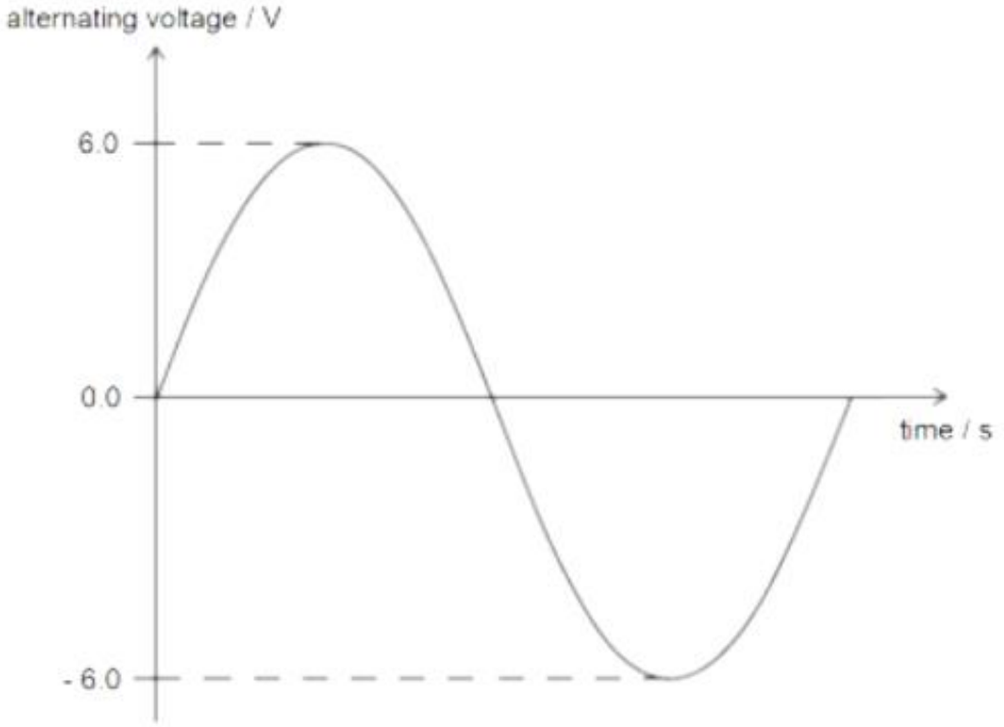
A. $\frac{2}{3}$

B. $\frac{3}{5}$

C. $\frac{3}{2}$

D. $\frac{5}{3}$

A resistor of $2\,\Omega$ is connected to an alternating power supply. The graph below shows the variation of voltage across the resistor with time.



What is the average power dissipated in the resistor?

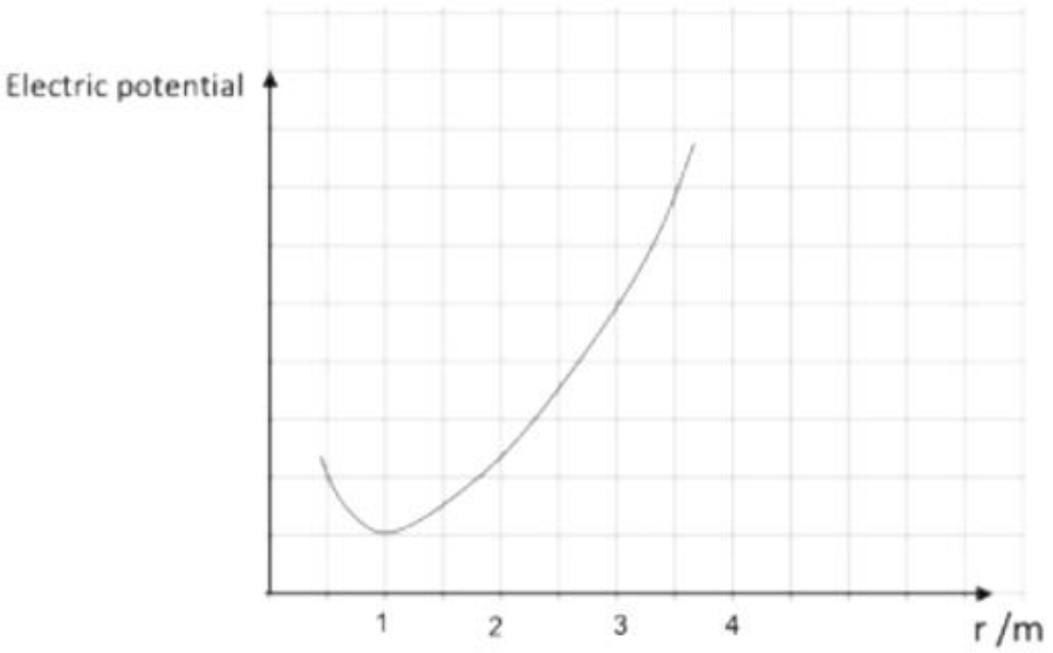
A. $\frac{18}{\sqrt{2}}\,W$

B. $\frac{9}{\sqrt{2}}\,W$

C. $9\,W$

D. $18\,W$

The graph shows the variation of the total electric potential due to two point electric charges q_1 and q_2 located $4.0\,m$ apart. The distance r is defined to be zero at the location of q_1.



What is the ratio of $\frac{q_2}{q_1}$?

A. 3

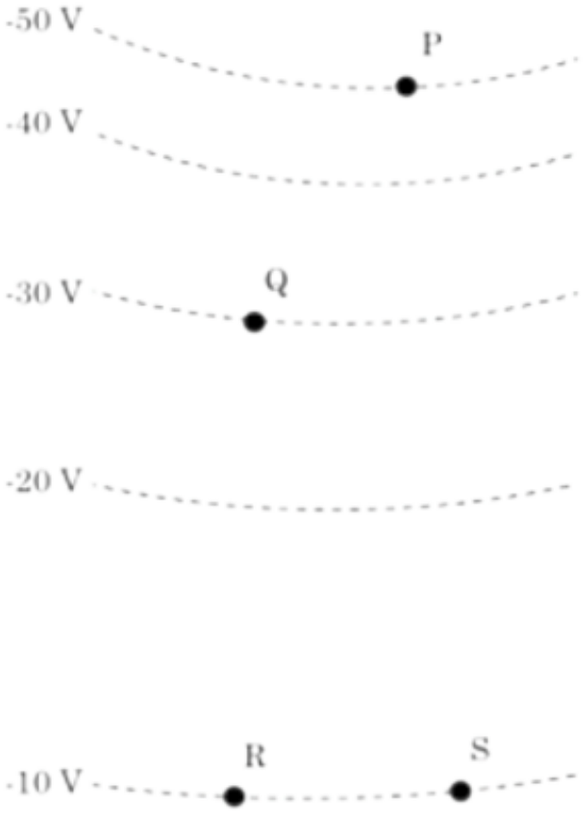
B. 4

C. 9

D. 16

Equipotential lines representing the corresponding potentials are shown in the diagram, in an electric field.

Which of the following is a correct statement regarding this electric field?



A. The electric field is uniform.

B. The work done in moving an electron from P to Q is $20\,eV$

C. The work done in moving an electron from S to Q is $20\,eV$

D. The work done in moving an electron from R to S is $20\,eV$

A person is standing by the side of the road as a bus drives by. The bus emits a sound with a frequency of f_0 Hz. At a given instant, the frequency heard by the person is 10% percent higher than the emitted frequency. The speed of sound is 330 $m\,s^{-1}$.

Which of the following is correct for the speed of the bus and the direction of travel of the bus?

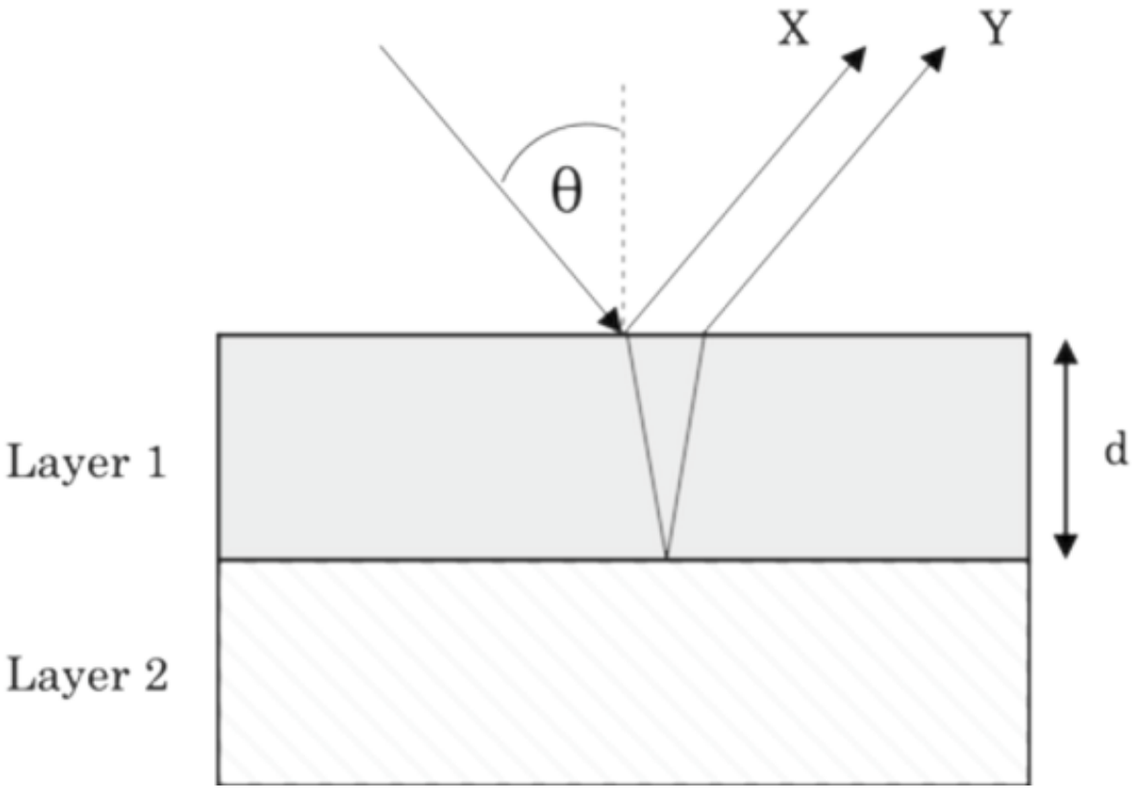
	Speed of the bus	**Direction of travel of the bus**
A.	30 $m\,s^{-1}$	Away from the person
B.	33 $m\,s^{-1}$	Away from the person
C.	30 $m\,s^{-1}$	Towards the person
D.	33 $m\,s^{-1}$	Towards the person

Light from a point source is incident on the pupil of the eye of an observer. The diameter of the pupil is $3.0\,mm$.

What is the smallest angular separation of two distinct point sources of light, frequency $5.0 \times 10^8\,MHz$, that can be resolved by the observer?

A. 2.0×10^{-4} rad
B. 4.0×10^{-4} rad
C. 2.4×10^{-4} rad
D. 4.9×10^{-4} rad

Monochromatic light is incident from air on a set of thin films as shown. The first layer is used as a coating for the second layer. The refractive index of layer 1 is greater than the refractive index of layer 2. Layer 1 has negligible thickness. Two rays of light, X and Y, are shown.



Which of the following is true for the phase difference and type of interference between X and Y?

	Phase difference between X and Y	**Type of interference between X and Y**
A.	0	Constructive
B.	0	Destructive
C.	π	Constructive
D.	π	Destructive

A mass-spring system has a period of T_0. Another mass-spring system has a mass twice as large with a spring that requires four times as much force to obtain the same extension as the first system.

What is the new period in terms of T_0?

A. $2T_0$

B. $\sqrt{2}T_0$

C. $\dfrac{T_0}{\sqrt{2}}$

D. $\dfrac{T_0}{2}$

A thin metal plate of mass m is held at an absolute temperature T, in an enclosure of temperature $T_s < T$. One face of the plate has an area A. The temperature of the plate decreases by a small value ΔT in a short interval Δt, due to radiation. Assuming the metal plate to be a perfect black body, its specific heat capacity is given by:

A. $\dfrac{\sigma A T^4 \Delta t}{m(\Delta T)}$

B. $\dfrac{\sigma A (T^4 - {T_s}^4) \Delta t}{m(\Delta T)}$

C. $\dfrac{2\sigma A T^4 \Delta t}{m(\Delta T)}$

D. $\dfrac{2\sigma A (T^4 - {T_s}^4) \Delta t}{m(\Delta T)}$

Which of the following energy resources is non-renewable?

A. Biomass

B. Solar

C. Wind

D. Uranium-235

Consider the following statements about nuclear binding energy:

The nuclear binding energy is:

I. proportional to the mass defect from nucleus formation.
II. the energy released when a nucleus is formed from its nucleons.
III. the energy required to remove a proton from the nucleus.

Which of the statements are correct?

A. I only
B. I and II only
C. II only
D. I, II and III

A 1.20 kg sample of a radioactive isotope decaying via beta decay with a half-life of 30 minutes is observed in a closed container in a laboratory. The decay results in a daughter nucleus that is also a solid. What is the approximate total mass measured after 90 minutes?

A. 0.00 kg

B. 0.15 kg

C. 0.60 kg

D. 1.20 kg

An electron in a hydrogen atom is excited from the ground state of $n = 1$ to the $n = 4$ level. What is the total number of frequencies that can be observed from the emission spectrum as the electron returns to ground state?

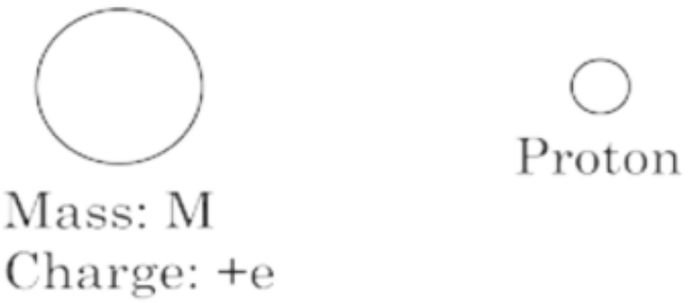
A. 12

B. 6

C. 4

D. 3

A proton and another object with charge +e exert electrical and gravitational forces on one another. To the nearest order of magnitude, what mass must the object have to be so that the net force acting on it is zero?



A. $10^1\ kg$

B. $10^3\ kg$

C. $10^6\ kg$

D. $10^9\ kg$

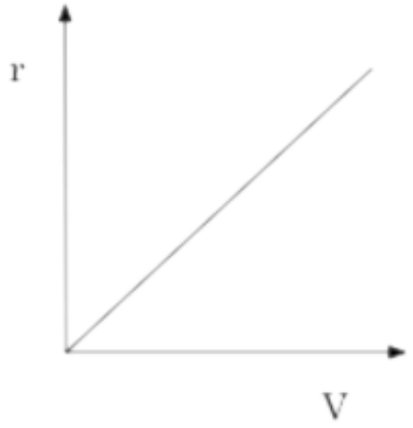
The tip of the seconds hand of a clock moves from the "12" marking to the "6" marking with a tangential speed of $2\,cm\,s^{-1}$.

Which of the following is correct about the angular speed and the centripetal acceleration?

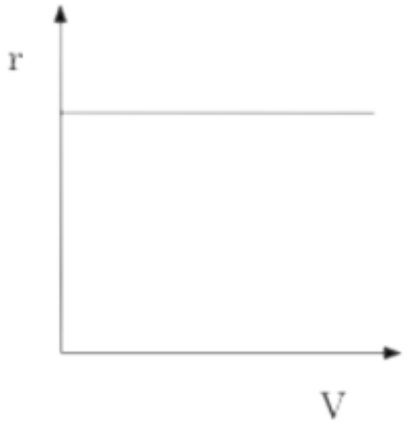
	Angular speed	Centripetal acceleration
A.	$\frac{\pi}{60}\ rad\ s^{-1}$	$\frac{\pi}{30}\ cm\ s^{-2}$
B.	$\frac{\pi}{60}\ rad\ s^{-1}$	$\frac{\pi}{15}\ cm\ s^{-2}$
C.	$\frac{\pi}{30}\ rad\ s^{-1}$	$\frac{\pi}{30}\ cm\ s^{-2}$
D.	$\frac{\pi}{30}\ rad\ s^{-1}$	$\frac{\pi}{15}\ cm\ s^{-2}$

An alpha particle of mass m and charge q, is accelerated through a potential difference V into a magnetic field of flux density B that is at right angles to the direction of motion. Which of the sketches below best describes the relationship between the radius of path r and the potential difference of the accelerating field?

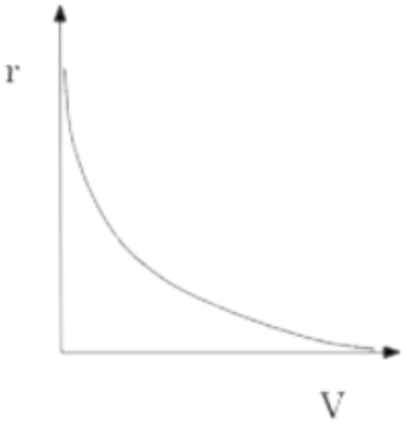
A.



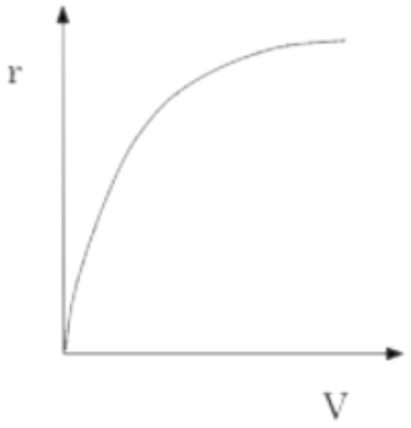
B.



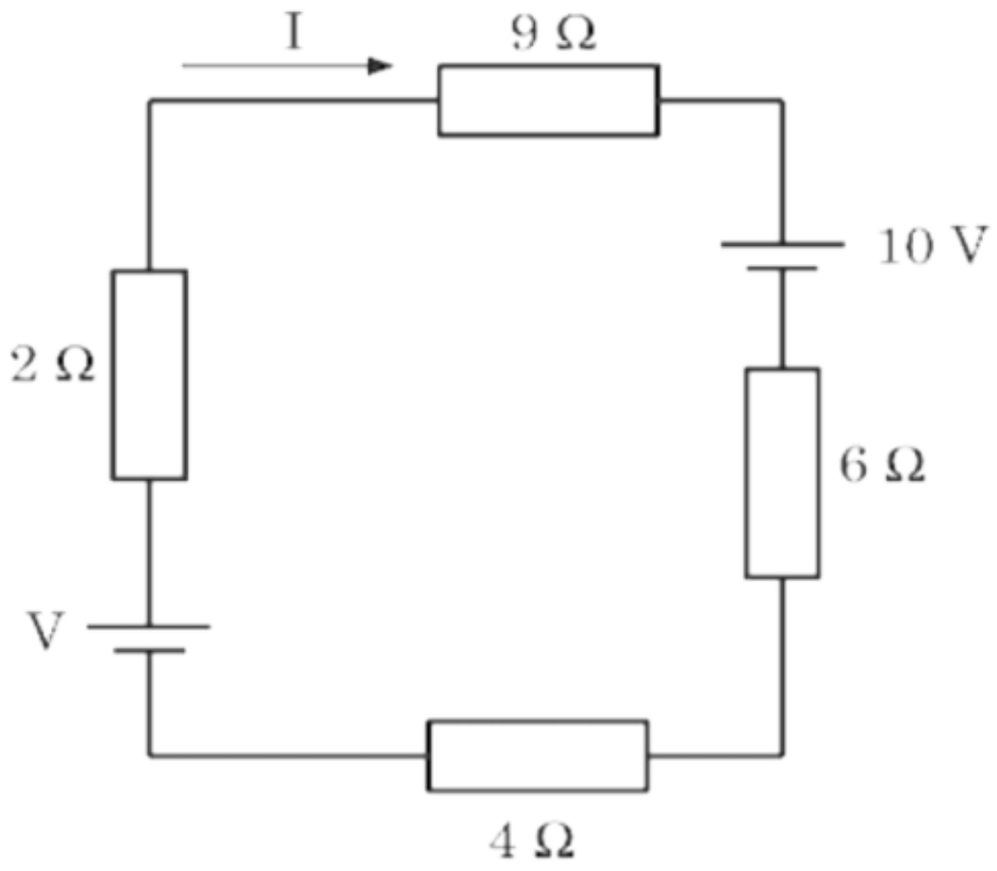
C.



D.



If the current in the circuit below is 0.5 A, what is the potential difference V?



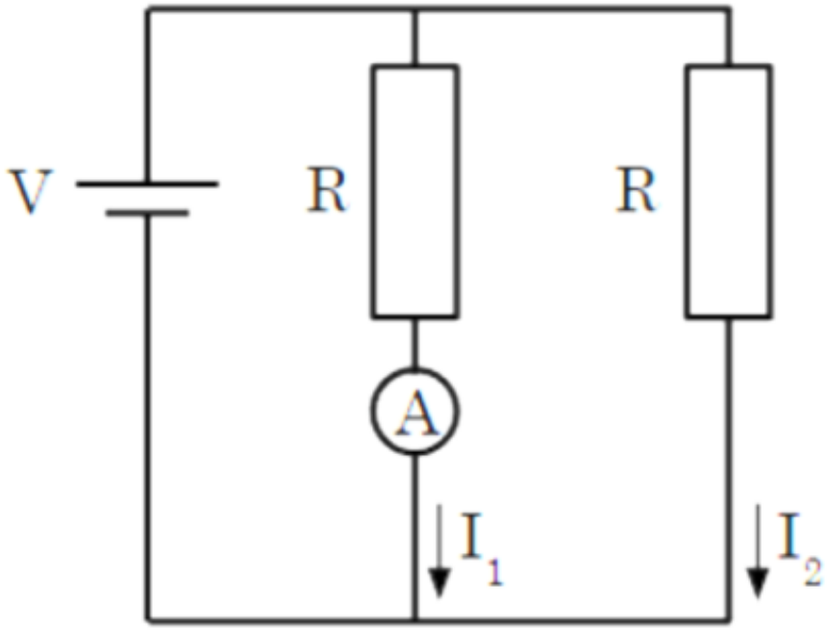
A. 0.5 V

B. 10.5 V

C. 20.5 V

D. 40.5 V

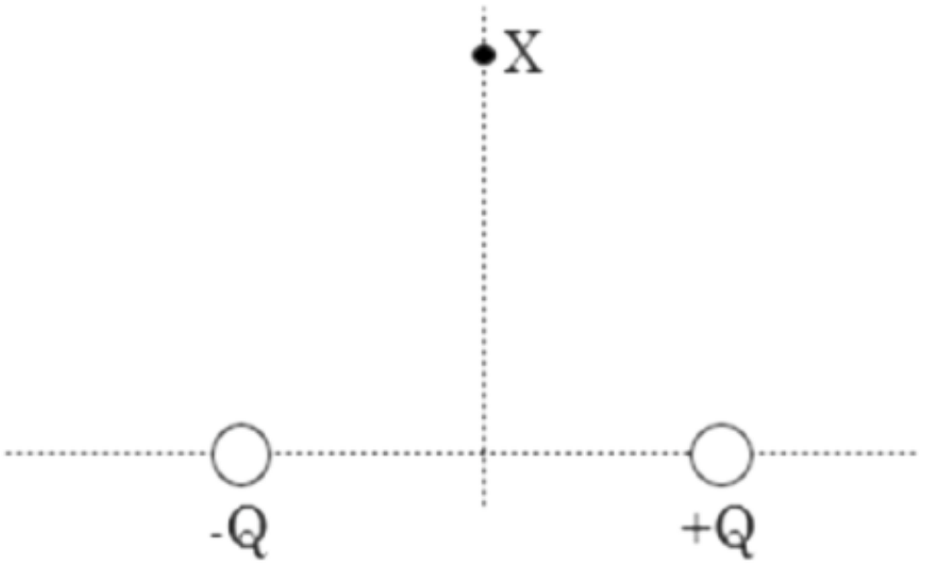
The circuit below consists of a cell and two identical resistors in parallel, with an ideal ammeter in one of the branches. The current in this branch is I_1 and the current in the other branch is I_2.



If the ideal ammeter is replaced by a real ammeter, what will be the effect on currents I_1 and I_2?

	I_1	I_2
A.	Decreases	Decreases
B.	Increases	Stays the same
C.	Decreases	Increases
D.	Decreases	Stays the same

A positive and a negative charge of equal magnitude are located on the same horizontal line.



What is the direction of the net electric field at the point marked X, equidistant from the two charges?

A. To the right

B. To the left

C. Up

D. Down

Estimate the speed of an alpha particle that has accelerated from rest in a uniform electric field $E = 50\,N\,C^{-1}$ over a distance of $2.0\,m$.

A. $10^{3}\ m\,s^{-1}$

B. $10^{4}\ m\,s^{-1}$

C. $10^{5}\ m\,s^{-1}$

D. $10^{9}\ m\,s^{-1}$

A student blows across the open end of a narrow cylinder which is closed at the other end. If the length of the cylinder is $15.0\,cm$ and the speed of sound is $340\,m\,s^{-1}$, What is the frequency of the wave at the third harmonic?

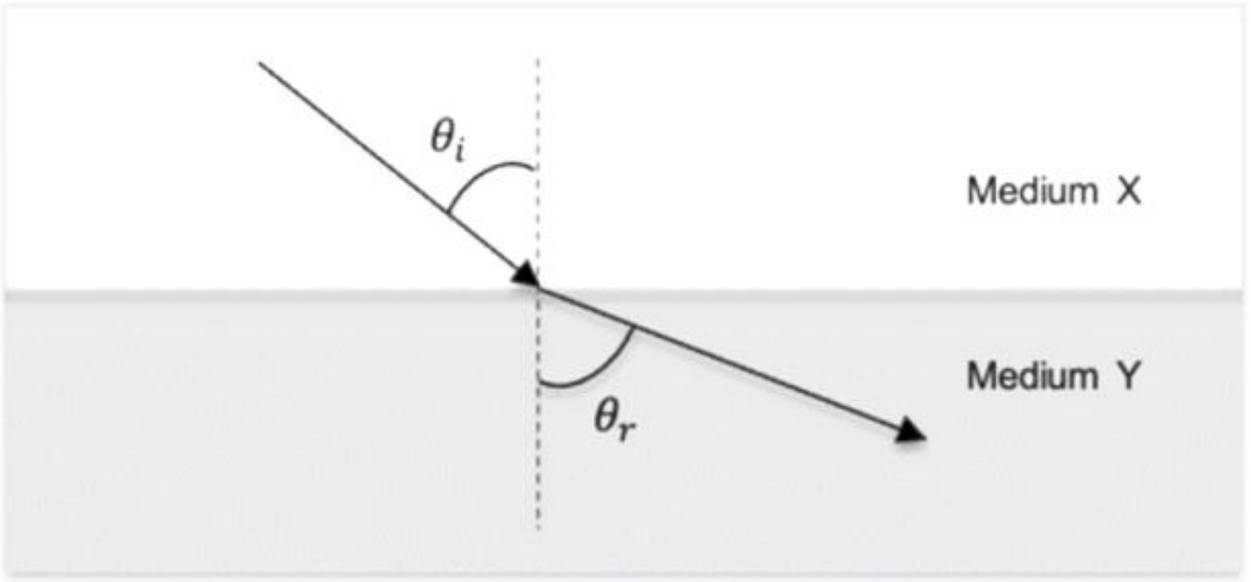
A. $1.1 \times 10^3\,Hz$

B. $1.7 \times 10^3\,Hz$

C. $2.8 \times 10^3\,Hz$

D. $3.4 \times 10^3\,Hz$

The diagram shows a beam of light passing from medium X to medium Y.



If the angle of incidence of the light increases, which of the following changes can be implemented to keep the angle of refraction the same?

I. Medium X can be replaced with another medium which has a lower refractive index.

II. Medium X can be replaced with another medium which has a higher refractive index.

III. Medium Y can be replaced with another medium which has a higher refractive index.

A. Only I

B. I and III only

C. II and III only

D. I, II, and III

Two loudspeakers produce sound in phase of total intensity I_0 at point A

One of the loudspeakers is removed. The new intensity at point A is now equivalent to:

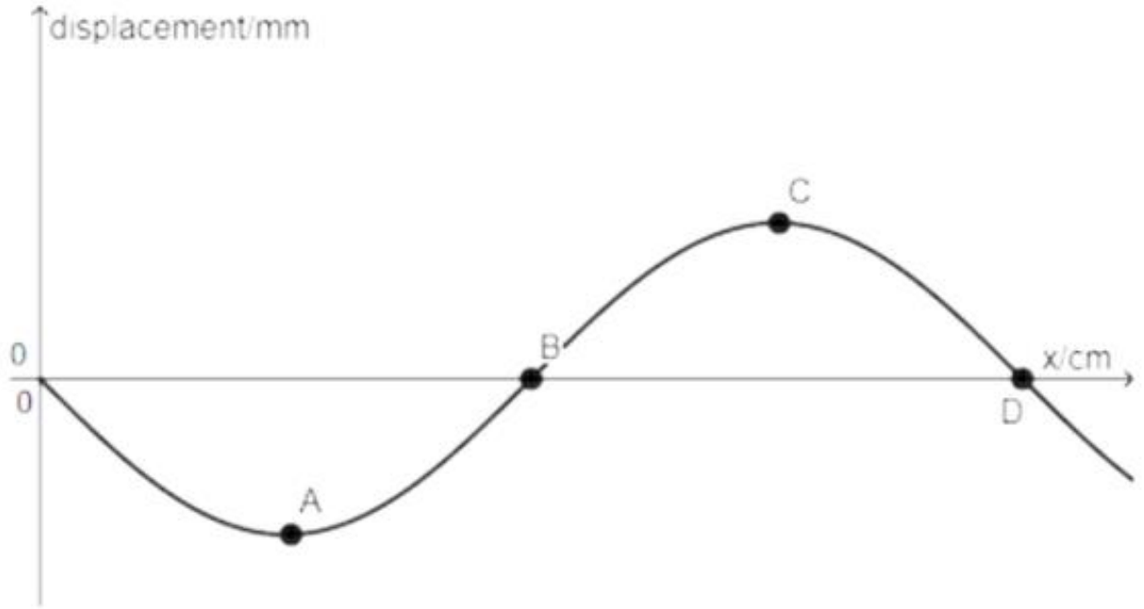
A. $\frac{I_0}{4}$

B. $\frac{I_0}{2}$

C. I_0

D. $2I_0$

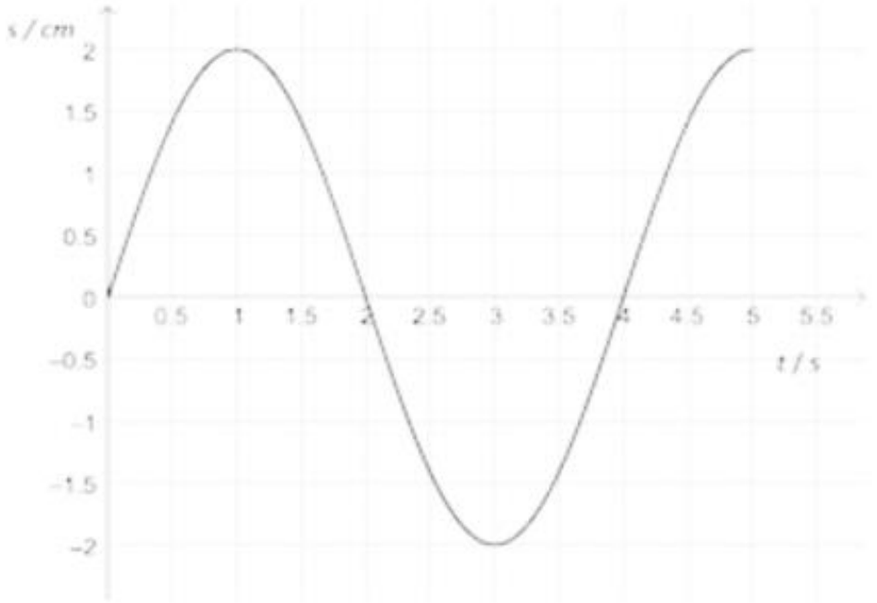
A longitudinal wave is travelling in a medium from left to right. The graph shows the variation of the displacement of the particles of this medium with distance along the medium x.



[Source: Created with GeoGebra - https://www.geogebra.org/graphing?lang=en]

Which point on the graph is at the center of a rarefaction? Displacements to the right of equilibrium positions are positive.

The graph shows the variation with time t of the displacement s of an object suspended by a spring. At what time is the acceleration in the negative direction at a maximum?



[Source: Created with GeoGebra - https://www.geogebra.org/graphing?lang=en]

A. 4.0 s

B. 3.0 s

C. 2.0 s

D. 1.0 s

An ideal gas is in a fixed volume container which sits on an electronic balance. More of the same gas is added to the container. Which of the following will not change?

A. The separation between the gas molecules

B. The collision frequency of the gas molecules with each other

C. The average size of the molecules

D. The reading on the electronic balance

100 ml of water at 20^oC is poured in an aluminum container and heated at a constant rate until all of the water is boiled. After time t_1 water starts to boil, and at time t_2 all of the water has boiled away.

Which of the following statements are correct?

I. If a glass container with the same mass is used instead of aluminum, t_1 increases. $(c_{\text{glass}} < c_{\text{aluminum}})$

II. If the container with water is thermally isolated, t_2 decreases.

III. If more water is added to the container, t_1 increases.

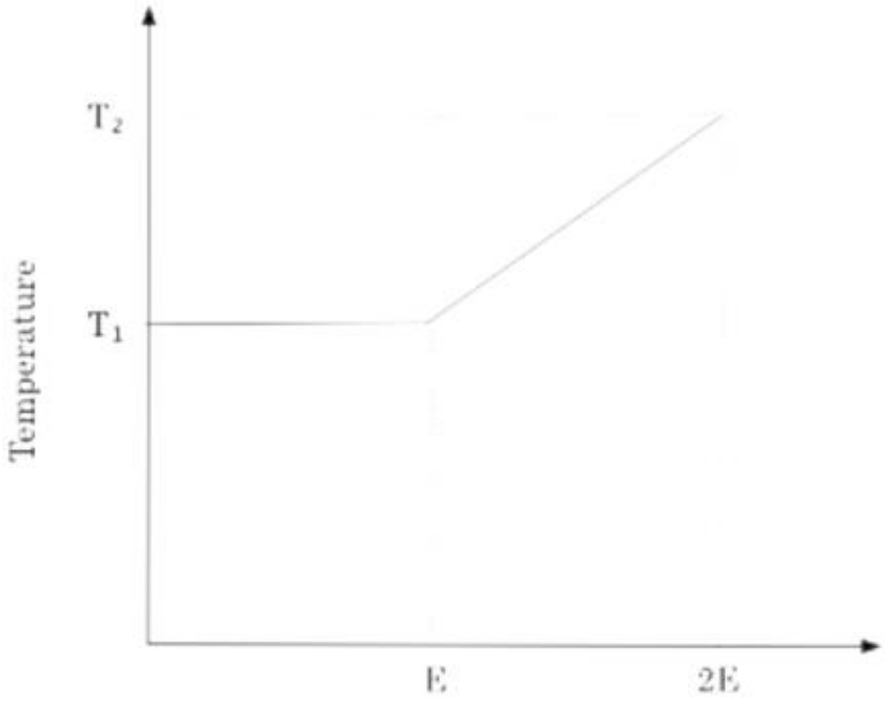
A. Only I

B. I and II only

C. II and III only

D. I, II and III

A material with a mass of m is heated. The graph shows the variation of the temperature of the material with the energy supplied.



Which one of the following gives the specific heat capacity of the material?

A. $\dfrac{2Em}{T_2 - T_1}$

B. $\dfrac{Em}{T_1}$

C. $\dfrac{2E}{m(T_2 - T_1)}$

D. $\dfrac{E}{m(T_2 - T_1)}$

A trolley is pushed in a level parking area of a market on a very rainy day. The rain fills the trolley at a rate of $R\ kg\ s^{-1}$. Ignoring frictional forces, what is the force needed to move the trolley at a constant speed of v?

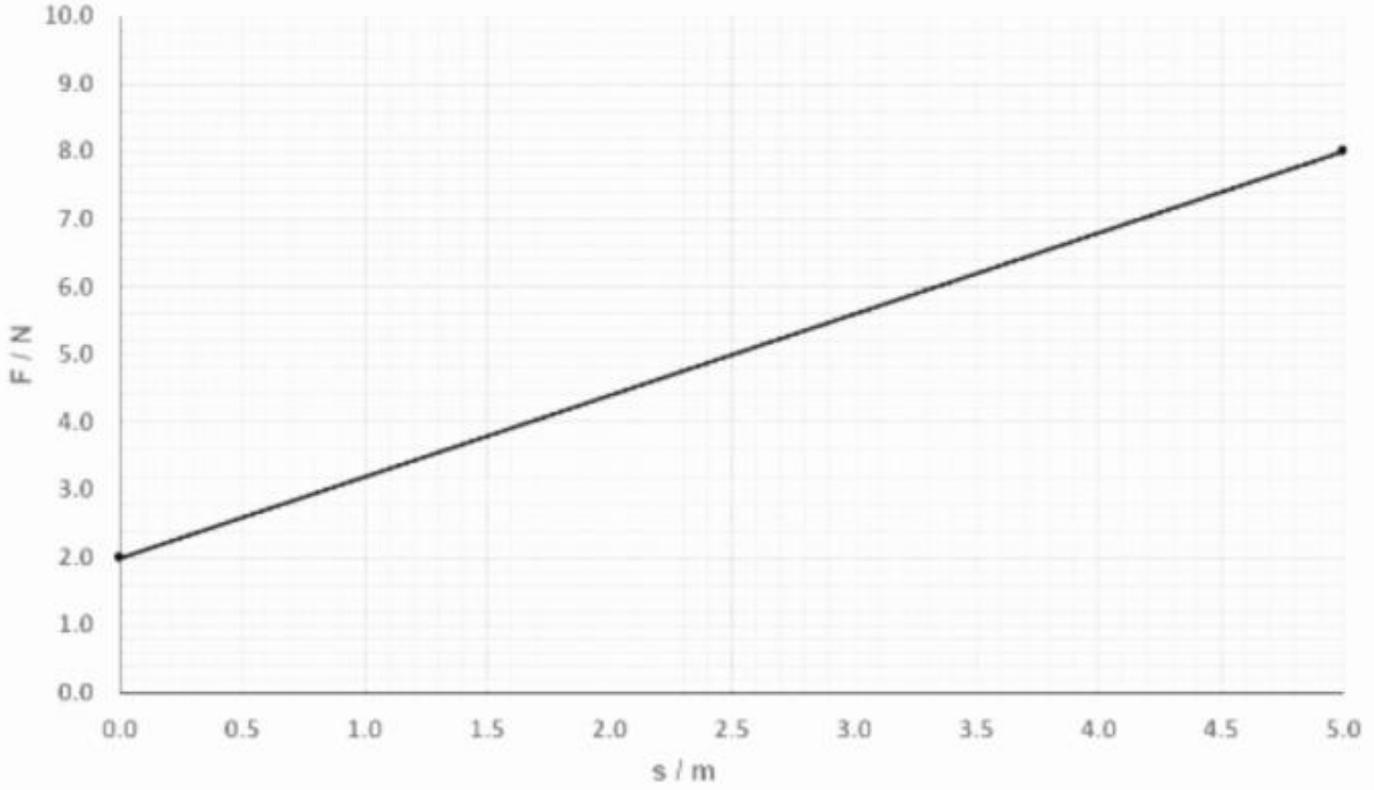
A. Rv

B. $\frac{R}{v}$

C. $\frac{v}{R}$

D. $R + v$

A box of mass $2.0\,kg$ starts to move on a level surface under the effect of a varying force F. The variation of F with the displacement s of the object is shown in the graph below.



What is the speed of the box at $s = 5\,m$?

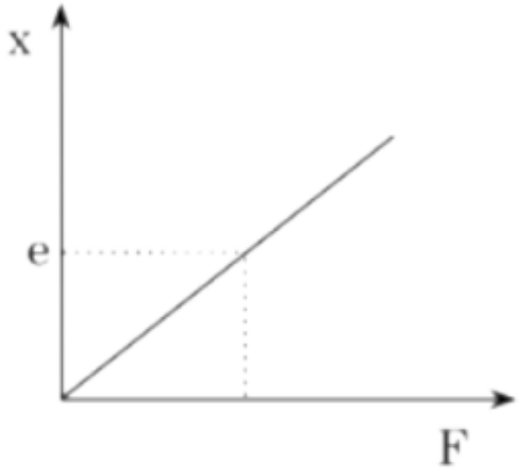
A. $5\,m\,s^{-1}$

B. $\sqrt{5}\,m\,s^{-1}$

C. $15\,m\,s^{-1}$

D. $\sqrt{15}\,m\,s^{-1}$

A varying force acts on a spring. The variation of the extension x of the spring with force F acting on it is shown in the graph below.



The elastic potential energy stored in the spring is E when the extension of the spring is e. What is the work done by force on the spring to increase the extension from e to $3e$?

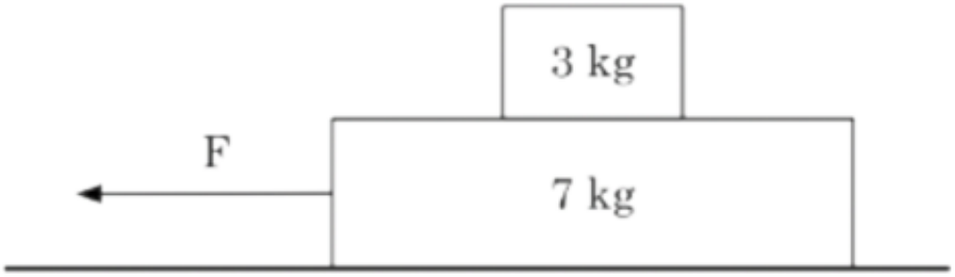
A. $2E$

B. $4E$

C. $8E$

D. $9E$

A box of mass $3\,kg$ is placed on a box of mass $7\,kg$. The coefficient of static friction between the surfaces of the boxes is 0.5. A horizontal force F is applied to the $7\,kg$ box which sits on a frictionless surface.



What is the maximum value of F that can move the boxes without the $3\,kg$ box slipping?

A. $0.1g$

B. $0.5g$

C. g

D. $5g$

A ball of mass m is falling vertically through the air. The drag force acting on the ball is given by kv^2 where k is constant and v is the speed of the ball. What is the maximum speed reached by the ball?

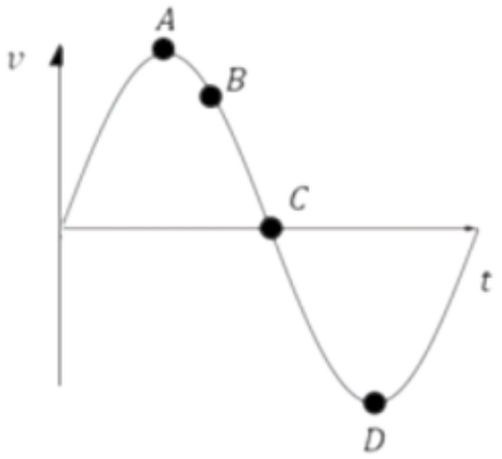
A. $\dfrac{k}{mg}$

B. $\dfrac{mg}{k}$

C. $\sqrt{\dfrac{k}{mg}}$

D. $\sqrt{\dfrac{mg}{k}}$

An object is moving in a straight line. The graph shows the variation of the velocity v of the object with time t.



Which of the following is correct according to the graph?

I. At point A, the object changes its direction.
II. At point C the object is at rest.
III. The magnitude of the acceleration at point D is greater than at point B.

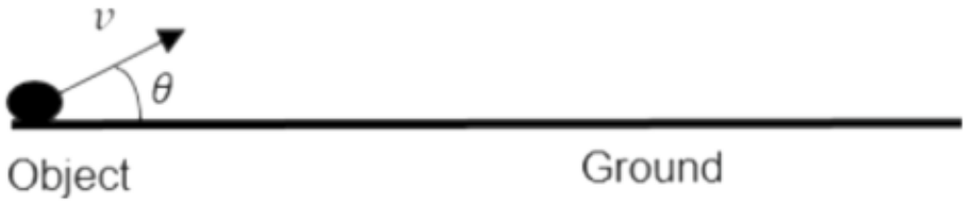
A. I only

B. II only

C. I and II only

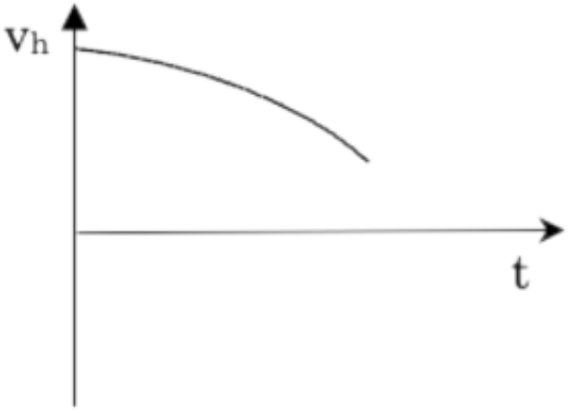
D. II and III only

An object is launched with an angle of θ from the ground and an initial velocity of v.

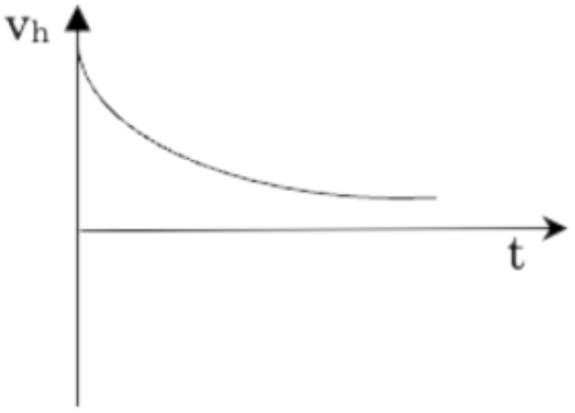


Which graph shows the variation of the horizontal component v_h of the velocity of the object with time t? (Air resistance is not ignored)

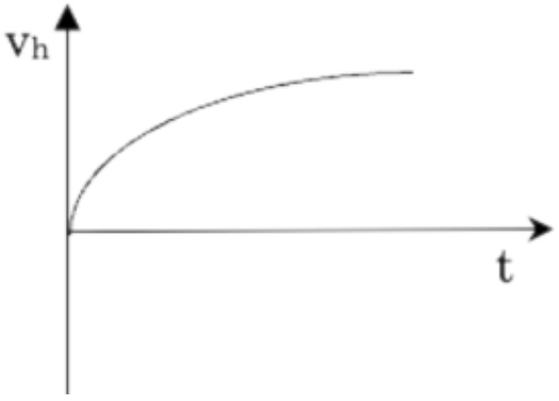
A.



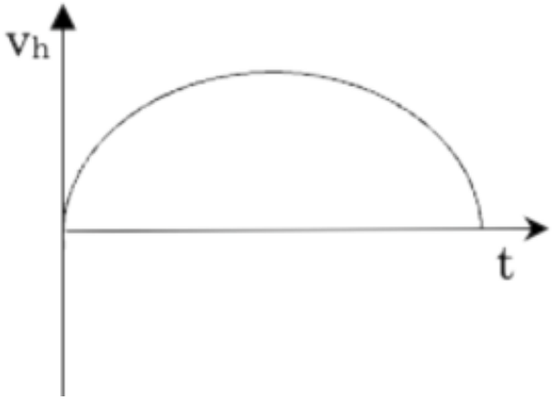
B.



C.



D.



A student is using the equation $pV = nRT$ to solve for n with the following percentage uncertainties in the measurements.

Quantity	Uncertainty
P	$\pm 2\,\%$
V	$\pm 6\,\%$
T	$\pm 1\,\%$

What is the percentage uncertainty in the calculated value of n?

A. $3\,\%$

B. $7\,\%$

C. $9\,\%$

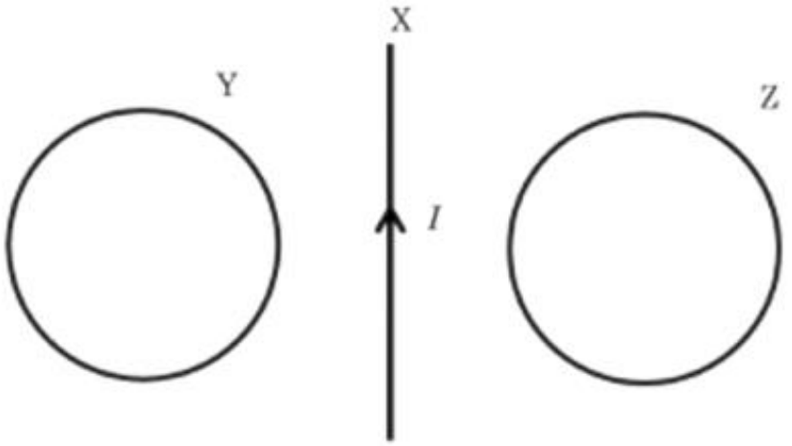
D. $12\,\%$

A body moves a distance of 1.5 km in 10 ks.

Which of the following gives the correct magnitudes of both of distance and time?

	Distance	**Time**
A.	$1.5 \times 10^{-4}\, dm$	$10^{16}\, ps$
B.	$1.5 \times 10^{4}\, dm$	$10^{16}\, ps$
C.	$1.5 \times 10^{9}\, \mu m$	$10^{-16}\, ps$
D.	$1.5 \times 10^{-9}\, \mu m$	$10^{-16}\, ps$

The current I in the conductor wire X is decreasing which induces currents both in loops Y and Z. The conductor wire and the loops lie in the same plane.



What is the direction of the induced currents in loop Y and loop Z?

	Loop Y	Loop Z
A.	clockwise	clockwise
B.	anti-clockwise	clockwise
C.	clockwise	anti-clockwise
D.	horizontal	anti-clockwise

During experiments observing beta decays, it was seen that the energy spectrum of the beta particles is continuous and momentum conservation was violated in beta decays. This provided evidence for the existence of:

A. Nuclear energy levels

B. Atomic energy levels

C. Neutrinos

D. Positrons

A student investigates the scattering of alpha particles. Initially, she uses a gold foil ($Z = 79$) and next she repeats the experiment using an aluminum ($Z = 13$) foil of the same thickness. The scattered alpha particles are observed on a detector that fluoresces.

Which of the following will be true as she switches from the gold foil to the aluminum foil?

I. The alpha particles deflect more from the gold nucleus than the aluminum.
II. The alpha particles approach the gold nucleus closer than the aluminum nucleus.
III. There is no change in the observed scattering pattern.

A. I only

B. II only

C. III only

D. II and III only

A parallel plate capacitor is charged by a dc source. It is then disconnected from the dc source. What happens when the plate separation is now increased?

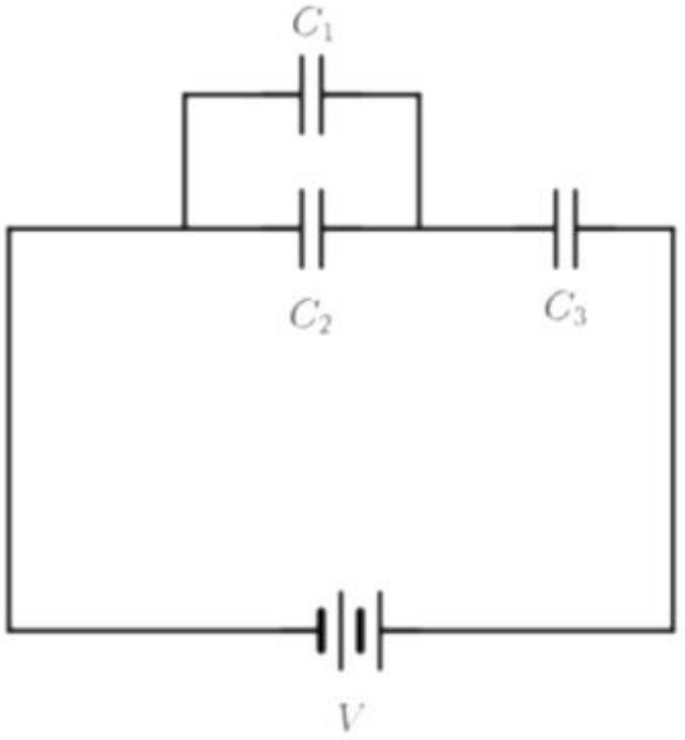
A. The stored energy increases

B. The capacitance increases

C. The potential difference between the plates decreases

D. The charge stored on the plates increases

Three capacitors, C_1, C_2, and C_3 are connected to a battery, as shown.



[Source: Created with GeoGebra by Tom Walsh- https://www.geogebra.org/m/JbAKa82Y]

When the capacitors are fully charged, the ratio of charge on C_3 to the charge on C_2, $\frac{Q_3}{Q_2}$ is $\frac{3}{2}$. What is the ratio of $\frac{C_1}{C_2}$?

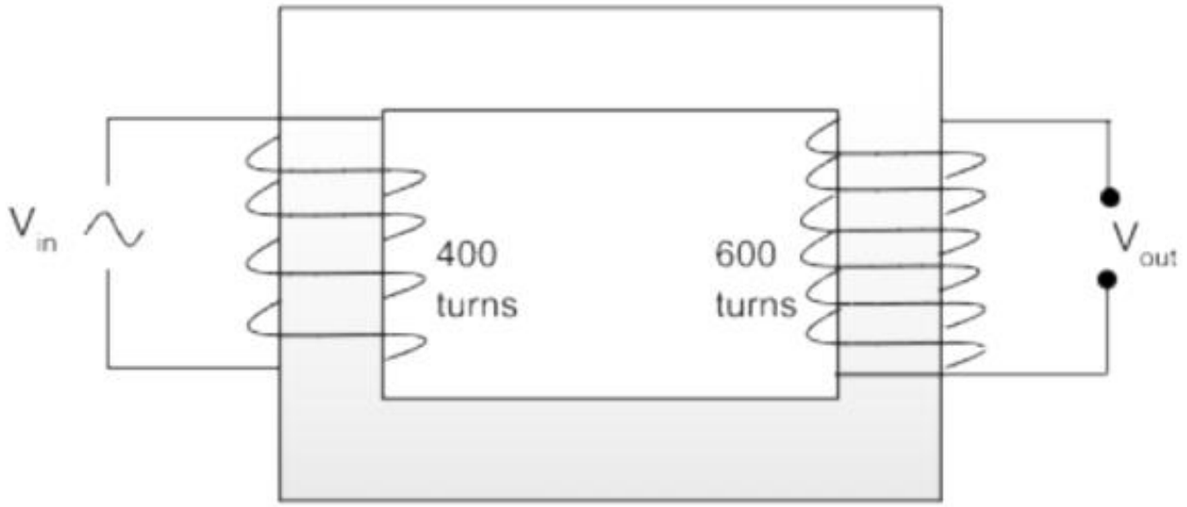
A. $\frac{1}{2}$

B. 1

C. $\frac{2}{3}$

D. 2

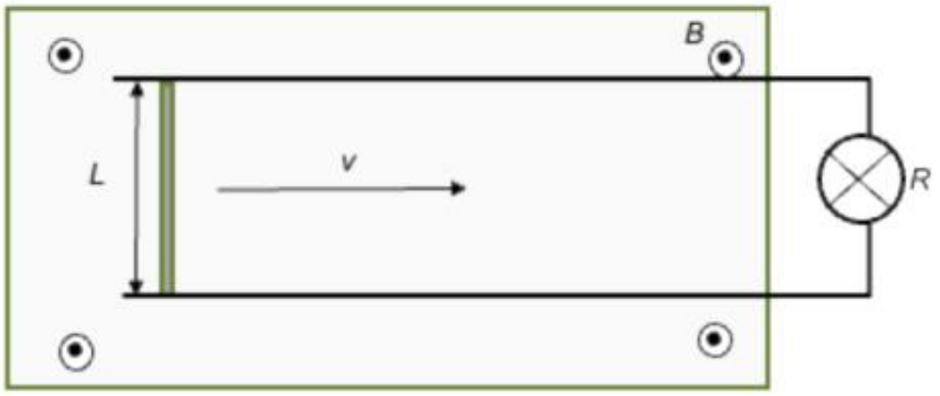
A transformer with an efficiency of 50% has 400 turns in its primary coil, and 600 turns in its secondary coil. In the primary coil the input rms (root-mean-square) voltage is 120 V and the input rms current is 6 A.



What is the output rms voltage and the output rms current in its secondary coil?

	rms Voltage / V	rms Current / A
A.	90	4
B.	180	2
C.	90	2
D.	180	4

A conducting rod of length L is moved in a region of uniform magnetic field B to light the filament bulb with a resistance of R. The direction of the magnetic field is out of plane.



What is the maximum output power of the bulb?

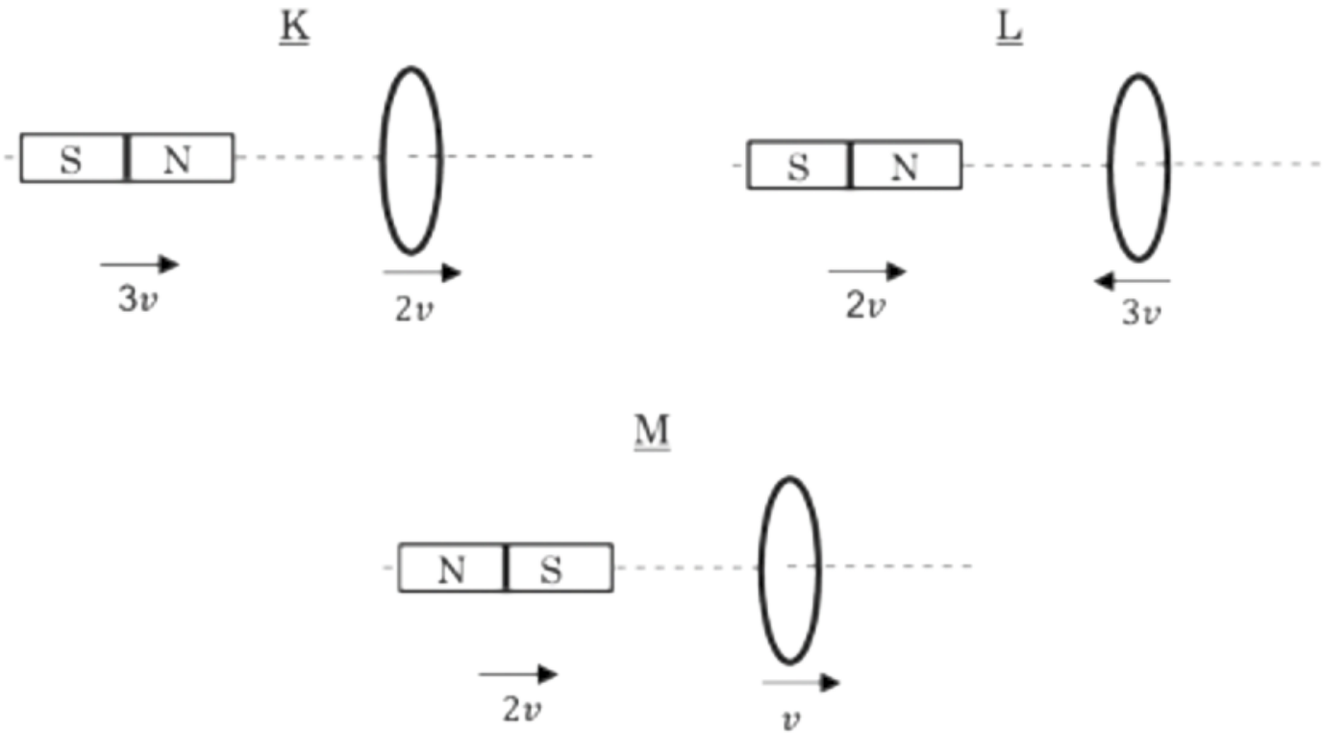
A. $\dfrac{BvL}{R}$

B. $\dfrac{B^2v^2L^2}{R}$

C. $\dfrac{B^2v^2L^2}{R^2}$

D. zero

A bar magnet is aligned along the axis of a conducting loop. The magnet and the loop move with velocities as given situations, K, L, and M. The distance between the bar and loop is the same in all scenarios.



Which is correct about the magnitudes of induced emf, ε, at the instant shown in each situation?

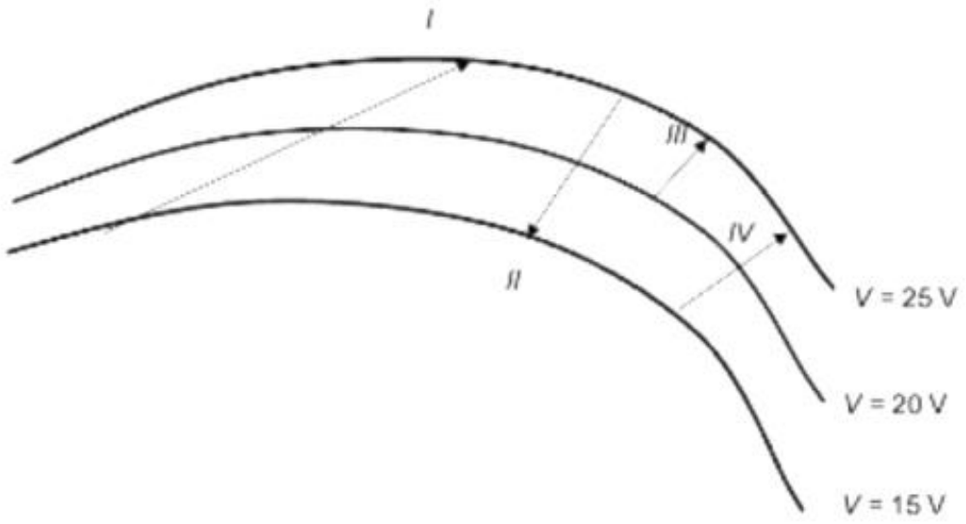
A. $\varepsilon_K = \varepsilon_L > \varepsilon_M$

B. $\varepsilon_L > \varepsilon_K = \varepsilon_M$

C. $\varepsilon_M > \varepsilon_K > \varepsilon_L$

D. $\varepsilon_K > \varepsilon_L > \varepsilon_M$

Four identical negatively charged objects move in an electric field along paths shown as arrows below. Equipotential lines for the field are shown. Initially, all four objects have the same kinetic energy.



What is the relationship between the kinetic energies of the objects at the end of their paths?

A. $\mathrm{I} = \mathrm{IV} > \mathrm{III} > \mathrm{II}$

B. $\mathrm{I} > \mathrm{IV} = \mathrm{II} > \mathrm{III}$

C. $\mathrm{I} = \mathrm{II} = \mathrm{IV} > \mathrm{III}$

D. $\mathrm{I} > \mathrm{IV} > \mathrm{III} > \mathrm{II}$

A car of speed $3v$ approaches another car of speed v from the rear on a level road.

The car with a speed of $3v$ uses its horn to clear its way. The frequency of the emitted sound wave is f and the speed of the sound wave is $10v$. What is the observed frequency of the sound wave by an observer in the front car?

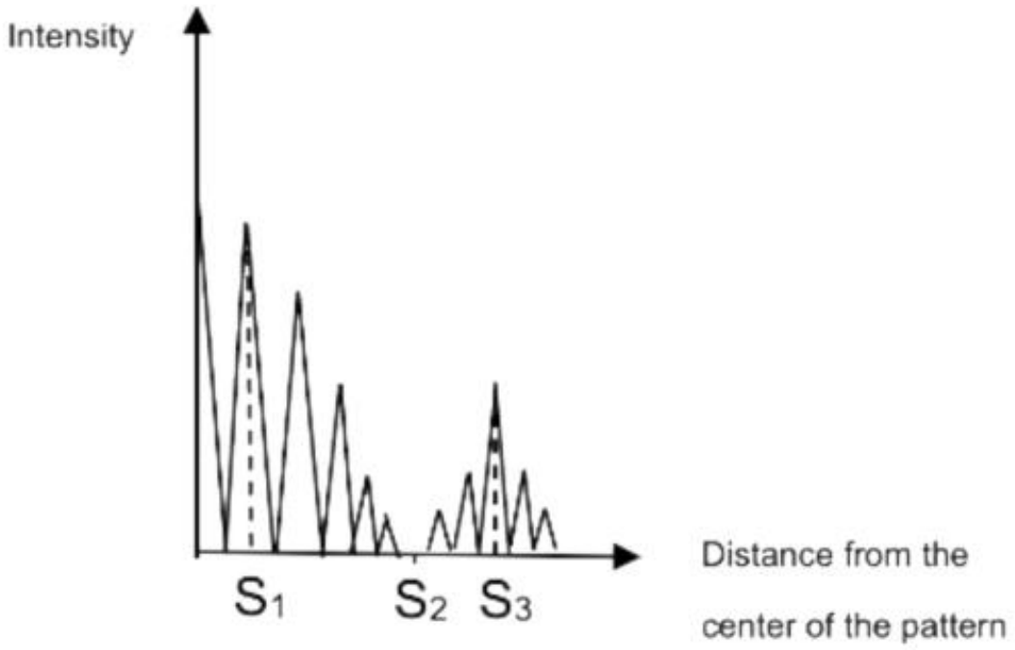
A. $\frac{2}{3}f$

B. $\frac{11}{7}f$

C. $\frac{9}{7}f$

D. $\frac{10}{7}f$

A coherent light is incident on a double slit that has slit separation of d and slit width of b. An interference pattern on a screen is observed. The graph shows the variation of intensity with distance from the centre of the pattern.



S_1, S_2 and S_3 are the separations between various points on the pattern and the center of the pattern. The distance between the screen and slits is D. What is the wavelength of the incident light?

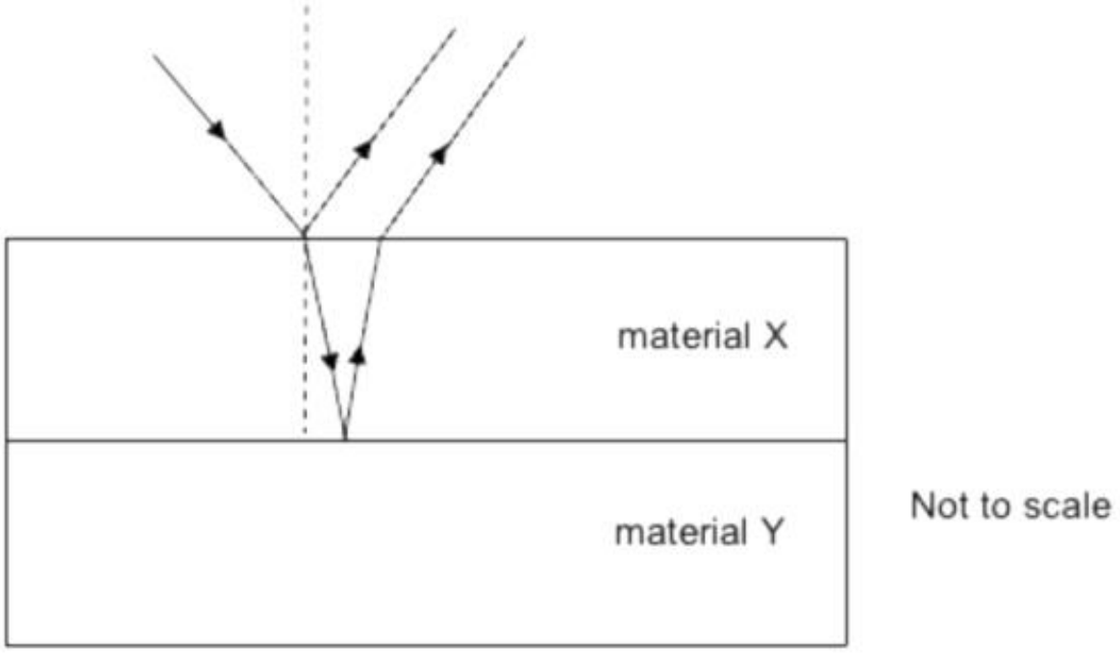
A. $\frac{bS_3}{D}$

B. $\frac{dS_3}{D}$

C. $\frac{bS_1}{D}$

D. $\frac{bS_2}{D}$

A material Y is covered with a thin film of material X. A ray of monochromatic light is incident from air almost normally to the surface of material X. The wavelength of the light in material X is λ. Light reflects from two different boundaries and interferes destructively. The diagram shows how light reflects from the boundaries .



Light travels slower in material Y than in X. Which of the following statements is false?

A. The path difference between reflected light from material X and reflected light from material Y is $m\lambda$ where m is an integer.

B. The path difference between reflected light from material X and reflected light from material Y is $(m + \frac{1}{2})\lambda$ where m is an integer.

C. The phase difference between incident light and reflected light from material Y is π.

D. The phase difference between incident light and reflected light from material X is π.

An object on a horizontal spring performs simple harmonic motion. The position of the object as a function of time is given by $x = 5\,cos(2t)$.

Which of the following expressions gives the acceleration of this object as a function of time?

A. $-20\,sin(2t)$

B. $-5\,sin(2t)$

C. $-5\,cos(2t)$

D. $-20\,cos(2t)$

A mass-spring system executes simple harmonic motion with a period T in a vertical plane. What is the period when the oscillating mass is doubled and the system is brought to a planet where the gravitational field strength at the surface is halved?

A. $2T$

B. $\sqrt{2}T$

C. T

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

An object has a surface area of $2.0\,m^2$ and emissivity $e = 0.5$. The object emits electromagnetic radiation of peak wavelength $2.90 \times 10^{-5}\,m$. What is the best estimate for the energy radiated by the object in one second?

A. $1.4\,J$

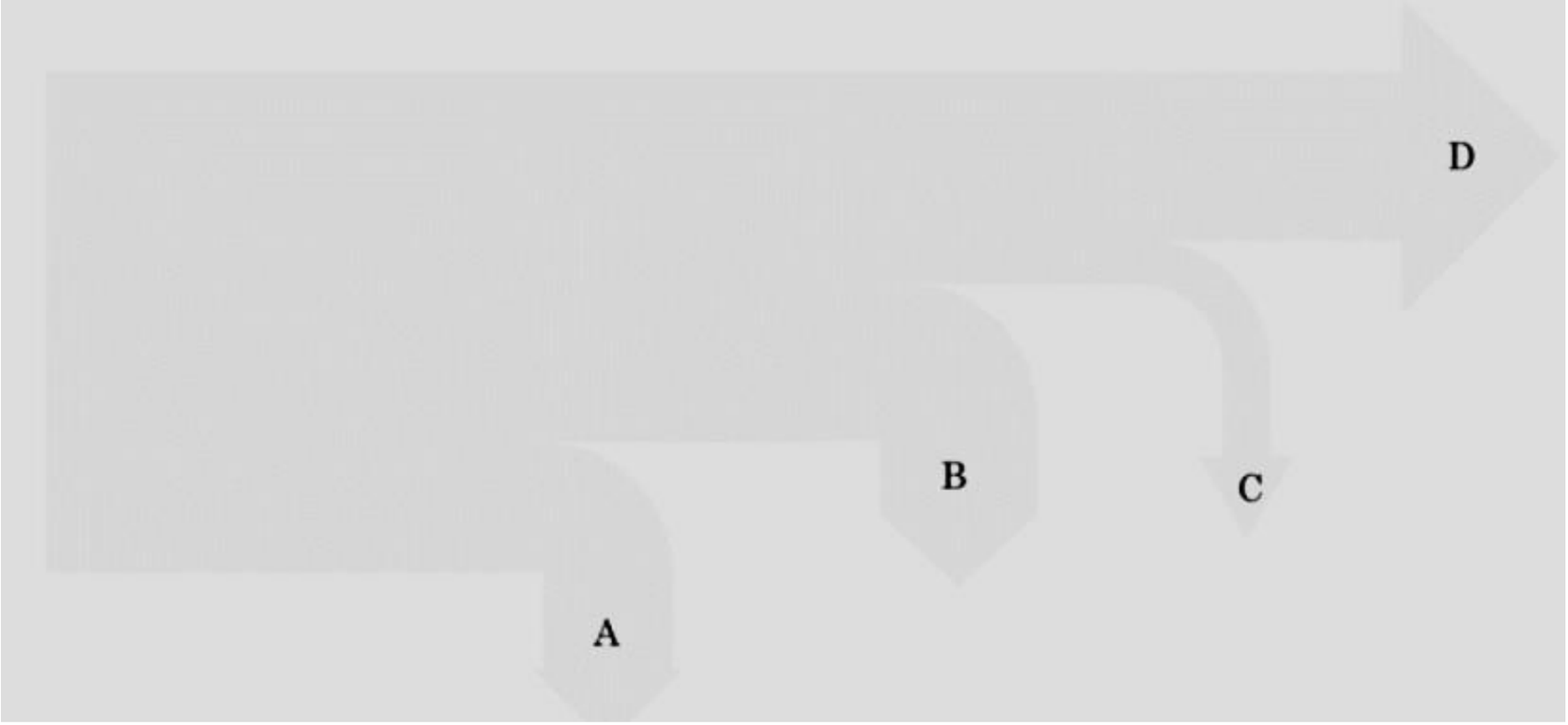
B. $2.8\,J$

C. $5.7\,J$

D. $11.3\,J$

The Sankey diagram below shows the energy degraded at different stages of a nuclear power plant.

Which of the following sections corresponds to the stage with the highest energy degradation?



Which of the following lists three fundamental forces in decreasing order of range?

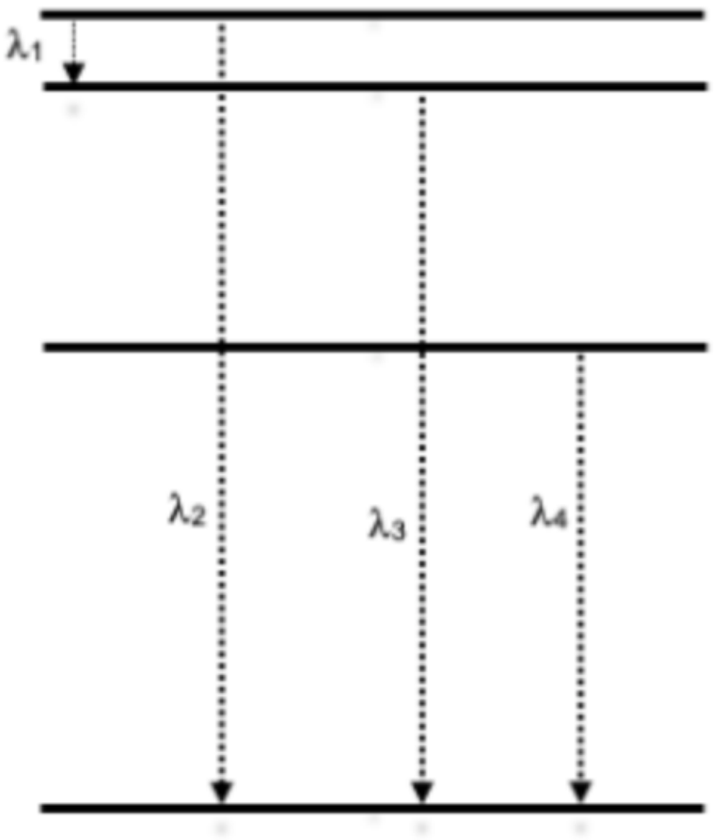
A. weak, strong, electromagnetic

B. strong, weak, gravitational

C. electromagnetic, strong, weak

D. gravitational, weak, strong

The diagram shows atomic energy levels of an element, and wavelengths are labeled corresponding to emission for electron transition between certain energy levels.



Which of the following shows these wavelengths in decreasing order?

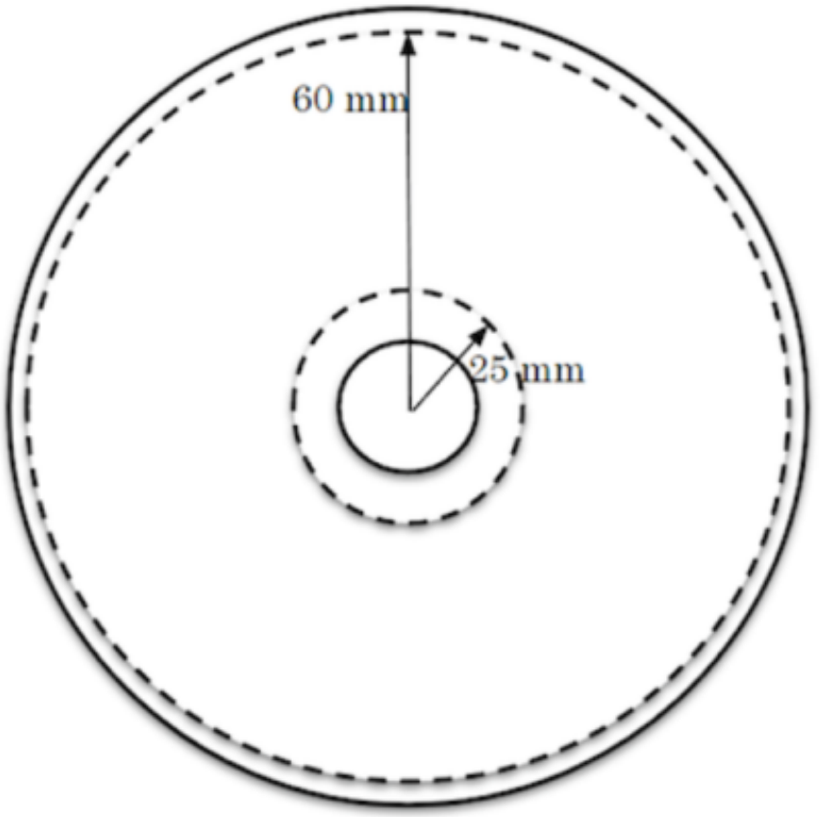
A. $\lambda_1, \lambda_2, \lambda_3, \lambda_4$

B. $\lambda_4, \lambda_3, \lambda_2, \lambda_1$

C. $\lambda_1, \lambda_4, \lambda_3, \lambda_2$

D. $\lambda_2, \lambda_3, \lambda_4, \lambda_1$

A CD stores data on its surface on a number of concentric circular tracks of different radii. The radius of the first track is 25 mm and that of the last track is 60 mm as shown in the diagram.

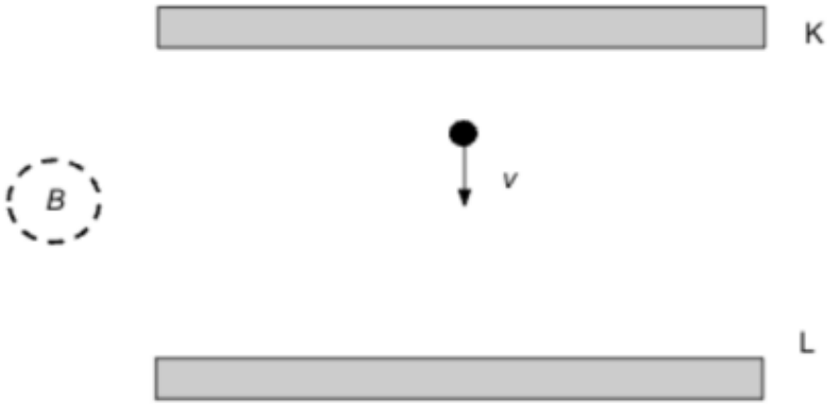


The data from the CD is read by rotating the disk under a laser system where the tangential speed is always 1.5 $m\,s^{-1}$ for the track being read.

Which of the following is correct about the angular speed of the first track ω_1 and the angular speed of the last track ω_2?

	ω_1	ω_2
A.	$60\,rad\,s^{-1}$	Same as ω_1
B.	$60\,rad\,s^{-1}$	Less than ω_1
C.	$25\,rad\,s^{-1}$	Same as ω_1
D.	$25\,rad\,s^{-1}$	Greater than ω_1

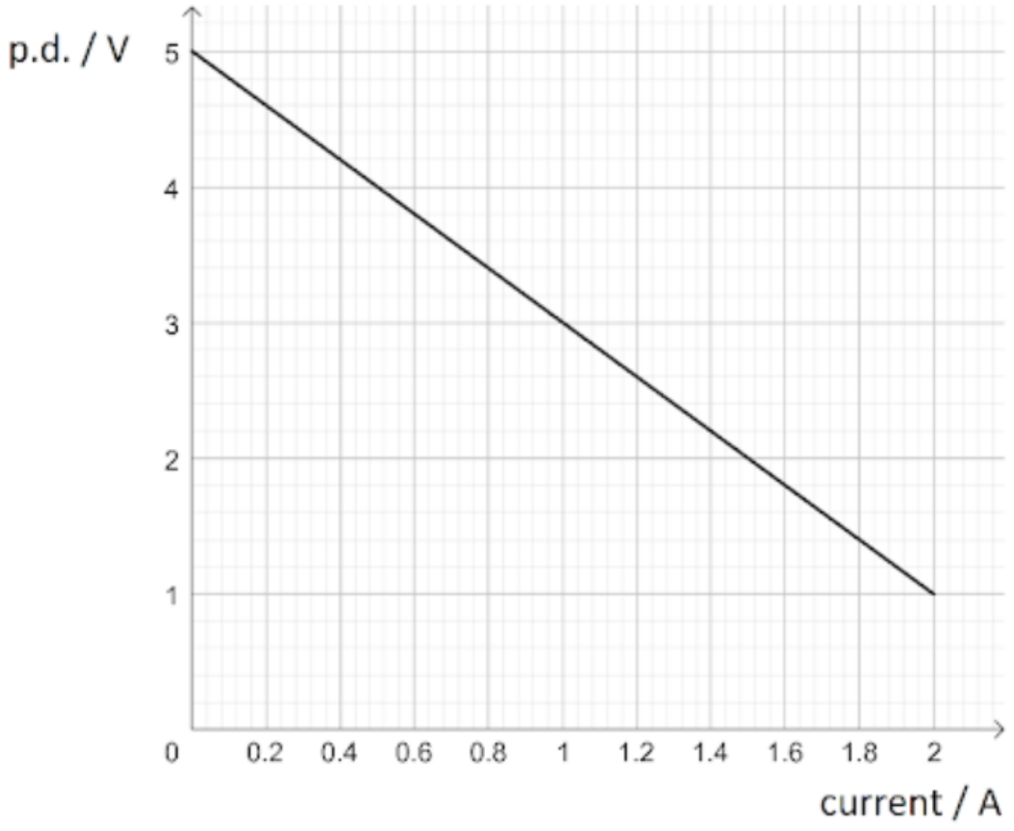
An object of mass m and charge q is dropped vertically between two parallel plates, K and L. A magnetic field B can be created perpendicular to the plane of the paper. The electric field between plates is E.



Which of the following is correct about the magnitude of magnetic and electric fields when the object falls vertically at a constant velocity v?

	E	**B**
A.	$\frac{mg}{q}$	$\frac{mg}{qv}$
B.	mv	0
C.	mg	$\frac{m}{qv}$
D.	$\frac{mg}{q}$	0

A cell is connected to a variable resistor. The terminal potential difference (p.d.) and current through the cell are measured and plotted on the graph shown. What is the internal resistance of the cell?



[Source: Created with GeoGebra, - https://www.geogebra.org/graphing?lang=en]]

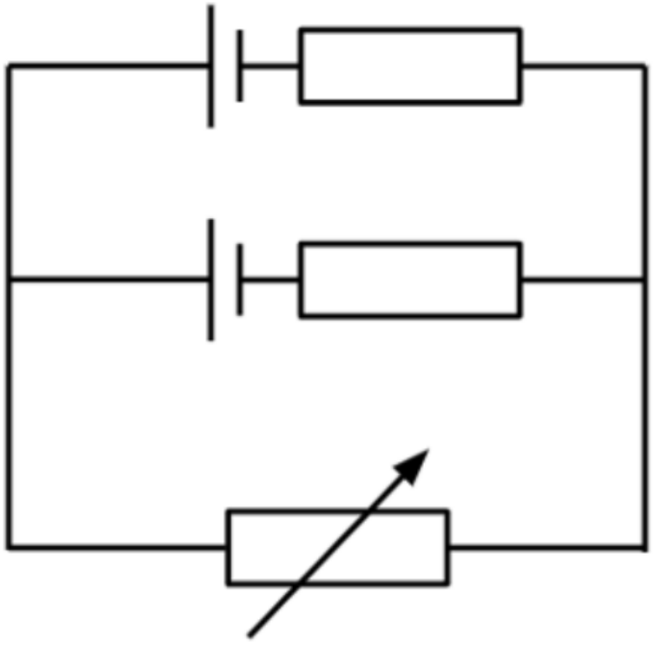
A. $5.0\,\Omega$

B. $4.0\,\Omega$

C. $3.0\,\Omega$

D. $2.0\,\Omega$

In the following circuit, two cells are connected in parallel to an external circuit containing a variable resistor. The emf of each cell is 3.0 V and the internal resistance (shown) of each is 5.0 Ω.



If the variable resistor is set at 7.5 Ω, what is the current in the external circuit?

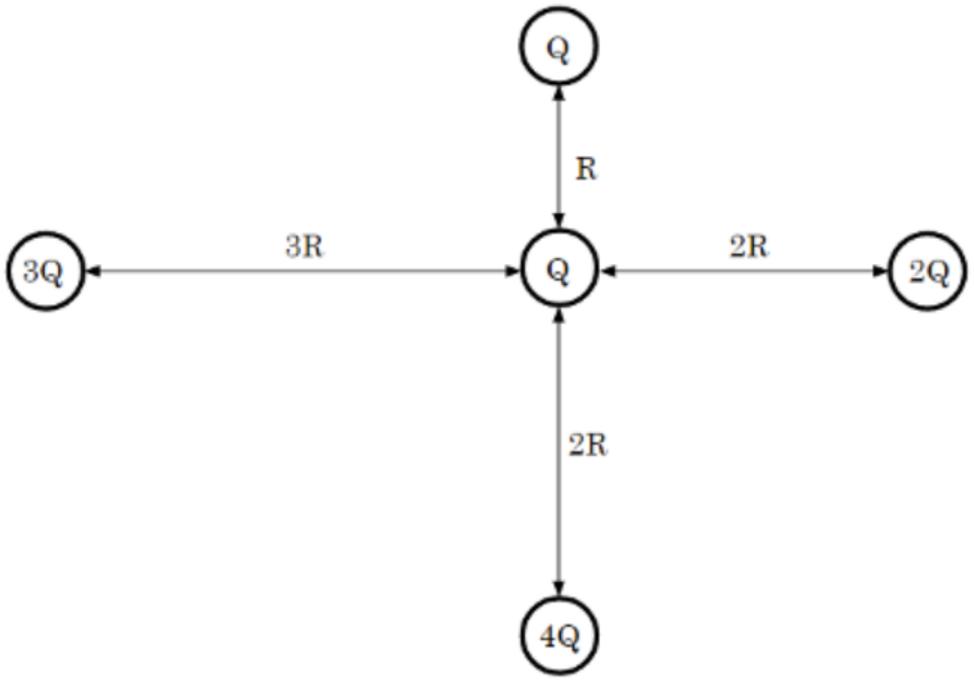
A. 0.1 A

B. 0.15 A

C. 0.3 A

D. 0.5 A

In the following diagram, the size of the charges is small compared to the distance R.



What is the direction of the force on the charge in the center?

A. Up

B. To the right

C. To the left

D. The charge does not move

A wire carries electrical current. If 9.0×10^{12} electrons pass a given point in the wire every 4.5 seconds, what is the current in the wire?

A. $2.0 \times 10^{-7}\ A$

B. $3.2 \times 10^{-7}\ A$

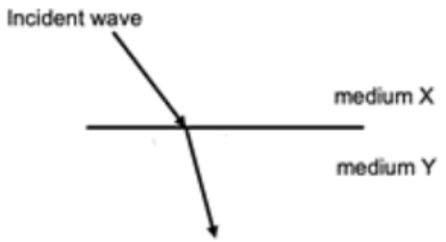
C. $3.2 \times 10^{-4}\ A$

D. $2.0 \times 10^{12}\ A$

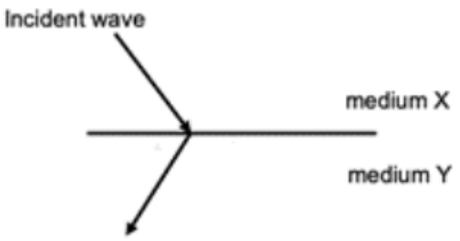
A wave is incident on a boundary between two media, X and Y. The wave travels faster in medium Y than in medium X

Which of the following diagrams shows a possible path for this wave?

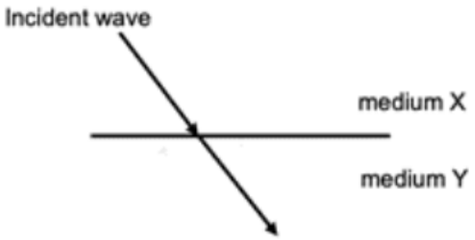
A.



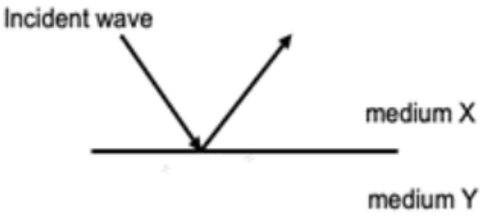
B.



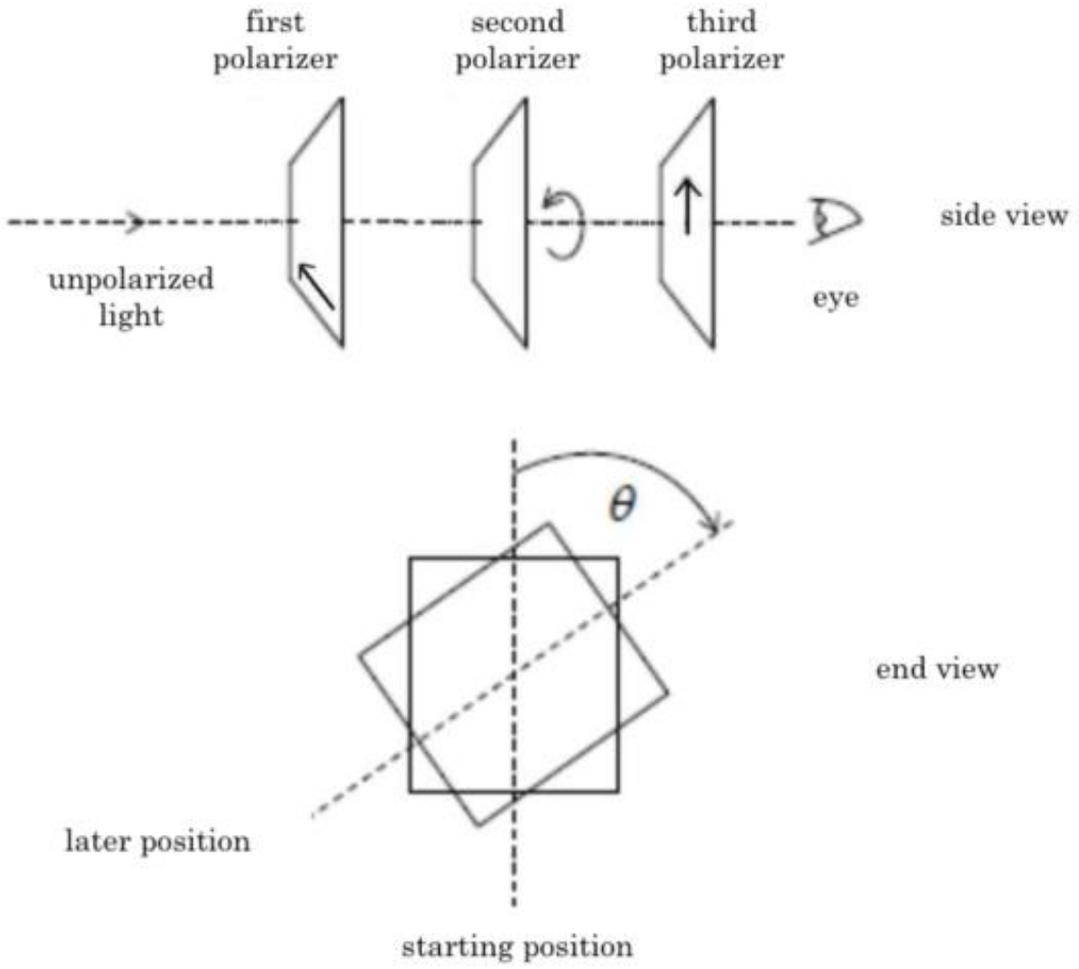
C.



D.

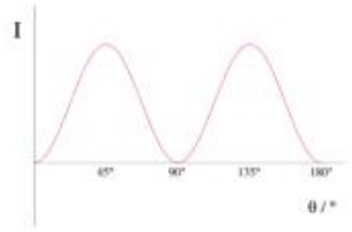


Unpolarized light is incident on three polarizers. The axes of polarization of first and third polarizers are initially perpendicular. The second polarizer can be rotated as shown.

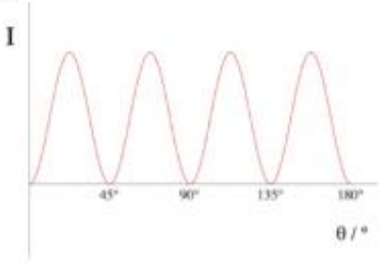


When the angle $\theta = 0^\circ$ no light is transmitted. The angle θ of the second polariser is varied from 0 to 180 degrees. Which of the following represents the variation with θ of the intensity I of the light transmitted through to the eye?

A.



B.



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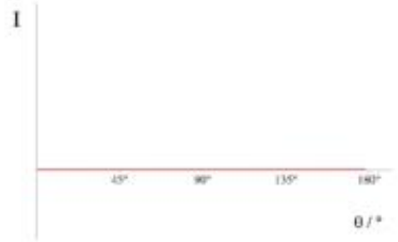
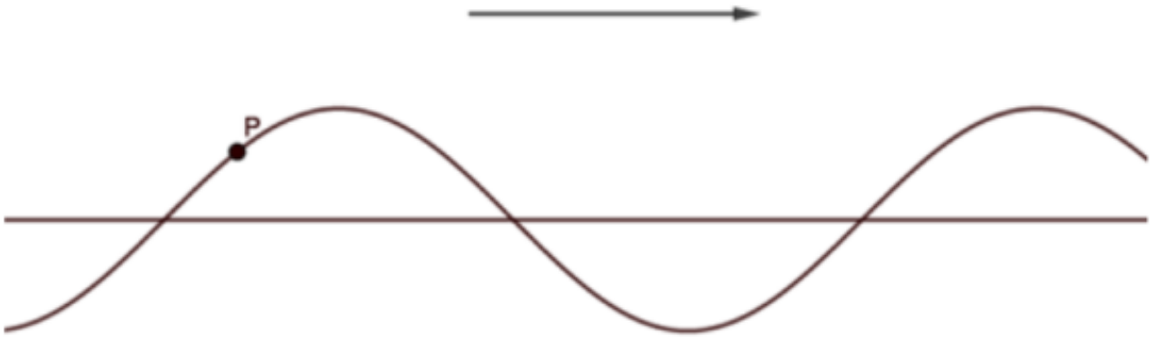


D.

A wave travels on a rope as shown, where P is a point on the rope halfway between the equilibrium position and the maximum displacement at the instant shown.



[Source: Created with GeoGebra - https://www.geogebra.org/graphing?lang=en]

Which is correct about the direction and magnitude of the velocity of point P after half a period compared to the shown position?

	Direction	Magnitude
A.	Up	Increases
B.	Up	Same
C.	Down	Decrease
D.	Down	Same

A radio wave of frequency 90 MHz travels a distance d. The number of wavelengths that can fit into this distance is 6000. What is d?

A. $1.8\,km$

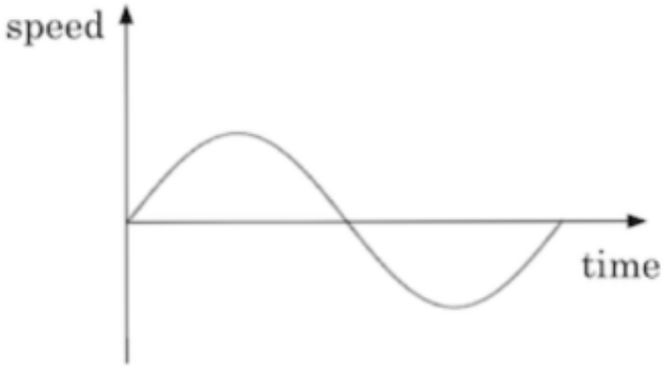
B. $3.3\,km$

C. $20\,km$

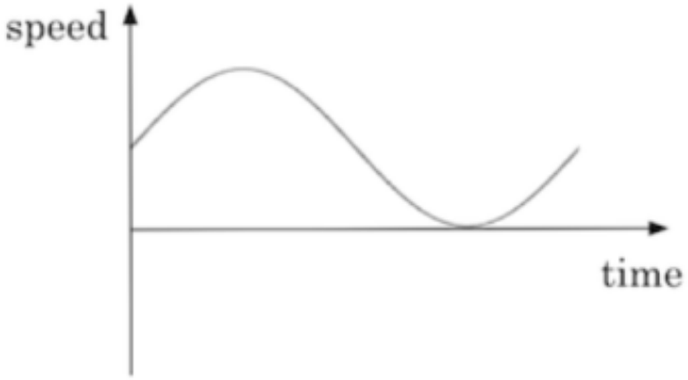
D. $200\,km$

A body performs simple harmonic motion (shm). Which of the following could be the speed against the time graph for one period of motion?

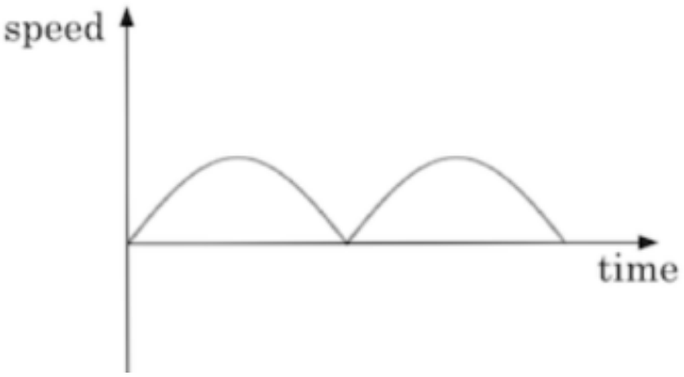
A.



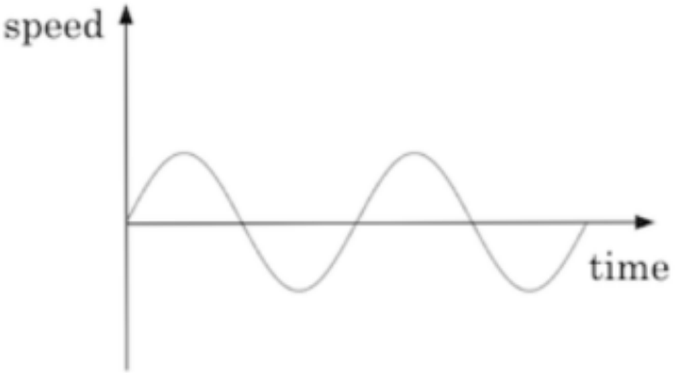
B.



C.



D.



An inflated balloon containing an ideal gas at temperature T in degrees Celsius floats in a room where the atmospheric pressure is P. The volume remains constant at V. If the balloon contains M moles of the gas, which of the following is true?

A. $M = \dfrac{PV}{R(T + 273)}$

B. $M = \dfrac{R(T + 273)}{PV}$

C. $M = \dfrac{k_b P}{RV}$

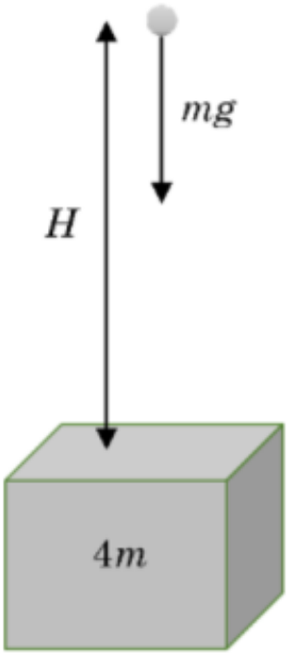
D. $M = \dfrac{PV}{k_b(T - 273)}$

Systems A and B both consist of an ideal gas at initial temperature T. In System A, the temperature of the gas is increased. In System B, gas molecules are added with the temperature of the system remaining constant.

Which of these statements about the total intermolecular potential energy of the two systems is correct?

	System A	**System B**
A.	Potential energy increases	Potential energy increases
B.	Potential energy is constant	Potential energy increases
C.	Potential energy is constant	Potential energy is constant
D.	Potential energy increases	Potential energy is constant

A thermally isolated system consists of a coin of weight mg and specific heat capacity c suspended in a vacuum at a vertical distance H above a solid block. The block has mass $4m$, specific heat capacity $2c$ and latent heat of fusion L. The melting temperature of the block is an amount ΔT greater than the initial temperature of the block and the coin. The coin is dropped on to the block.



What is the minimum value of H required for the block to melt due to the collision?

A. $\dfrac{8c\Delta T}{g}$

B. $\dfrac{8c\Delta T + 4L}{g}$

C. $\dfrac{9c\Delta T + 4L}{g}$

D. $\dfrac{9c\Delta T - 4L}{g}$

An object starts to move in a straight line under the effect of two opposite forces of 12 N and 16 N.

After 5 s, the displacement of the object is 25 m. What is the mass of the object?

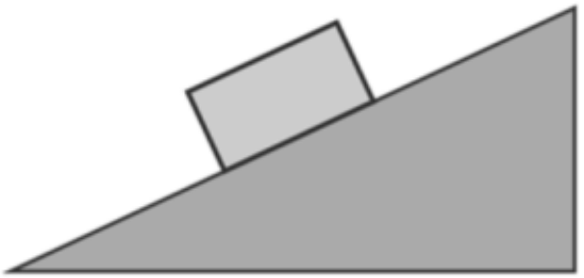
A. 1 kg

B. 2 kg

C. 3 kg

D. 4 kg

A block of mass 4.0 kg rests on an inclined plane.



The coefficient of static friction between the block and the plane μ_s is 0.4.

Which of the following gives the angle of inclination at which the block will start to slide?

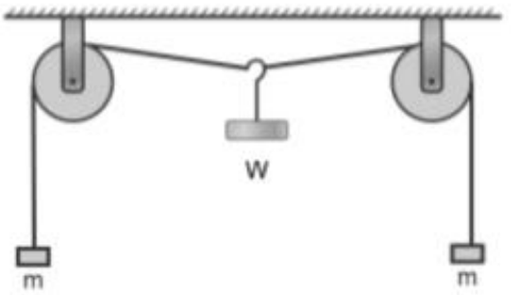
A. $sin^{-1}(0.4)$

B. $tan^{-1}(0.4)$

C. $cos^{-1}(0.4)$

D. $tan^{-1}(0.6)$

A piece of metal of weight W is suspended by two identical strings. Each string passes through a pulley and is attached to a block of mass m. The system is in equilibrium



[Created with Chemix (https://chemix.org)]

What must be true for m such that the two strings attached to the piece of metal are almost horizontal?

A. $m < \frac{W}{g}$

B. $\frac{W}{2g} < m < \frac{W}{g}$

C. $m > \frac{W}{g}$

D. $m < \frac{W}{2g}$

The take off speed of a passenger aircraft is $75.0\ m\,s^{-1}$. A plane starts from rest and accelerates at a steady rate of $1.25\ m\,s^{-2}$. Which of the following correctly states the minimum duration of taxiing, and the minimum length of the runway needed for the take off?

	Duration of Taxiing	**Length of the runway**
A.	$\frac{75.0 m\,s^{-1}}{1.25\,m\,s^{-2}}$	$\frac{(75.0\,m\,s^{-1})^2}{(2)(1.25\,m\,s^{-2})}$
B.	$\frac{75.0\,m\,s^{-1}}{1.25\,m\,s^{-2}}$	$\frac{(75.0\,m\,s^{-1})^2}{1.25\,m\,s^{-2}}$
C.	$\frac{(75.0\,m\,s^{-1})^2}{(2)(1.25\,m\,s^{-2})}$	$\frac{75.0\,m\,s^{-1}}{1.25\,m\,s^{-2}}$
D.	$\frac{(75.0\,m\,s^{-1})^2}{(2)(1.25\,m\,s^{-2})}$	$\frac{(75.0\,m\,s^{-1})^2}{(2)(1.25\,m\,s^{-2})}$

A body is moving in a straight line with a constant acceleration of a. Its speed increases from u to v in a time of t. Consider the folloing expressions:

I. $ut + \frac{(v-u)t}{2}$

II. $vt - \frac{1}{2}at^2$

III. $\frac{(v-u)t}{2}$

Which expression(s) can be used to determine the displacement of the body during the time interval t?

A. I only

B. II only

C. I and II only

D. II, and III only

A ball is projected with an initial speed of $2\,m\,s^{-1}$ making an angle of 35^o with the horizontal as shown.

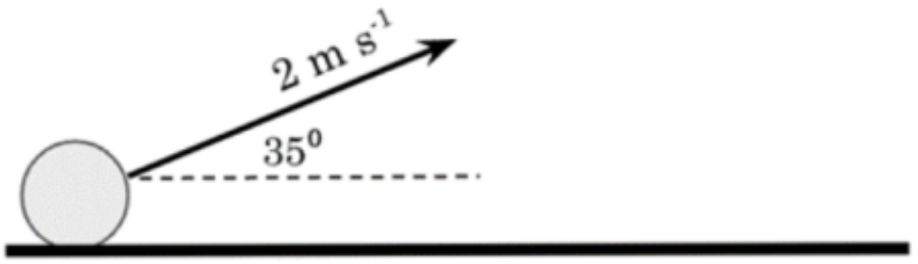


Diagram is not to scale

Which expression gives the vertical component of the velocity vector?

A. $2\,m\,s^{-1}$

B. $2\,cos(35^o)\,m\,s^{-1}$

C. $2\,sin(35^o)\,m\,s^{-1}$

D. $2\,tan(35^o)\,m\,s^{-1}$

An object starting from rest travels a distance d after a time t. If $d = (20 \pm 1)\, m$, and the time is measured as $t = (2.0 \pm 0.4)\, s$. Which of the following gives the correct values of the fractional and absolute uncertainties of acceleration?

	Fractional	**Absolute /m s^{-2}**
A.	0.25	$\pm$ 2.5
B.	0.30	$\pm$ 3.0
C.	0.45	$\pm$ 4.5
D.	1.4	$\pm$ 14

What is the unit of capacitance expressed in fundamental SI units?

A. $kg^{-1}\,m^{-2}\,A^{2}\,s^{4}$

B. $kg\,m^{2}\,A^{-2}\,s^{-4}$

C. $kg^{-1}\,m^{-2}\,C^{2}\,s^{2}$

D. $kg\,m^{2}\,C^{-2}\,s^{-2}$

A pure radioactive sample of mass m has a decay constant of λ. Its activity is given by A. Another pure sample of the same material has a mass $2m$. Consider the following statements about the sample of mass $2m$ after an interval of two half lives.

I. The decay constant is $\frac{\lambda}{2}$.

II. The activity is $\frac{A}{2}$.

III. The mass of decayed nucleons in the sample is $\frac{m}{2}$.

Which of the statements is/are correct?

A. I only

B. II only

C. III only

D. II and III only

The activity of a 100% pure radioactive sample is $10^6\ Bq$. The activity of the sample after 20% of nuclei have decayed is:

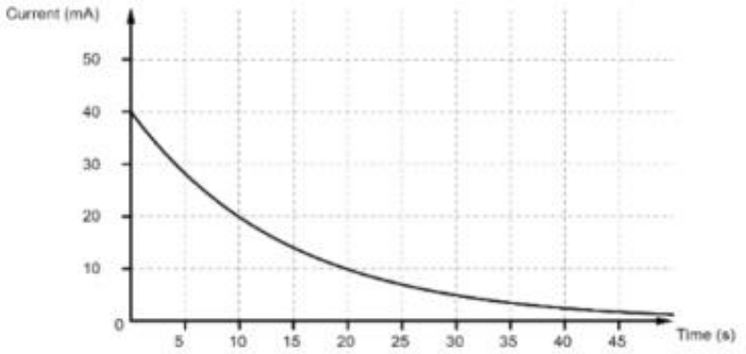
A. $0.2 \times 10^6\ Bq$

B. $0.4 \times 10^6\ Bq$

C. $0.6 \times 10^6\ Bq$

D. $0.8 \times 10^6\ Bq$

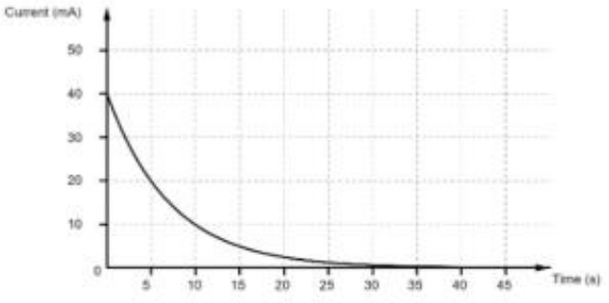
A parallel plate capacitor of capacitance C is charged through a resistance R using a battery of voltage V. The graph shows the variation of the current through the resistor with time.



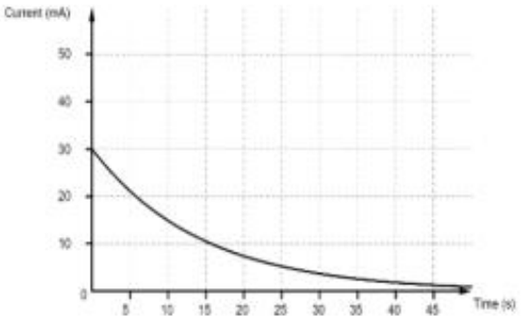
[Source: Created with GeoGebra by Tom Walsh- https://www.geogebra.org/m/jrWMapS7]

Graphs **K** and **L** show the new variation of the current through the capacitor with time after making changes in the circuit.

K



L.



Consider the following statements:

I. When only the capacitor is changed to $\frac{C}{2}$, it is possible to obtain graph **K**.

II. When only the voltage of the battery is decreased, it is possible to obtain graph **L**.

III. When only the resistor is replaced with a resistance of $2R$, it is possible to obtain graph **K**.

Which statement(s) is/are correct?

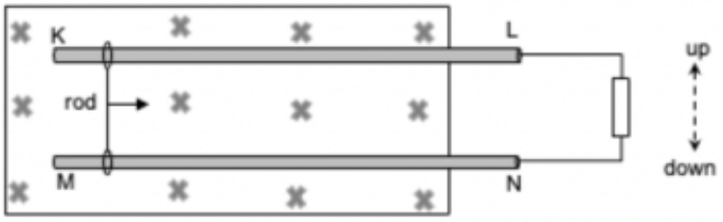
A. I and II only

B. II and III only

C. I and III only

D. I, II and III

A conducting rod with a length of $0.20\,m$ is placed on two parallel conducting rails KL and MN as shown.



The uniform magnetic field (into the page) is normal to the plane of the conducting rails and has a magnitude of $5.0\,T$. A resistance of $1.5\,\Omega$ is connected between the ends L and N of the rails. The copper rod moves at a constant speed of $3.0\,m\,s^{-1}$ in the direction shown. What is the magnitude and the direction of induced current passing through the resistor?

	Magnitude of the current	**Current direction through the resistor**
A.	2.0 A	up
B.	5.0 A	up
C.	2.0 A	down
D.	5.0 A	down

A planet of mass $25M$ and its moon of mass M are shown in the diagram. At point X on the line joining their centers, the resultant gravitational field is zero, and the gravitational potential due to the moon is V.

What is the total gravitational potential at X?

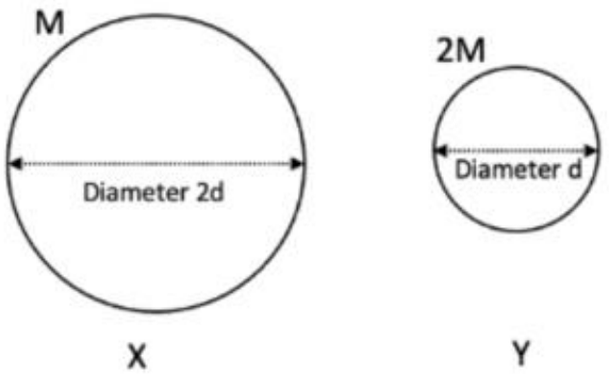
A. $2V$

B. $3V$

C. $6V$

D. $26V$

Planet X has half the mass and twice the diameter of planet Y. The escape speed from the surface of planet X is given by v. What is the escape speed from the surface of planet Y ?



A. $\frac{v}{2}$

B. $\frac{v}{\sqrt{2}}$

C. $v\sqrt{2}$

D. $2v$

A train is traveling at $30\,m\,s^{-1}$ towards a stationary observer. It sounds a horn of frequency $450\,Hz$.

Which of the following statements is true about the observed frequency compared with the emitted frequency as the train approaches?

	Observed frequency compared to emitted frequency	Change in observed frequency over time
A.	Lower	No change
B.	Higher	Increases
C.	Lower	Decreases
D.	Higher	No change

The lights of a vehicle are $1.22\,m$ apart. The wavelength of light emitted from the vehicle is λ. The diameter of a human pupil is $10000\,\lambda$. What is the maximum distance between the vehicle and the human observer for identifying the lights as two separate sources?

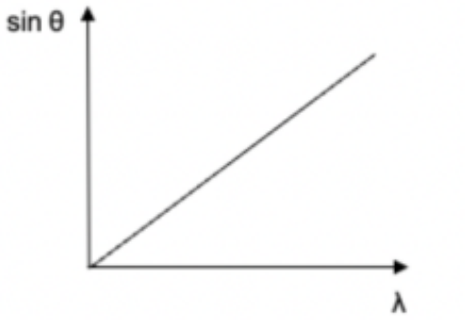
A. $1.2 \times 10^4\,m$

B. $1.2 \times 10^3\,m$

C. $1.0 \times 10^4\,m$

D. $1.0 \times 10^3\,m$

A beam of light is incident on a diffraction grating that has N lines per cm. An interference pattern is observed on a distant screen. The graph shows the variation of deflection angle θ for the fifth maximum with wavelength λ of the beam.



Which of the following gives the gradient of the graph?

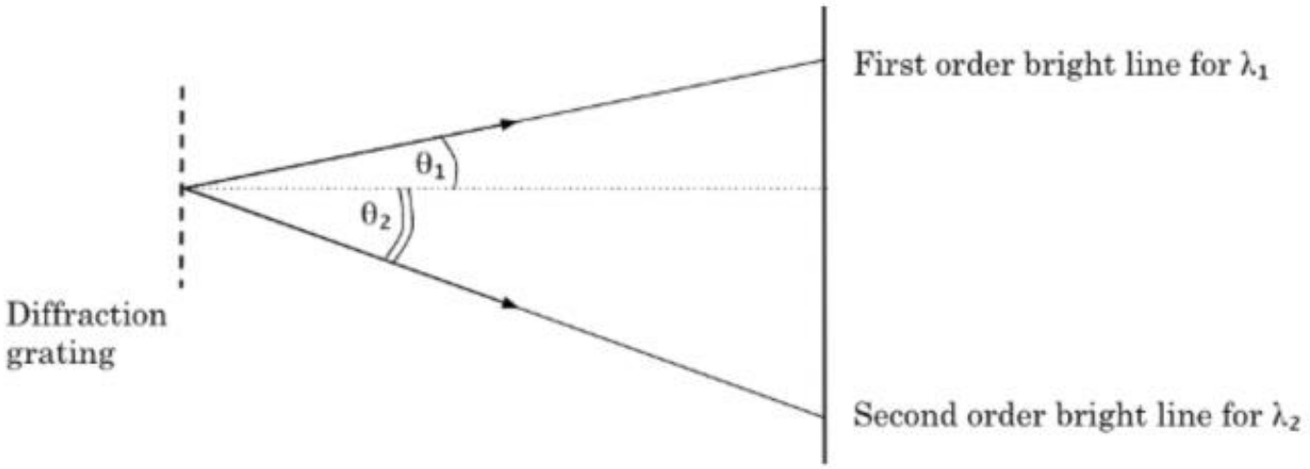
A. $100N\,m^{-1}$

B. $500N\,m^{-1}$

C. $\frac{N}{100}\,m^{-1}$

D. $\frac{N}{500}\,m^{-1}$

Light of wavelength λ_1 and λ_2 is incident on a diffraction grating with the slit spacing of d. A series of bright lines are formed on a screen.



What is the ratio $\frac{sin\,\theta_1}{sin\,\theta_2}$?

A. $\frac{2\lambda_1}{\lambda_2}$

B. $\frac{2\lambda_2}{\lambda_1}$

C. $\frac{\lambda_1}{2\lambda_2}$

D. $\frac{\lambda_2}{2\lambda_1}$

A spring-mass system executes simple harmonic motion with an amplitude of $20\,cm$ and maximum elastic potential energy of $100\,J$. What is the displacement of the mass when the elastic potential energy of the system is $25\,J$?

A. $20\,cm$

B. $15\,cm$

C. $10\,cm$

D. $5\,cm$

The albedo at the poles of Earth during a particular day is 0.8. What is the value of the absorbed intensity if the solar intensity is $700\,W\,m^{-2}$?

A. $140\,W\,m^{-2}$

B. $560\,W\,m^{-2}$

C. $875\,W\,m^{-2}$

D. $3500\,W\,m^{-2}$

A spherical object of surface area A and absolute temperature T can be regarded as a black body. The power of the radiation emitted from the object is P. What would be the power of the radiation emitted by an object with an absolute temperature of $2T$ and a surface area of $\frac{A}{2}$?

A. P

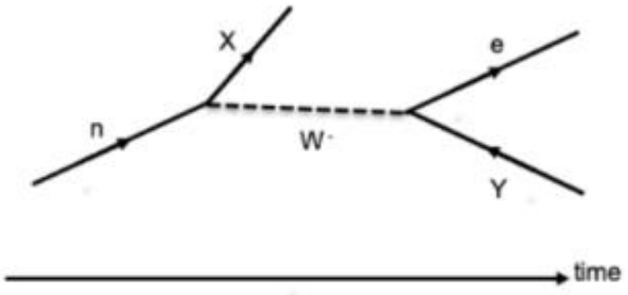
B. $2P$

C. $4P$

D. $8P$

The Feynman diagram shows the decay of a neutron.

What are the particles labeled X and Y?



	X	Y
A.	proton	neutrino
B.	neutron	neutrino
C.	proton	antineutrino
D.	neutron	antineutrino

Which of the following correctly lists the fundamental forces in decreasing order of strength?

A. Weak nuclear, strong nuclear, electromagnetic, gravitational

B. Strong nuclear, electromagnetic, weak nuclear, gravitational

C. Gravitational, electromagnetic, weak nuclear, strong nuclear

D. Electromagnetic, gravitational, strong nuclear, weak nuclear

Which of the following correctly shows the change in total binding energy per nucleon in nuclear fission and nuclear fusion?

	Nuclear fission	Nuclear fusion
A.	increases	increases
B.	decreases	increases
C.	decreases	decreases
D.	increases	decreases

An element X is bombarded with alpha particles and a new element Y is formed with a neutron emitted. The following equation can be written for the nuclear reaction.

$$\mathrm{{}_{2}^{4}He} + \mathrm{{}_{A}^{\square}X} \rightarrow \mathrm{{}_{B}^{\square}Y} + \mathrm{n}$$

The atomic numbers of X and Y are A and B respectively. Which of the following is correct for A and B?

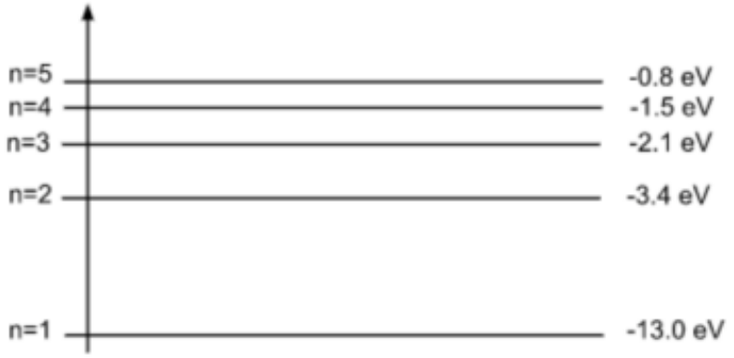
A. $A - 1 = B$

B. $A + 1 = B$

C. $A - 2 = B$

D. $A + 2 = B$

The diagram gives energy levels of a single-electron atom.



How many different wavelengths can be detected in the emission spectrum of the atom?

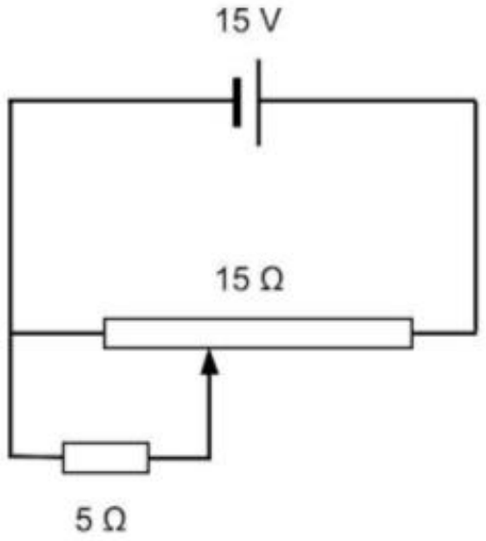
A. 4

B. 5

C. 9

D. 10

In the circuit shown, a resistor of $5\,\Omega$ is connected to a long resistive wire with resistance of $15\,\Omega$ through a sliding contact that can move along the entire length of the wire. Both are connected to a power supply with $15\,V$ of emf and negligible internal resistance.

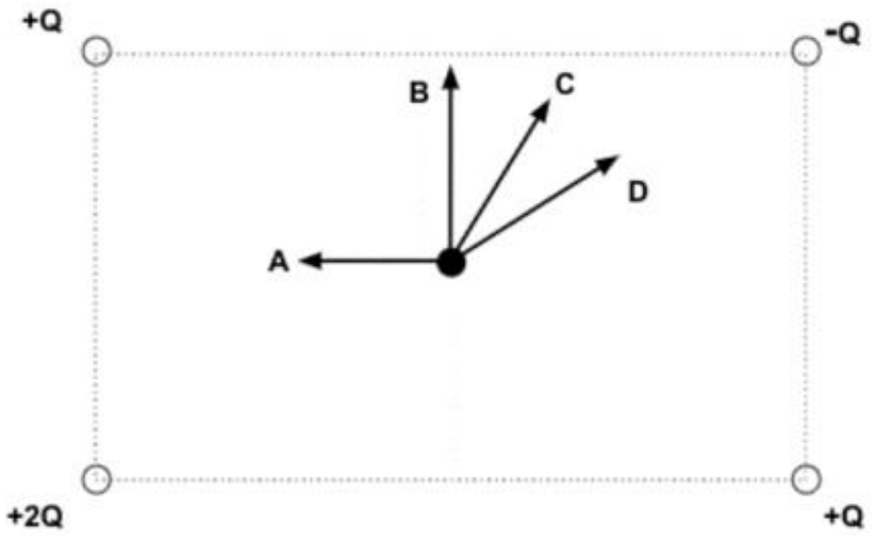


[Source: Created with GeoGebra, - https://www.geogebra.org/m/JbAKa82Y]

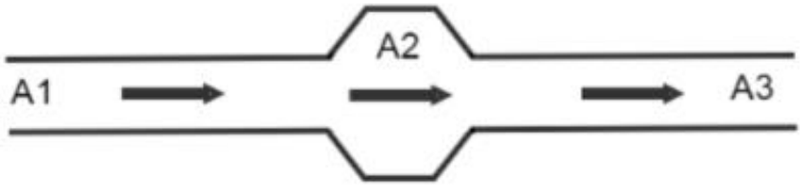
What is the maximum and minimum values of current through the power supply?

	Maximum current $/A$	**Minimum current** $/A$
A.	3.0	0.75
B.	4.0	0.75
C.	3.0	1.0
D.	4.0	1.0

Four fixed charged point particles are at the vertices of a rectangle. Which arrow represents the net electric field at the center of the rectangle?



A wire is deformed as shown, so that the cross sectional area of A2 is more than that of A1 and A3.



Which is correct about current and drift speed?

	Current	Drift speed
A.	Increased in A2	Same for all areas
B.	Increased in A2	Decreases in A2
C.	Same for all areas	Decreases in A2
D.	Same for all areas	Same for all areas

A point charge is moved between two parallel plates separated by a distance of $5\,cm$. The potential difference between the points is $50\,V$.

What is the average electric field E?

A. $1000\,N\,C^{-1}$

B. $250\,N\,C^{-1}$

C. $10\,N\,C^{-1}$

D. $2.5\,N\,C^{-1}$

Incident light of wavelength $600\,nm$ is emitted towards two slits separated by $10\,\mu m$. The interference pattern is observed on a wall. The distance between two adjacent maxima is $0.12\,m$. What is the distance of the wall from the slits?

A. $2.0\,mm$

B. $2.0\,cm$

C. $2.0\,dm$

D. $2.0\,m$

The speed of light in medium X is $\frac{2}{3}$ of the speed in medium Y, while the speed of light in medium Z is $\frac{4}{5}$ of the speed in medium Y. When light travels from medium X to medium Z with an angle of incidence i, what is the sine of the angle of refraction, $sin(r)$?

A. $\frac{6}{5}\,sin\,(i)$

B. $\frac{5}{6}\,sin\,(i)$

C. $\frac{15}{8}\,sin\,(i)$

D. $\frac{8}{15}\,sin\,(i)$

A sheet of polarizing material is arranged with a vertical transmission axis. Light of intensity I is incident on the sheet. Which of the following statements are true about the transmitted light?

I. The electric field vector makes an angle of 0^o with transmission axis

II. The transmitted intensity after passing through the polarizer is $\frac{I}{\sqrt{2}}$

III. The magnetic field makes an angle 45^o with the vertical transmission axis.

A. I only

B. I and III

C. I and II

D. I, II, and III

A sound probe measures the intensity of sound waves from a speaker at a distance d from the speaker as I_1.

The volume of the speaker is adjusted to double the amplitude of emitted sound waves, and the probe measures the sound intensity at a distance of $2d$ from the speaker as I_2.

What is $\frac{I_1}{I_2}$?

A. 16

B. 1

C. $\frac{1}{4}$

D. $\frac{1}{16}$

An ideal gas is enclosed in a syringe. The gas has a volume of $20\,mL$, a temperature of 20^oC, and pressure of $10\,kPa$. The syringe is heated to 40^oC, and the volume of the gas is reduced to $5\,mL$.

What is the new pressure?

A. $80\,kPa$.

B. $20\,kPa$.

C. $2\,kPa$.

D. $43\,kPa$.

Which of the following real gases at atmospheric pressure would be least likely to approximate to an ideal gas?

A. Helium gas at temperature of 56 K

B. Oxygen gas at temperature of 500 K

C. Nitrogen at temperature of 374 K

D. Hydrogen gas at temperature of 22 K

A car is moving with a kinetic energy of $10^5\ J$.

Estimate the order of magnitude of its momemtum.

A. $10^3\ kg\,m\,s^{-1}$

B. $10^4\ kg\,m\,s^{-1}$

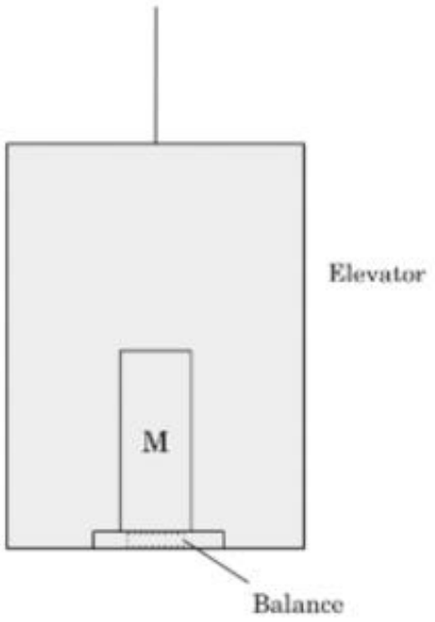
C. $10^5\ kg\,m\,s^{-1}$

D. $10^6\ kg\,m\,s^{-1}$

A table tennis ball of mass m is dropped on a level surface from a height H. The ball rebounds to a height $h < H$ after impact. Which of the following is correct about the nature of the collision and magnitude of the change in momentum (Δp) of the ball as a result of this impact?

	Nature of the collision	**Change in momentum Δp**
A.	Elastic	$m(\sqrt{2gH} - \sqrt{2gh})$
B.	Inelastic	$m(\sqrt{2gH} - \sqrt{2gh})$
C.	Elastic	$m(\sqrt{2gH} + \sqrt{2gh})$
D.	Inelastic	$m(\sqrt{2gH} + \sqrt{2gh})$

A box with a mass of M rests on a balance in an elevator that is moving downwards. The elevator slows with an acceleration of $\frac{g}{4}$.



Which of the following gives the reading of the balance?

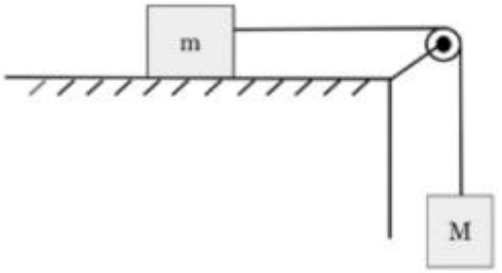
A. $\frac{5Mg}{4}$

B. Mg

C. $\frac{3Mg}{4}$

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

An object of mass m rests on a rough surface. Another object of mass M is connected to it with a rope.



The image below shows the free-body diagram of horizontal forces on the object of mass m.

Which of the following correctly describes the Newton's 3rd Law force paired with F_2?

A. The pull of mass m upwards on the earth.

B. The upward contact force on the mass m.

C. The tension force to the right on the mass m.

D. The friction force to the right on the surface.

An object is moving at constant velocity. Which of the following could be the free-body diagram representing the forces acting on the object?

A.

B.

C.

D.

A ball is released from rest and falls vertically for 3 seconds on Earth. Air resistance is negligible. What is the average speed of the ball during the motion?

A. $3\ m\,s^{-1}$

B. $10\ m\,s^{-1}$

C. $15\ m\,s^{-1}$

D. $30\ m\,s^{-1}$

A student throws a ball with an initial velocity in the horizontal direction. Air resistance is negligible. At $t = 2.0\,s$, the ball has travelled a distance x in the horizontal direction and a distance y in the vertical direction.

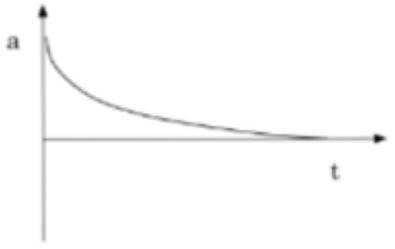
What are the horizontal and vertical distances covered at $t = 1.0\,s$, in terms of x and y?

	Horizontal distance	Vertical distance
A.	$\frac{x}{2}$	$\frac{y}{4}$
B.	$\frac{x}{2}$	$\frac{y}{2}$
C.	$\frac{x}{4}$	$\frac{y}{2}$
D.	$\frac{x}{4}$	$\frac{y}{4}$

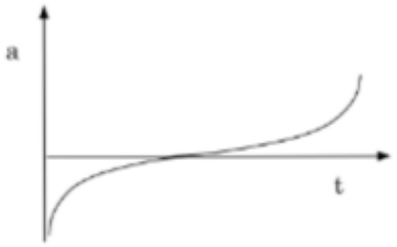
A cargo container is released from an airplane. A parachute is opened remotely a few seconds later to land it safely. Which graph shows the variation of the vertical acceleration with time t for the cargo container from when it leaves the plane until landing?

A.

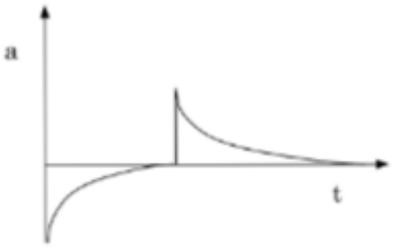
B.



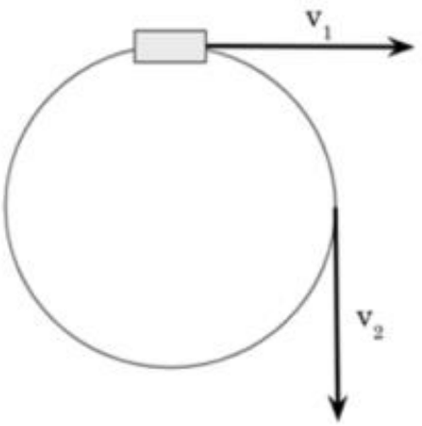
C.



D.



A car moves clockwise in a circular path as shown. The direction of its instantaneous velocity at two different times is shown in the diagram.



Which of the following vectors shows the direction of the change in velocity?

A.

B.

C.

D.

The mass and circumference of a standard volleyball are $270 \pm 10\,g$ and $66 \pm 1\,cm$ respectively. What is the percentage uncertainty in the density of the ball calculated from these values?

A. $(\frac{10}{270} + (3)(\frac{1}{66})) \times 100\%$

B. $(3)(\frac{1}{66}) \times 100\%$

C. $(\frac{10}{270} - (3)(\frac{1}{66})) \times 100\%$

D. $(\frac{10}{270} - (\frac{1}{3})(\frac{1}{66})) \times 100\%$

Which of the following is **not** a fundamental SI unit?

A. ampere

B. kelvin

C. newton

D. mole

Consider a nucleus of tritium ${}^{3}_{1}\mathrm{H}$ and nucleus X, which has double the diameter of tritium. Nucleus X contains and equal number of protons and neutrons. The tritium nucleus experiences an acceleration of a when placed in an electric field.

What is the acceleration of nucleus X when placed in the same electric field?

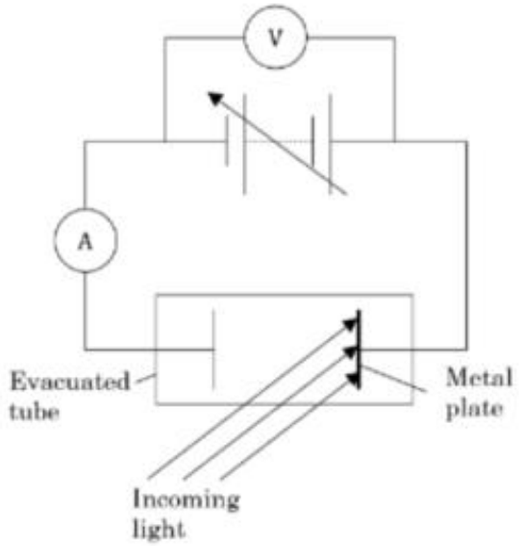
A. $\frac{1}{8}a$

B. $\frac{1}{2}a$

C. $\frac{2}{3}a$

D. $\frac{3}{2}a$

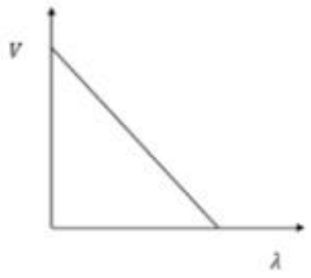
The diagram below shows the circuit used in an experiment to investigate the photoelectric effect.



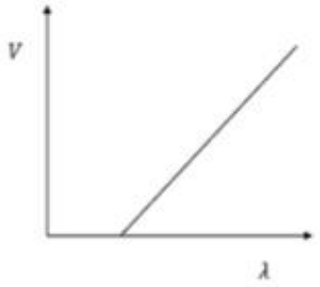
In the experiment, the wavelength λ of the incoming light is varied. For each wavelength the voltage is varied and the minimum voltage V required to bring the current in the circuit to zero is measured.

Which of the following graphs correctly shows the relation between V and λ?

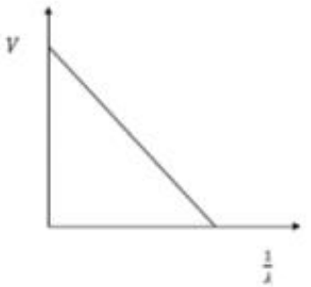
A.



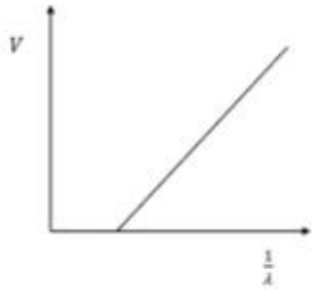
B.



C.



D.



A potential barrier has a width w. A proton with speed v has a certain probability of tunneling through the barrier. Below are three ways in which the situation can be changed.

I. Increasing v
II. Increasing w
III. Replacing the proton with a carbon atom of speed v

Which of these changes would result in a lower tunneling probability?

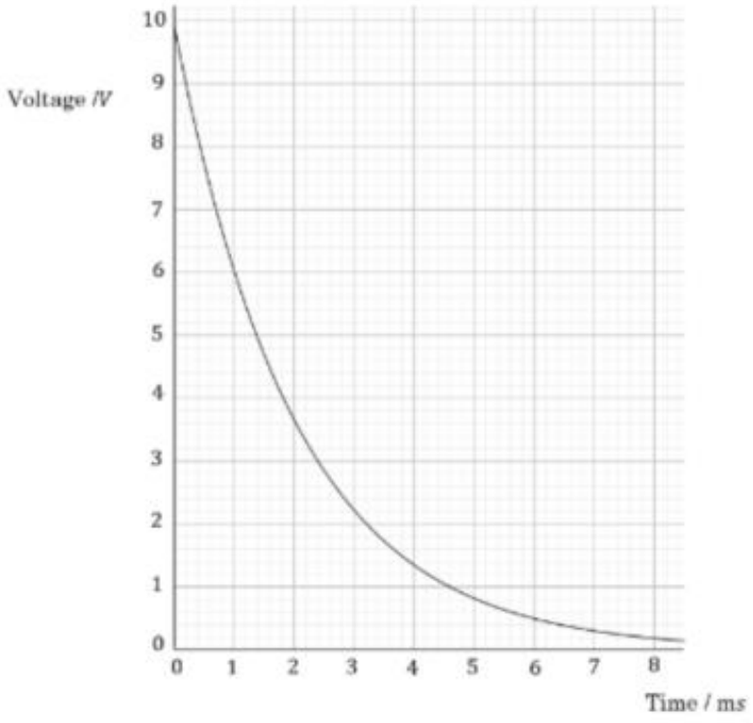
A. I and II only

B. I and III only

C. II and III only

D. I, II, and III

The graph below shows voltage against time for a capacitor of capacitance C discharging across a resistor.



What is the resistance of the resistor?

A. $\dfrac{1.4 \times 10^{-3}}{C}$

B. $\dfrac{2 \times 10^{-3}}{C}$

C. $(1.4 \times 10^{-3})C$

D. $(2 \times 10^{-3})C$

The number of turns in the secondary coil of a transformer is double the number of turns in the primary coil. In the primary coil, the maximum current is I. In the secondary coil the rms voltage is V.

What is the average power output of the transformer?

A. $\frac{\sqrt{2}IV}{4}$

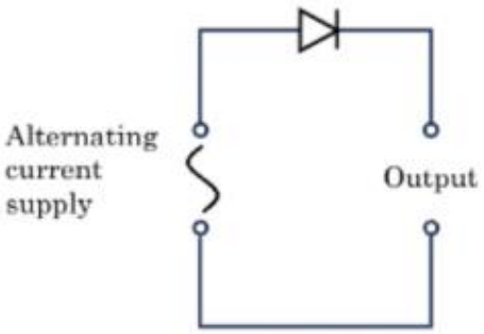
B. $\frac{IV}{2}$

C. $\frac{\sqrt{2}IV}{2}$

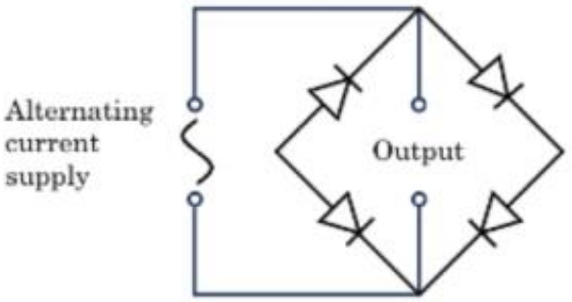
D. $\sqrt{2}IV$

For which of the following circuits will the output be a half-wave rectified current?

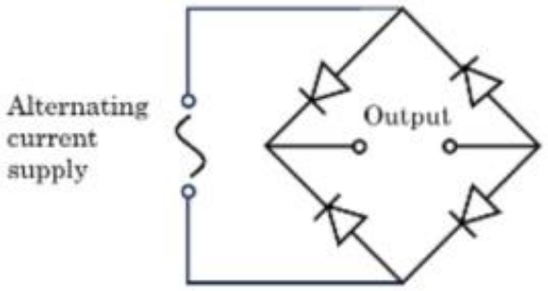
A.



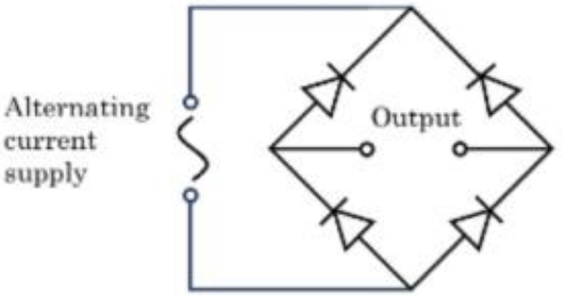
B.



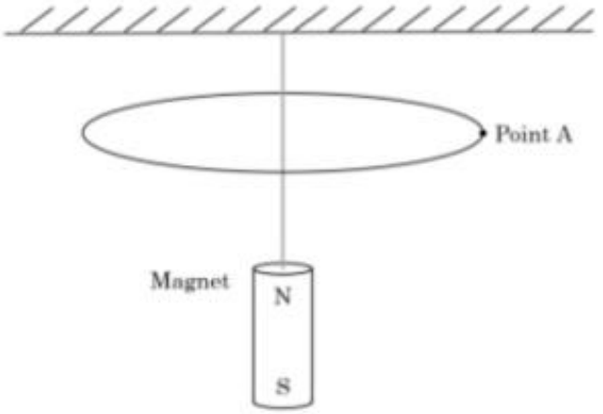
C.



D.



A magnet is suspended by string. A conducting ring is placed horizontally such that its center is directly above the magnet. Point A lies on the ring. This is illustrated below.



The ring is released from rest and does not rotate as it falls.

Which row correctly shows the position of the ring relative to the magnet and the direction of the current at point A when the emf in the ring is maximum?

	Position of the ring	**Direction of current at point A**
A.	Above the magnet	Into the page
B.	Above the magnet	Out of the page
C.	Below the magnet	Into the page
D.	Below the magnet	Out of the page

A rock of mass m has a weight W on the surface of a planet of radius r. What is the minimum speed at which the rock must be projected off the surface of the planet for it to completely escape the planet's gravitational field?

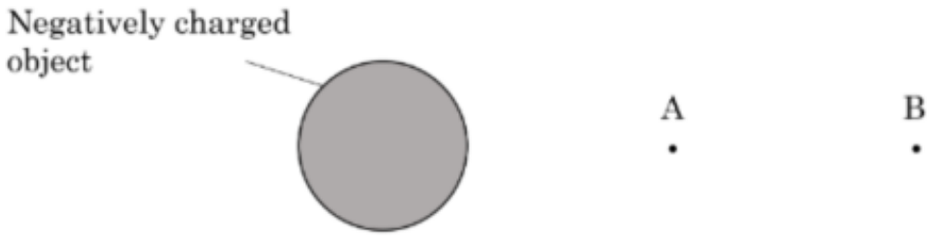
A. $\sqrt{Wr}$

B. $\sqrt{2Wr}$

C. $\sqrt{\frac{Wr}{m}}$

D. $\sqrt{\frac{2Wr}{m}}$

The diagram below shows a massive negatively charged object.



The magnitude of the gravitational potential difference between point A and B is ΔV_g and the magnitude of the electric potential difference between points A and B is ΔV_e.

What is the external work done moving a small object of mass m and charge $-q$ from point A to point B?

A. $-m\Delta V_g - q\Delta V_e$

B. $m\Delta V_g - q\Delta V_e$

C. $q\Delta V_e - m\Delta V_g$

D. $q\Delta V_e + m\Delta V_g$

A theory to describe observed changes in the pitch of fast-moving sources of sound was first developed in 1842. This same theory later played an important role in interpreting evidence for which of the following?

A. the equivalence of the electric and magnetic forces

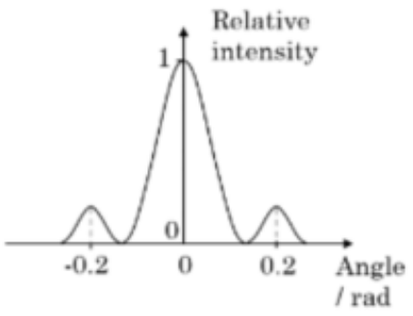
B. the particulate nature of light

C. the wave like nature of particles

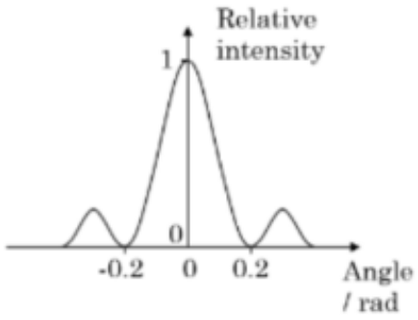
D. the expansion of the universe

Light of wavelength $500\,nm$ passes through a single slit of width $2.5\mu m$. Which of the following correctly shows the diffraction pattern for the light?

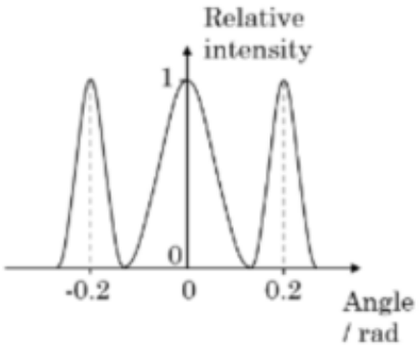
A.



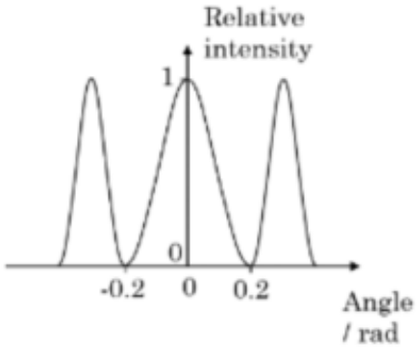
B.



C.



D.



A mass is placed on the end of a spring of natural length $5\,cm$ causing it to oscillate in simple harmonic motion with an angular frequency ω. The length of the spring when the speed of the mass is maximum is $15\,cm$.

What is ω? Assume $g = 10\,m\,s^{-2}$.

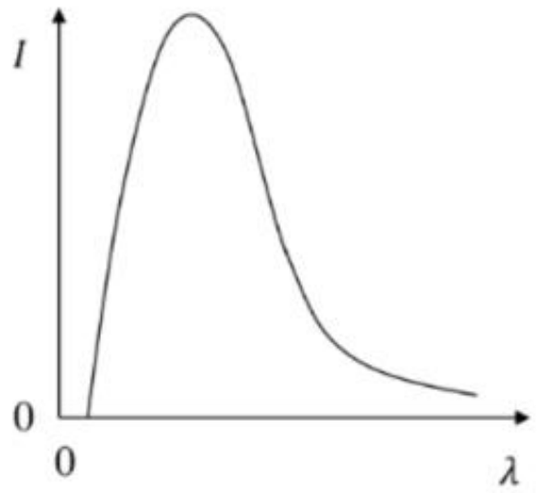
A. $\pi\,\text{rad}\,s^{-1}$

B. $5\,\text{rad}\,s^{-1}$

C. $2\pi\,\text{rad}\,s^{-1}$

D. $10\,\text{rad}\,s^{-1}$

The graph below shows wavelength against intensity for a black body.



How would the shape of the graph change if the surface of the black body were at a higher temperature?

A. Peak becomes lower and shifts to the left

B. Peak becomes lower and to shifts the right

C. Peak becomes higher and shifts to the left

D. Peak becomes higher and shifts to the right

What energy transfer is performed by a photovoltaic cell?

A. Electromagnetic to electrical

B. Electromagnetic to thermal

C. Chemical to electrical

D. Chemical to thermal

Wind turbine A has blades of length l and wind turbine B has blades of length $2l$. Wind turbine A has a useful power output P when the wind speed is v. Wind turbine B has a useful power output P when the wind speed is $\frac{v}{2}$.

What is $\frac{\text{efficiency of wind turbine } A}{\text{efficiency of wind turbine } B}$?

A. $\frac{1}{4}$

B. $\frac{1}{2}$

C. 1

D. 2

Below are three statements about the Rutherford-Geiger-Marsden experiment:

I. It provided evidence that the atom is mostly empty space
II. It provided evidence that atoms have a small positively charged center
III. It provided evidence that electrons exist in discrete energy levels

Which of the statements are correct?

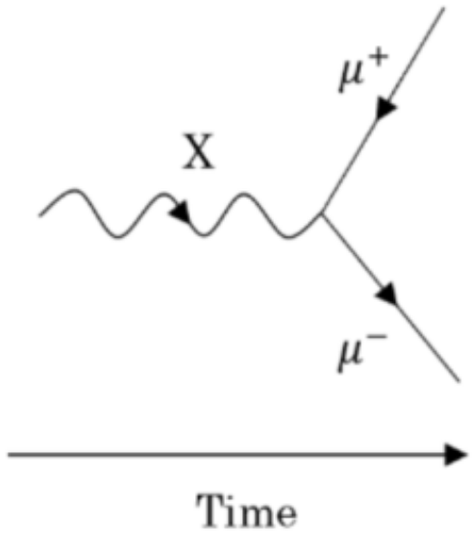
A. I and II only

B. I and III only

C. II and III only

D. I, II, and III

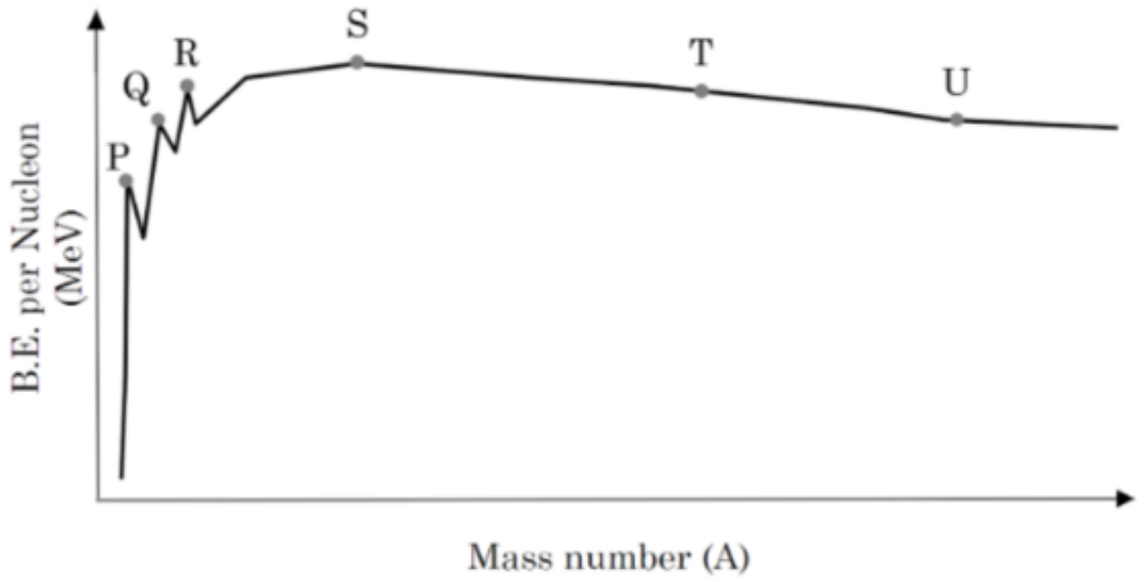
A Feynman diagram is shown below.



What is the name of this process and the name of the exchange particle X?

	Process	**Exchange particle**
A.	Annihilation	Photon
B.	Annihilation	W^+
C.	Pair production	Photon
D.	Pair production	W^+

The graph below shows a graph of binding energy per nucleon against mass number for some nuclei. Nuclei P, Q, R, S, T and U are labelled.



Which of the following nuclear reactions involving nuclei P, Q, R, S, T and U will result in the largest amount of energy released per reaction?

A. $P + Q \rightarrow R$

B. $R \rightarrow P + Q$

C. $S + T \rightarrow U$

D. $U \rightarrow S + T$

The total mass of small number of completely separated nucleons is m_1. All of the nucleons join together to form a nucleus of mass m_2.

Below are three statements.

I. m_1 is greater than m_2

.

II. The difference in energy between the nucleus and the separated nucleons is the difference of m_1 and m_2 multiplied by the speed of light squared

.

III. Energy is released when the nucleus is formed from the separated nucleons

A. I and II only

B. I and III only

C. II and III only

D. I, II, and III

An atom of ${}^{A}_{Z}\mathrm{X}$ follows a sequence of three decays: Beta plus, alpha, beta plus.

What is the number of neutrons in the final nucleus produced?

A. A

B. $A - Z$

C. $A - 4$

D. $A - Z - 4$

Planet Y has a mass three times greater than planet X. The gravitational field strength at the surface planet Y is six times greater than the gravitational field strength on planet X. The radius of planet X is r. What is the radius of planet Y?

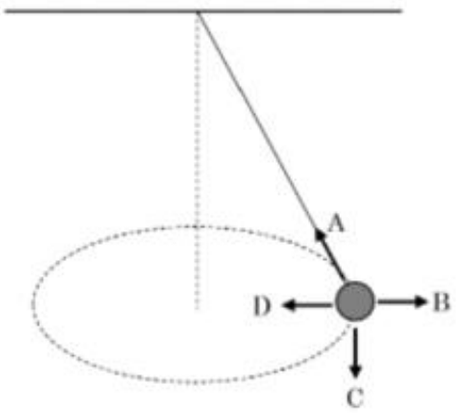
A. $\frac{r}{2}$

B. $\frac{r}{\sqrt{2}}$

C. r

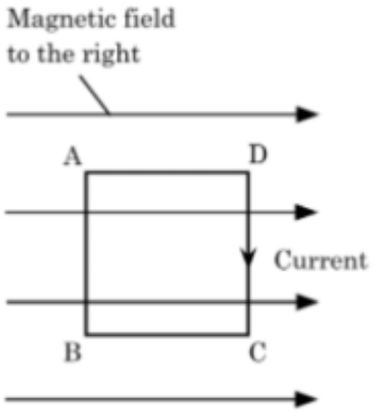
D. $r\sqrt{2}$

The diagram below shows an object attached to a light inextensible string. The object is travelling in a horizontal circle at a constant speed.



What is the direction of the resultant force acting on the object?

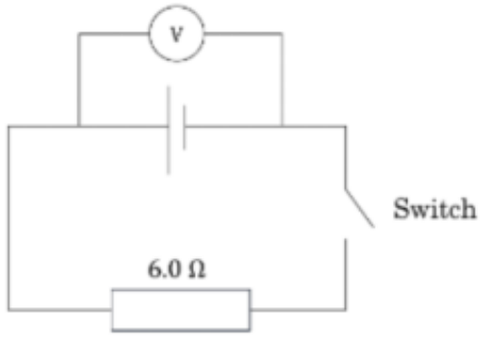
The diagram below shows a square coil ABCD in a magnetic field. The plane of the coil is parallel to a magnetic field of magnetic flux density $1\,mT$. The area of the coil is $25\,cm^2$. A clockwise current of $1\,A$ flows through the coil.



What is the magnitude and direction of the force acting on side AB?

	Magnitude of force / N	**Direction of force on AB**
A.	2.5×10^{-6}	Into the page
B.	2.5×10^{-6}	Out of the page
C.	5×10^{-5}	Into the page
D.	5×10^{-5}	Out of the page

The diagram below shows a circuit containing a cell, a voltmeter, a 6.0 Ω resistor and an open switch.



The reading on the voltmeter decreases by 20% when the switch is closed. What is the internal resistance of the cell?

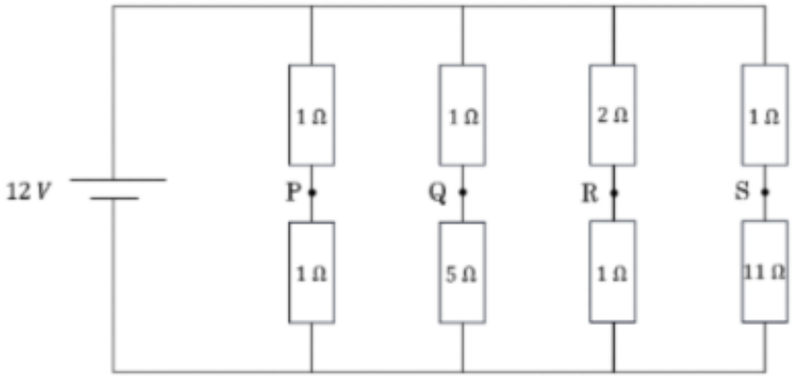
A. 1.2 Ω

B. 1.5 Ω

C. 4.5 Ω

D. 4.8 Ω

The diagram shows a circuit containing eight resistors connected to a cell of emf 12 V and negligible internal resistance.



A voltmeter is connected between two points in the circuit. Which of the following connections will result in a potential difference reading of the largest magnitude?

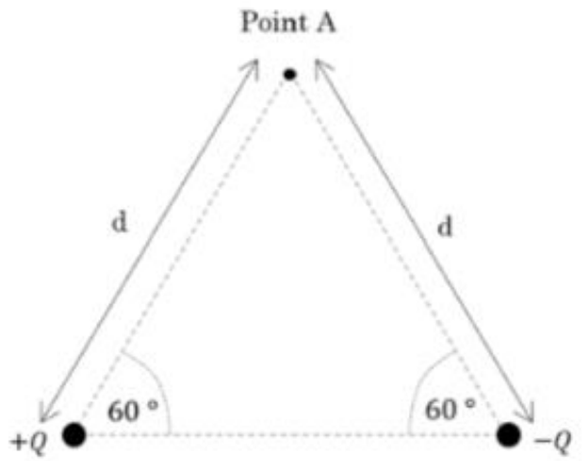
A. P to Q

B. Q to R

C. Q to S

D. R to S

Two charges are positioned as shown, each a distance d from point A.



What is the magnitude and direction of the electric field at point A due to the two charges?

	Magnitude	Direction
A.	$\frac{2kQ\cos(60^\circ)}{d^2}$	To the left
B.	$\frac{2kQ\cos(60^\circ)}{d^2}$	To the right
C.	$\frac{2kQ\sin(60^\circ)}{d^2}$	To the left
D.	$\frac{2kQ\sin(60^\circ)}{d^2}$	To the right

The shortest distance between a node and an antinode on a standing wave is $10\,cm$. The frequency of the wave is $100\,Hz$. What is the speed of the wave?

A. $2.5\,m\,s^{-1}$

B. $10\,m\,s^{-1}$

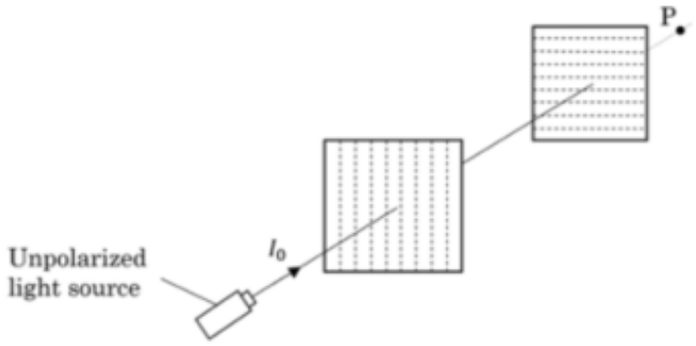
C. $20\,m\,s^{-1}$

D. $40\,m\,s^{-1}$

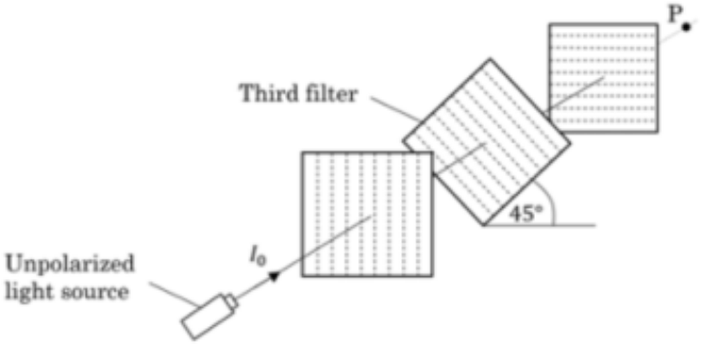
A microwave has a wavelength of 1 cm when it is traveling through a medium of refractive index 2.0. What is the nature of the wave and the number of oscillations per second?

	Nature of the wave	Number of oscillations per second
A.	Longitudinal	1.5×10^{10}
B.	Longitudinal	6.0×10^{10}
C.	Transverse	1.5×10^{10}
D.	Transverse	6.0×10^{10}

Point P lies directly in front of an unpolarized light source of intensity I_0. Two polarizing filters are placed between the light source and point P. The polarizing filters are placed perpendicular to each other such that no light is detected at point P. This is illustrated below.



A third (middle) polarizing filter is now placed between the two filters at an angle of 45° to them both. This is illustrated below.



Which of the following is correct for when the middle filter is introduced? $\left(\cos(45^\circ) = \frac{\sqrt{2}}{2}\right)$

A. The intensity of light at point P remains at zero.

B. The intensity of light at point P increases to $\frac{I_0}{8}$.

C. The intensity of light at point P increases to $\frac{I_0}{4}$.

D. The intensity of light at point P increases to $\frac{\sqrt{2}I_0}{4}$.

Below are three statements about a mass spring system moving in simple harmonic motion

I. When the velocity of the mass is maximum its acceleration is zero.
II. The velocity of the mass is inversely proportional to its displacement from the equilibrium position.
III. The acceleration of the mass is always directed towards a fixed point.

Which of the statements are correct?

A. I and II only

B. I and III only

C. II and III only

D. I, II, and III

A box of volume V contains n moles of an ideal gas. A student varies the temperature of the gas and measures how the pressure inside the box varies.

The student plots the results on a graph with pressure in Pa against temperature in $^{\circ}C$. The student then draws a line of best fit extrapolating the data until the line crosses the temperature axis.

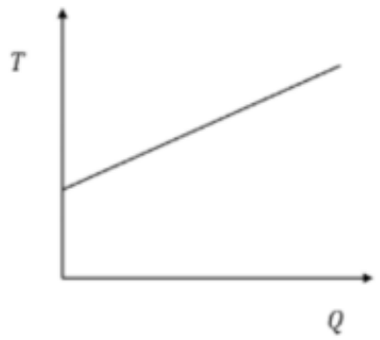
Which row correctly shows the gradient and temperature axis intercept of the graph?

	Gradient	**Temperature Axis Intercept / $^{\circ}C$**
A.	$\frac{nR}{V}$	-273
B.	$\frac{nR}{V}$	0
C.	$\frac{V}{nR}$	-273
D.	$\frac{V}{nR}$	0

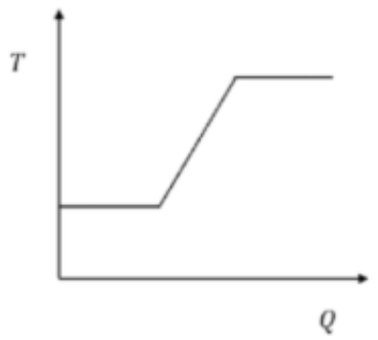
A substance is initially in solid form. Heat energy is added at a constant rate until the substance just reaches its boiling point.

Which graph correctly shows how the temperature of the substance T varies with heat energy added Q ?

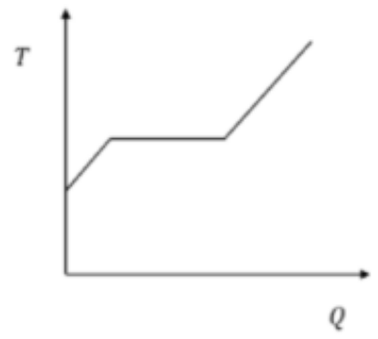
A.



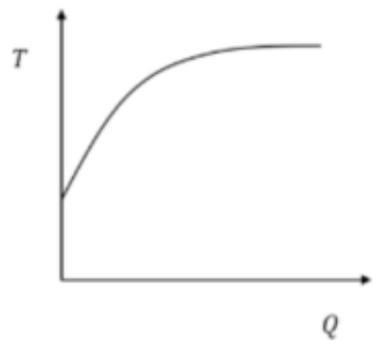
B.



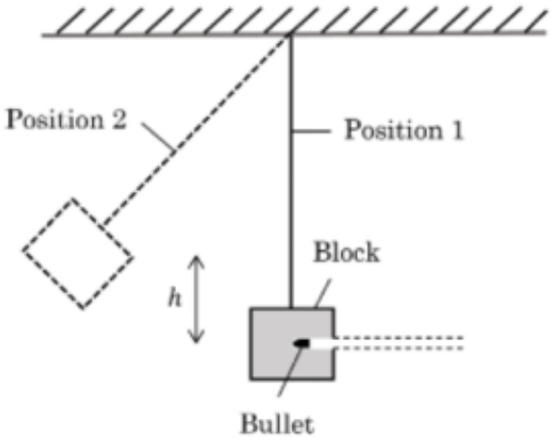
C.



D.



A bullet of mass m is fired horizontally at a speed v into a block of mass M. The block remains inside the bullet upon collision. The block is connected to a light inextensible string so that the collision of the bullet causes the block to move from position 1 to a maximum height at position 2 as shown in the diagram.



If air resistance is negligible, which of the following expressions is gives the value of h, the vertical distance moved by the center of mass?

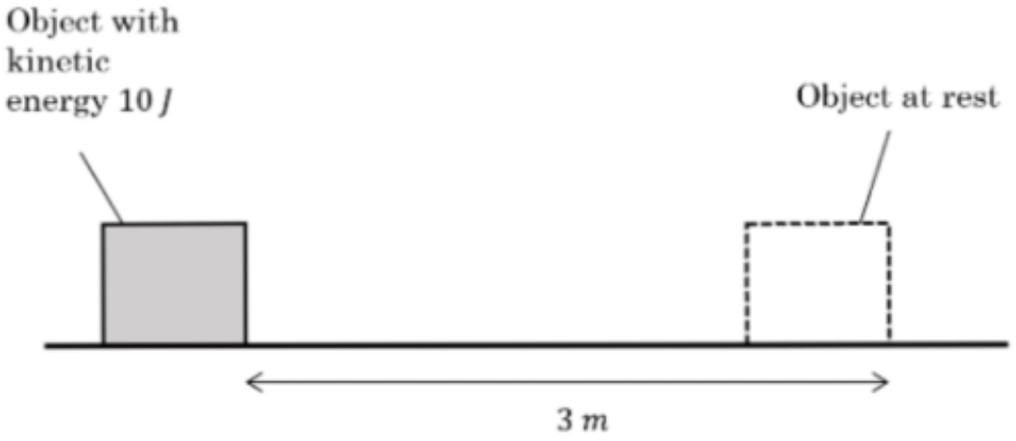
A. $\dfrac{mv^2}{2gM}$

B. $\dfrac{m^2v^2}{2gM^2}$

C. $\dfrac{mv^2}{2g(m+M)}$

D. $\dfrac{m^2v^2}{2g(m+M)^2}$

An object of mass $2\,kg$ with initial kinetic energy $10\,J$ comes to rest as it travels a distance of $3\,m$ along a flat horizontal rough surface as shown in the diagram below.



What is the coefficient of dynamic friction between the object and the surface?

A. $\frac{1}{6}$

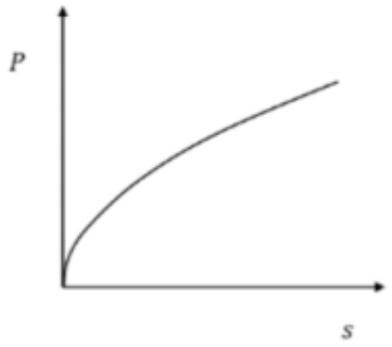
B. $\frac{1}{3}$

C. $\frac{1}{2}$

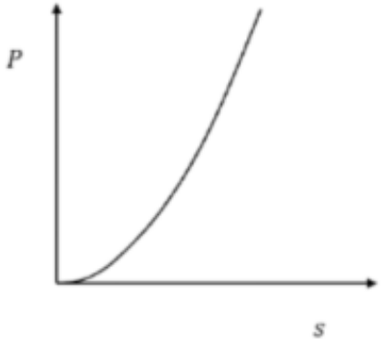
D. $\frac{2}{3}$

The engine of a car exerts a constant driving force as the car accelerates from rest along a straight horizontal road. Friction and air resistance are negligible. Which of the following graphs shows how the power of the engine P varies with distance traveled by the car s?

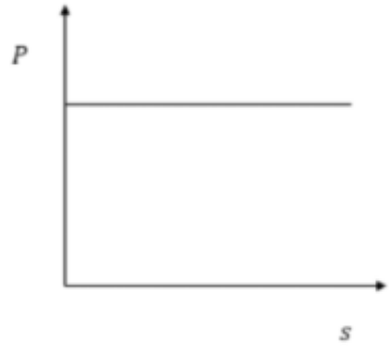
A.



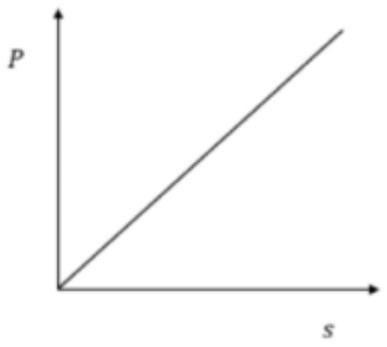
B.



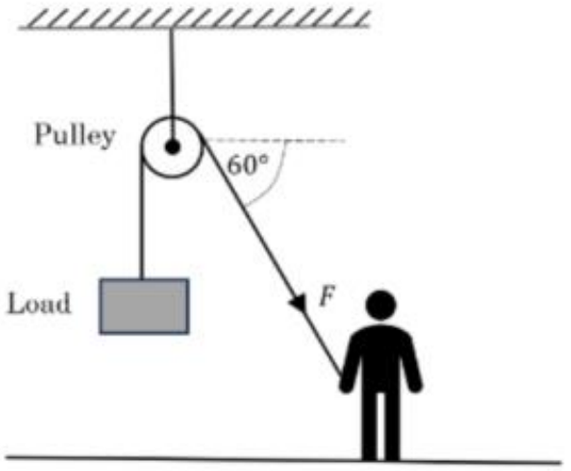
C.



D.



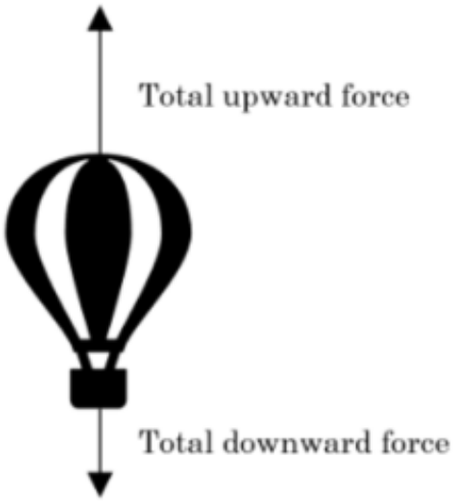
A person pulls a rope with a force F at an angle of 60° to the horizontal. The rope is connected to a load over a frictionless pulley as shown in the diagram below. The load is stationary.



Which of the following is correct about the weight of the load and the net force exerted on the pulley by the rope?

	Weight of the load	Net force exerted on the pulley by the rope
A.	Less than F	Less than $2F$
B.	Less than F	Equal to $2F$
C.	Equal to F	Less than $2F$
D.	Equal to F	Equal to $2F$

The diagram below shows the total upward and downward forces acting on a hot air balloon. The relative magnitudes of the forces are drawn to scale.



Below are three independent statements about the motion of the balloon.

I. The balloon is accelerating
II. The balloon is moving upwards
III. The balloon is moving downwards

Which of the statements could be true?

A. I and II only

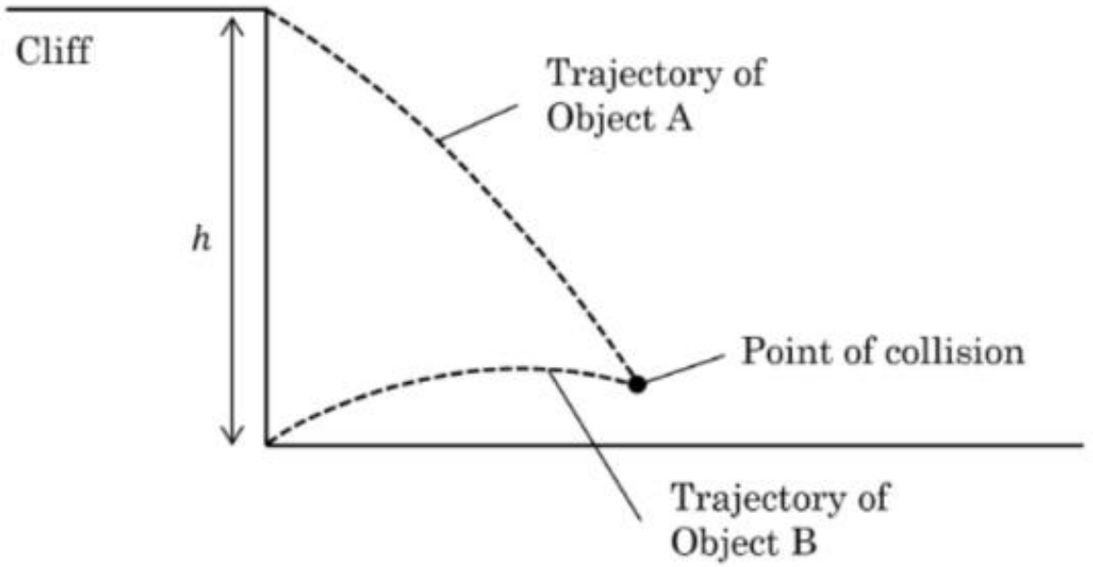
B. I and III only

C. II and III only

D. I, II and III

At time $T = 0$ object A is launched from the top of a cliff of height h at a velocity v and an angle of 30° below the horizontal. At the same time Object B is launched from the bottom of the cliff at an angle of 30° above the horizontal with the same velocity v. The objects collide at time $T = t$.

The trajectories of the objects are shown in the diagram below.



Air resistance is negligible. What is t?

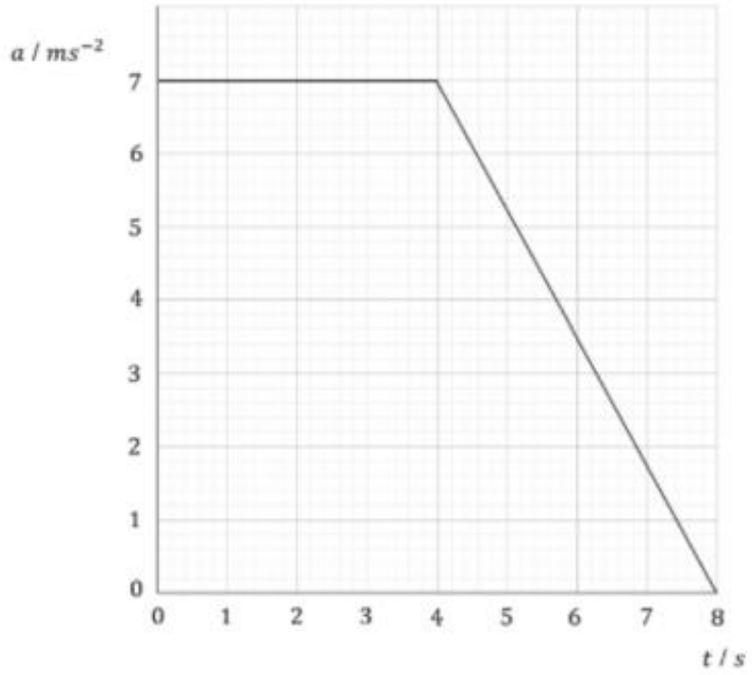
A. $t = \dfrac{h}{2v\ \cos(30^\circ)}$

B. $t = \dfrac{h}{2v\ \sin(30^\circ)}$

C. $t = \dfrac{h}{v\cos(30^\circ)}$

D. $t = \dfrac{h}{v\sin(30^\circ)}$

The graph below shows how the acceleration of an object a varies with time t.



What is the change in speed of the object?

A. $7.0\,m\,s^{-1}$

B. $28.0\,m\,s^{-1}$

C. $42.0\,m\,s^{-1}$

D. $56.0\,m\,s^{-1}$

Which of the following quantities has the same units as force per unit charge?

A. Electric current

B. Electric field strength

C. Electric potential difference

D. Electric potential energy