Diploma Programme
Programme du diplôme
Programa del Diploma

# Physics
# Higher level
# Paper 1

Thursday 28 April 2022 (morning)

1 hour

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**Instructions to candidates**

- Do not open this examination paper until instructed to do so.
- Answer all the questions.
- For each question, choose the answer you consider to be the best and indicate your choice on the answer sheet provided.
- A clean copy of the **physics data booklet** is required for this paper.
- The maximum mark for this examination paper is **[40 marks]**.

2222 – 6513

22 pages

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**1.** The radius of a circle is measured to be $(10.0 \pm 0.5)\,\text{cm}$. What is the area of the circle?

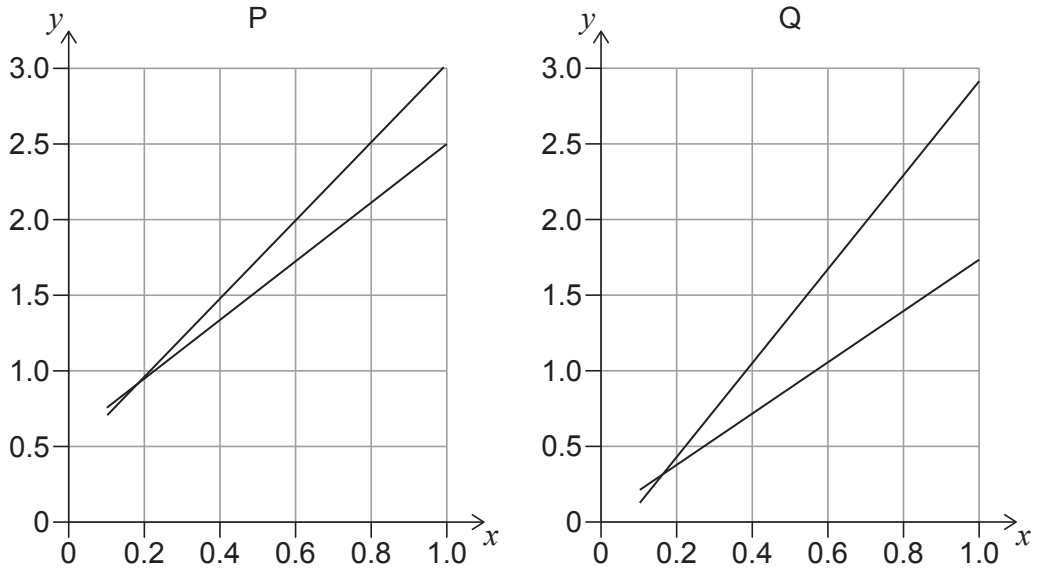
A. $(314.2 \pm 0.3)\,\text{cm}^2$

B. $(314 \pm 1)\,\text{cm}^2$

C. $(314 \pm 15)\,\text{cm}^2$

D. $(314 \pm 31)\,\text{cm}^2$

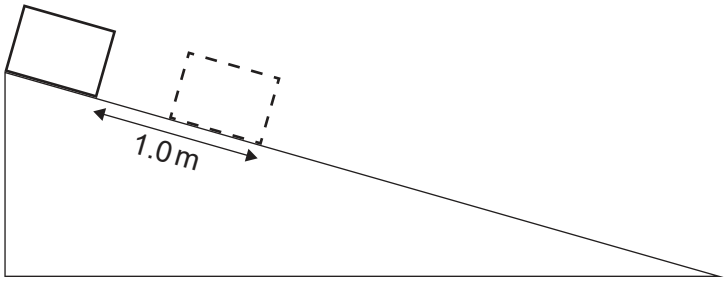
**2.** Two different experiments, P and Q, generate two sets of data to confirm the proportionality of variables $x$ and $y$. The graphs for the data from P and Q are shown. The maximum and minimum gradient lines are shown for both sets of data.




What is true about the systematic error and the uncertainty of the gradient when P is compared to Q?

| | **Systematic error** | **Uncertainty of the gradient** |
|---|---|---|
| A. | larger for set P | larger for set P |
| B. | larger for set Q | larger for set P |
| C. | larger for set P | larger for set Q |
| D. | larger for set Q | larger for set Q |

**3.** An object is sliding from rest down a frictionless inclined plane. The object slides 1.0 m during the first second.




What distance will the object slide during the next second?

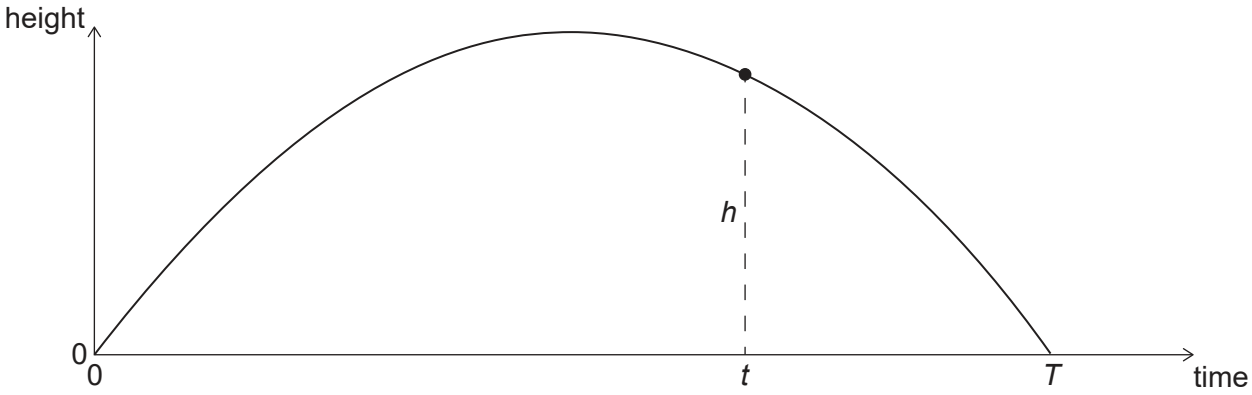
A. 1.0 m

B. 2.0 m

C. 3.0 m

D. 4.9 m

**4.** A ball is thrown upwards at time $t = 0$. The graph shows the variation with time of the height of the ball. The ball returns to the initial height at time $T$.




What is the height $h$ at time $t$?

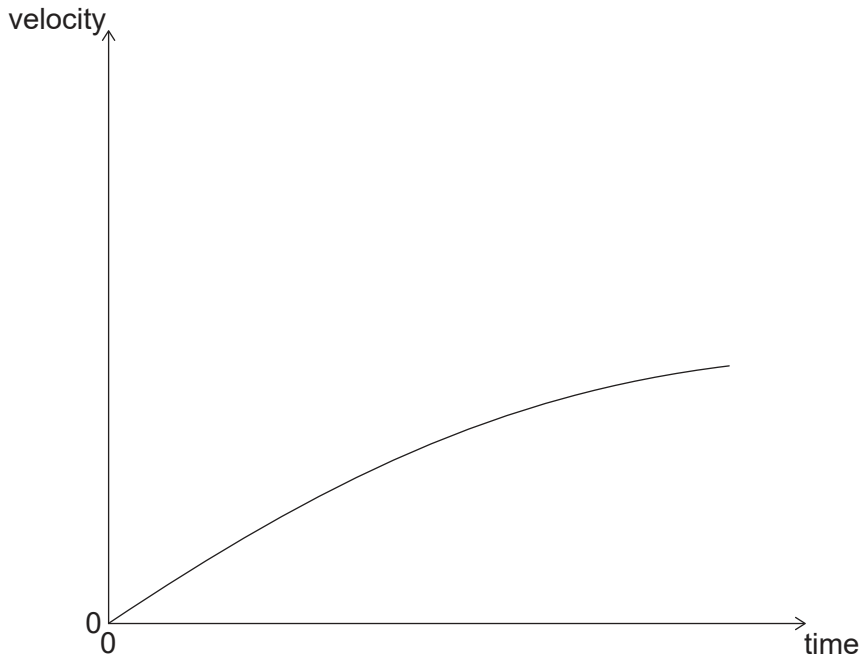
A. $\frac{1}{2}gt^2$

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

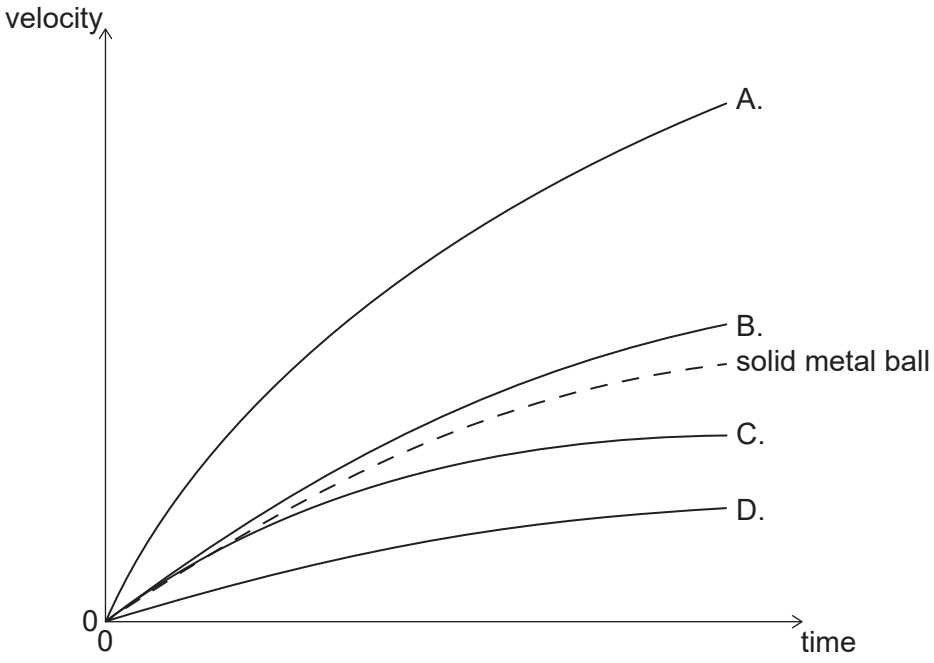
C. $\frac{1}{2}gT(T-t)$

D. $\frac{1}{2}gt(T-t)$

**5.** A solid metal ball is dropped from a tower. The variation with time of the velocity of the ball is plotted.




A hollow metal ball with the same size and shape is dropped from the same tower. What graph will represent the variation with time of the velocity for the hollow metal ball?



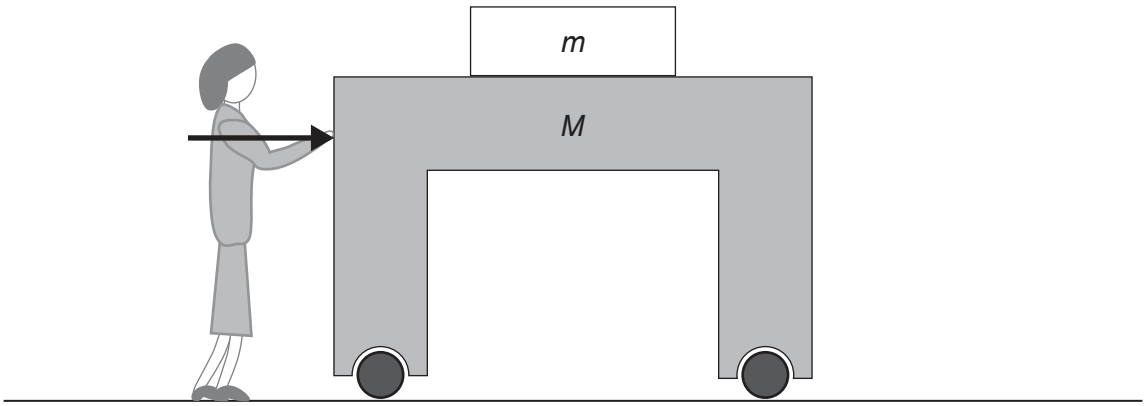
**6.** A rocket has just been launched vertically from Earth. The image shows the free-body diagram of the rocket. $F_1$ represents a larger force than $F_2$.


Which force pairs with $F_1$ and which force pairs with $F_2$, according to Newton's third law?

| | **Force pair with $F_1$** | **Force pair with $F_2$** |
|---|---|---|
| A. | force of rocket on exhaust gases | force of exhaust gases on rocket |
| B. | force of rocket on exhaust gases | gravitational force of rocket on Earth |
| C. | gravitational force of Earth on rocket | force of exhaust gases on rocket |
| D. | gravitational force of Earth on rocket | gravitational force of rocket on Earth |

**7.** A book of mass $m$ lies on top of a table of mass $M$ that rolls freely along the ground. The coefficient of friction between the book and the table is $\mu$. A person is pushing the rolling table.

What is the maximum acceleration of the table so that the book does not slide backwards relative to the table?




A. $\frac{g}{\mu}$

B. $\mu g$

C. $\frac{mg}{M\mu}$

D. $\frac{m}{M}\mu g$

**8.** Two blocks of different masses are released from identical springs of elastic constant $k = 100\,Nm^{-1}$, initially compressed a distance $\Delta x = 0.1\,m$. Block X has a mass of 1 kg and block Y has a mass of 0.25 kg.

What are the velocities of the blocks when they leave the springs?

| | Velocity of block X | Velocity of block Y |
|---|---|---|
| A. | $1.0\,ms^{-1}$ | $1.0\,ms^{-1}$ |
| B. | $2.0\,ms^{-1}$ | $1.0\,ms^{-1}$ |
| C. | $1.0\,ms^{-1}$ | $2.0\,ms^{-1}$ |
| D. | $2.0\,ms^{-1}$ | $2.0\,ms^{-1}$ |

**9.** What is true for an ideal gas?

A. $nRT = Nk_BT$

B. $nRT = k_BT$

C. $RT = Nk_BT$

D. $RT = k_BT$

**10.** Which assumption is part of the molecular kinetic model of ideal gases?

A. The work done on a system equals the change in kinetic energy of the system.

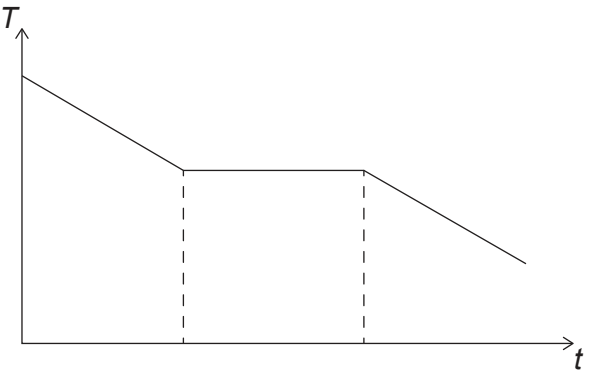
B. The volume of a gas results from adding the volume of the individual molecules.

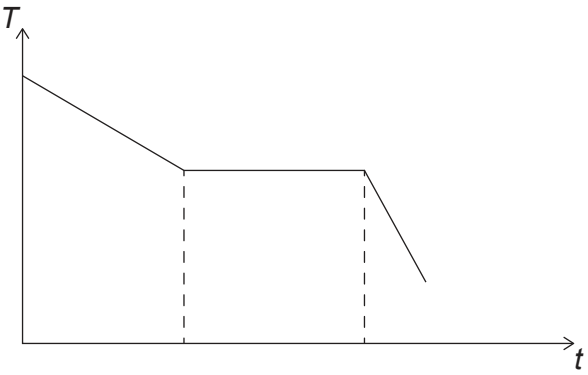
C. A gas is made up of tiny identical particles in constant random motion.

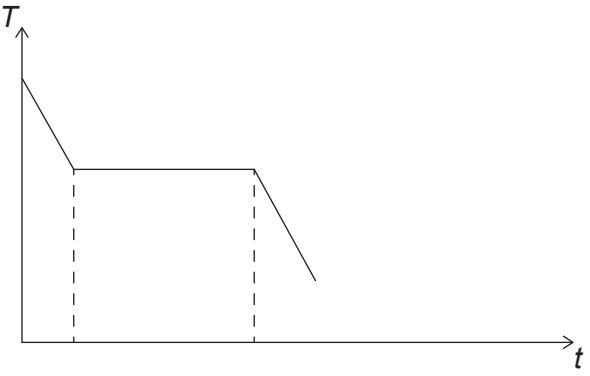
D. All particles in a gas have kinetic and potential energy.

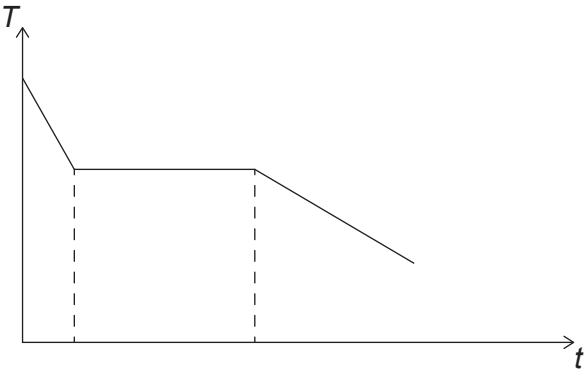
**11.** Water at room temperature is placed in a freezer. The specific heat capacity of water is twice the specific heat capacity of ice. Assume that thermal energy is transferred from the water at a constant rate.

Which graph shows the variation with time of the temperature of the water?

A. 


B. 


C. 


D. 


**12.** A particle undergoes simple harmonic motion. Which quantities of the motion can be simultaneously zero?

A. Displacement and velocity

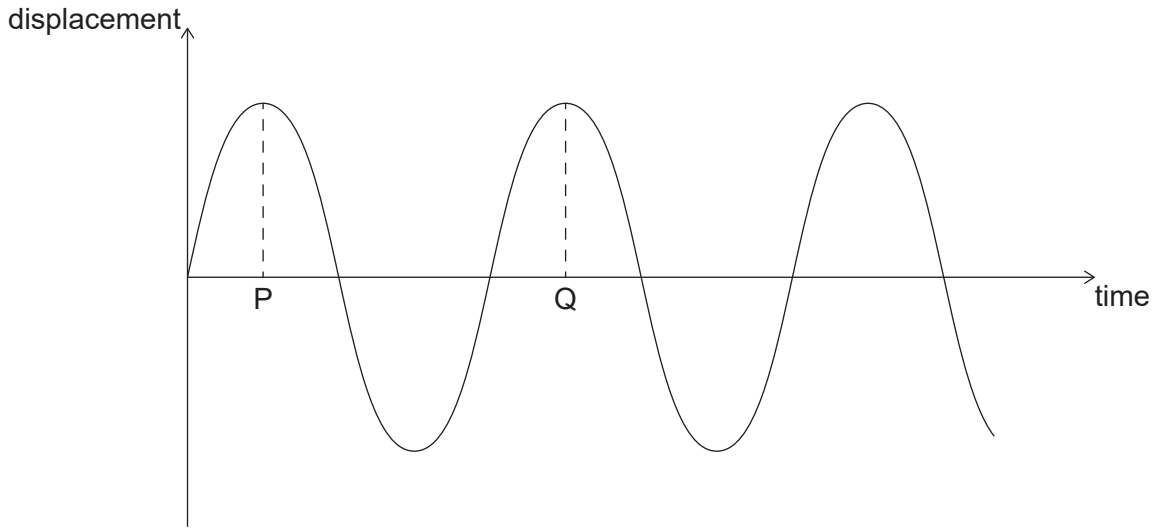
B. Displacement and acceleration

C. Velocity and acceleration

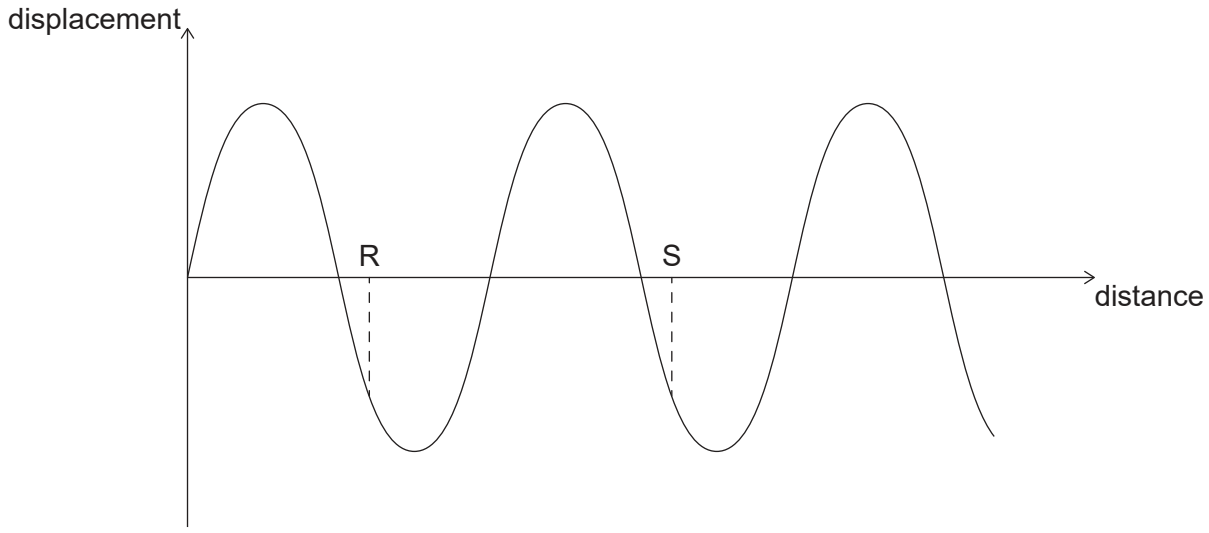
D. Displacement, velocity and acceleration

**13.** A wave travels along a string. Graph M shows the variation with time of the displacement of a point X on the string. Graph N shows the variation with distance of the displacement of the string. PQ and RS are marked on the graphs.

**Graph M**




**Graph N**




What is the speed of the wave?

A. $\frac{PQ}{RS}$

B. $PQ \times RS$

C. $\frac{RS}{PQ}$

D. $\frac{1}{PQ \times RS}$

**14.** The refractive index of glass is $\frac{3}{2}$ and the refractive index of water is $\frac{4}{3}$. What is the critical angle for light travelling from glass to water?

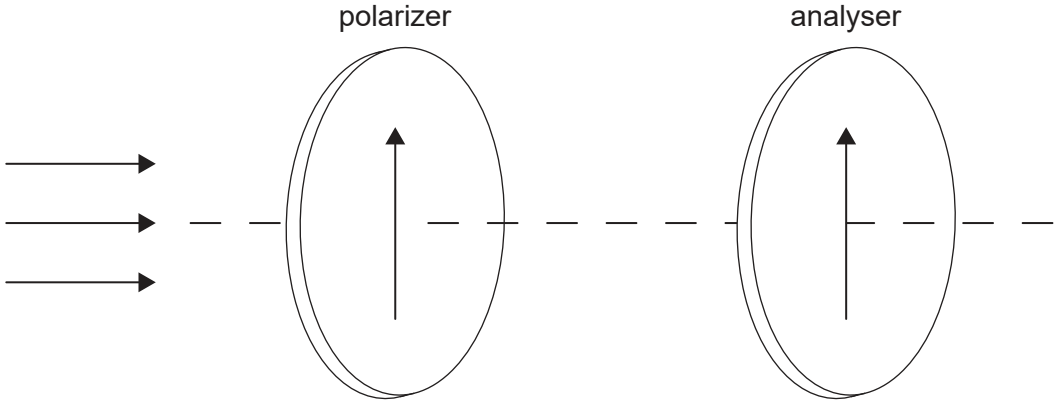
A. $\sin^{-1}\left(\frac{1}{2}\right)$

B. $\sin^{-1}\left(\frac{2}{3}\right)$

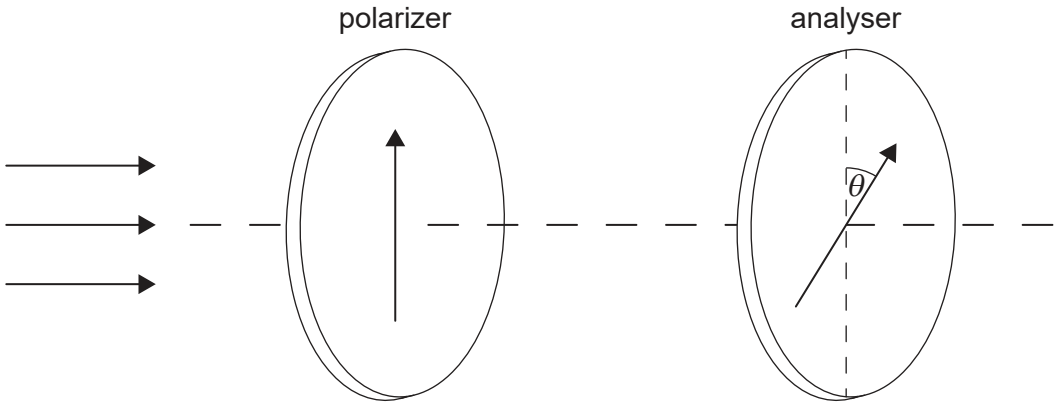
C. $\sin^{-1}\left(\frac{3}{4}\right)$

D. $\sin^{-1}\left(\frac{8}{9}\right)$

**15.** Unpolarized light with an intensity of $320\,\text{W}\,\text{m}^{-2}$ goes through a polarizer and an analyser, originally aligned parallel.




The analyser is rotated through an angle $\theta = 30°$. Cos $30° = \frac{\sqrt{3}}{2}$.

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**(Question 15 continued)**

What is the intensity of the light emerging from the analyser?

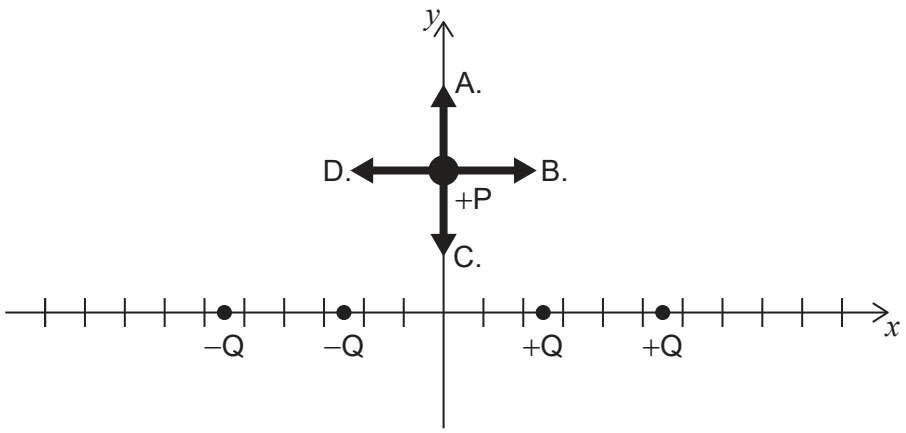
A. $120\,\mathrm{W\,m^{-2}}$

B. $80\sqrt{3}\,\mathrm{W\,m^{-2}}$

C. $240\,\mathrm{W\,m^{-2}}$

D. $160\sqrt{3}\,\mathrm{W\,m^{-2}}$

**16.** Four particles, two of charge +Q and two of charge –Q, are positioned on the $x$-axis as shown. A particle P with a positive charge is placed on the $y$-axis. What is the direction of the net electrostatic force on this particle?

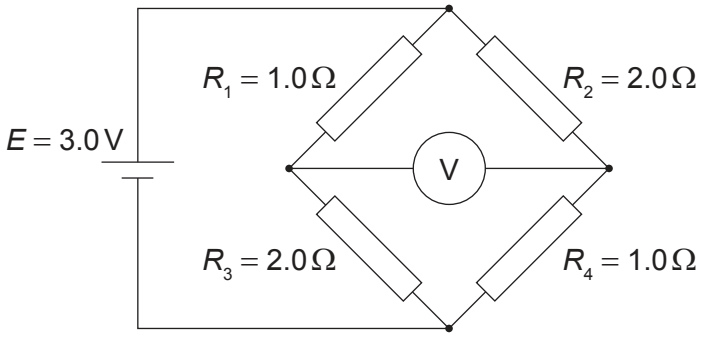



**17.** A battery of negligible internal resistance is connected to a lamp. A second identical lamp is added in series. What is the change in potential difference across the first lamp and what is the change in the output power of the battery?

| | Change in potential difference | Output power of battery |
|---|---|---|
| A. | decreases | decreases |
| B. | decreases | increases |
| C. | no change | decreases |
| D. | no change | increases |

**18.** A circuit consists of a cell of emf $E = 3.0\,\text{V}$ and four resistors connected as shown. Resistors $R_1$ and $R_4$ are $1.0\,\Omega$ and resistors $R_2$ and $R_3$ are $2.0\,\Omega$.

What is the voltmeter reading?



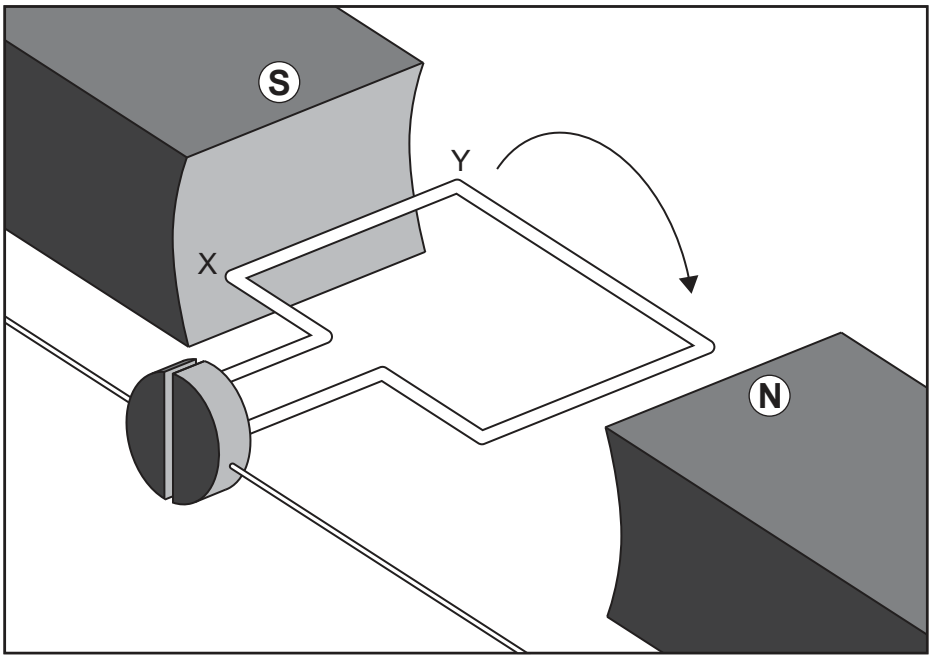

A. 0.50 V

B. 1.0 V

C. 1.5 V

D. 2.0 V

**19.** The coil of a direct current electric motor is turning with a period $T$. At $t = 0$ the coil is in the position shown in the diagram. Assume the magnetic field is uniform across the coil.




Which graph shows the variation with time of the force exerted on section XY of the coil during one complete turn?

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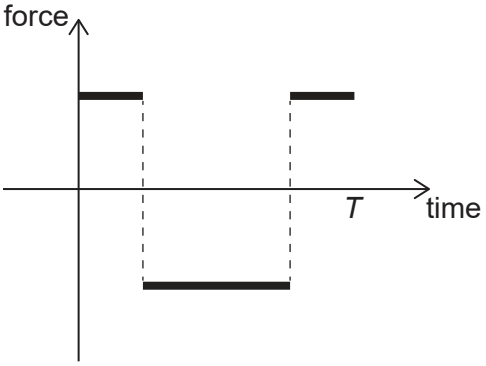
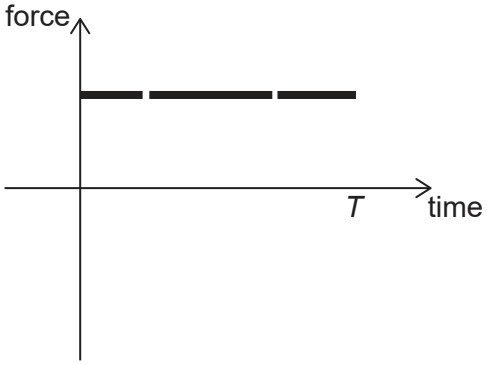
**(Question 19 continued)**

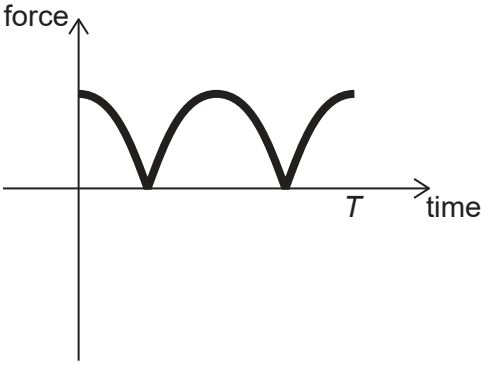
A.



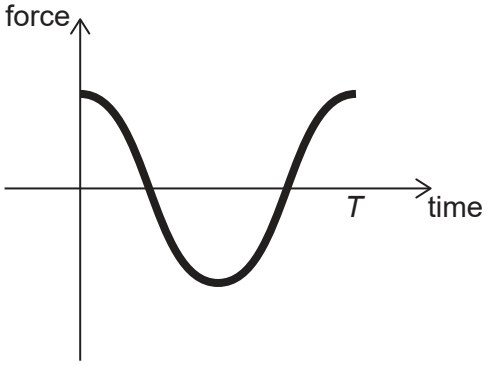

B.




C.




D.




**20.** A satellite is orbiting Earth in a circular path at constant speed. Three statements about the resultant force on the satellite are:

I. It is equal to the gravitational force of attraction on the satellite.

II. It is equal to the mass of the satellite multiplied by its acceleration.

III. It is equal to the centripetal force on the satellite.

Which combination of statements is correct?

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

**21.** An astronaut is orbiting Earth in a spaceship. Why does the astronaut experience weightlessness?

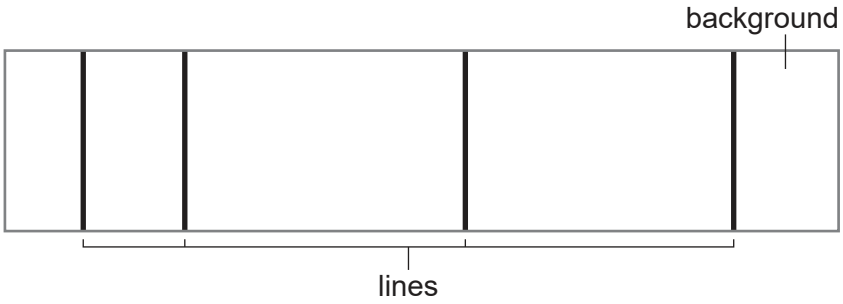
A. The astronaut is outside the gravitational field of Earth.

B. The acceleration of the astronaut is the same as the acceleration of the spaceship.

C. The spaceship is travelling at a high speed tangentially to the orbit.

D. The gravitational field is zero at that point.

**22.** White light is emitted from a hot filament. The light passes through hydrogen gas at low pressure and then through a diffraction grating onto a screen. A pattern of lines against a background appears on the screen.




What is the appearance of the lines and background on the screen?

| | Lines | Background |
|---|---|---|
| A. | dark | black |
| B. | white | coloured |
| C. | white | black |
| D. | dark | coloured |

**23.** Three statements about electrons are:

I. Electrons interact through virtual photons.

II. Electrons interact through gluons.

III. Electrons interact through particles W and Z.

Which statements identify the particles mediating the forces experienced by electrons?

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

**24.** A neutron is absorbed by a nucleus of uranium-235($^{235}_{92}$U). One possible outcome is the production of two nuclides, barium-144($^{144}_{56}$Ba) and krypton-89($^{89}_{36}$Kr).

How many neutrons are released in this reaction?

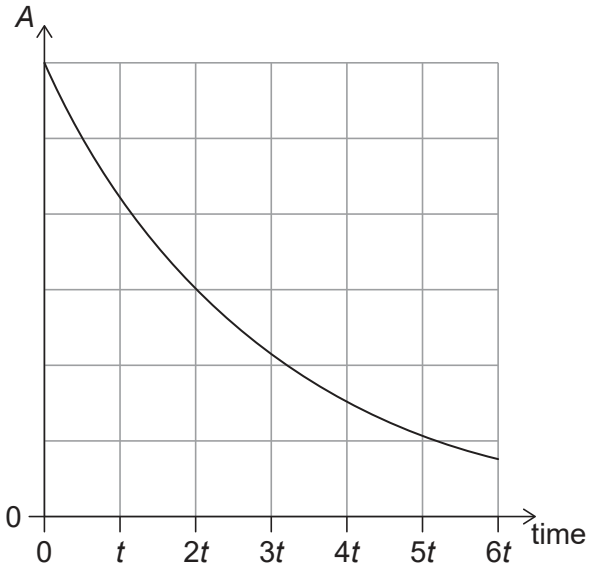
A. 0

B. 1

C. 2

D. 3

**25.** A radioactive nuclide X decays into a nuclide Y. The graph shows the variation with time of the activity *A* of X. X and Y have the same nucleon number.




What is true about nuclide X?

A. alpha ($\alpha$) emitter with a half-life of *t*

B. alpha ($\alpha$) emitter with a half-life of 2*t*

C. beta-minus ($\beta^-$) emitter with a half-life of *t*

D. beta-minus ($\beta^-$) emitter with a half-life of 2*t*

**26.** Photovoltaic cells and solar heating panels are used to transfer the electromagnetic energy of the Sun's rays into other forms of energy. What is the form of energy into which solar energy is transferred in photovoltaic cells and solar heating panels?

| | **Photovoltaic cells** | **Solar heating panels** |
|---|---|---|
| A. | electrical energy | thermal energy |
| B. | thermal energy | thermal energy |
| C. | electrical energy | electrical energy |
| D. | thermal energy | electrical energy |

**27.** Three statements about fossil fuels are:

I. There is a finite amount of fossil fuels on Earth.

II. The transfer of energy from fossil fuels increases the concentration of $CO_2$ in the atmosphere.

III. The geographic distribution of fossil fuels is uneven and has led to economic inequalities.

Which statements justify the development of alternative energy sources?

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

**28.** The age of the Earth is about $4.5 \times 10^9$ years.

What area of physics provides experimental evidence for this conclusion?

A. Newtonian mechanics

B. Optics

C. Radioactivity

D. Electromagnetism

**29.** A simple pendulum has a time period $T$ on the Earth. The pendulum is taken to the Moon where the gravitational field strength is $\frac{1}{6}$ that of the Earth.

What is the time period of the pendulum on the Moon?

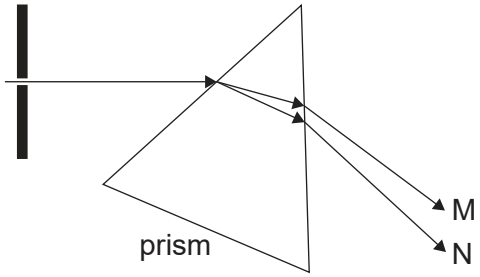
A. $T\sqrt{6}$

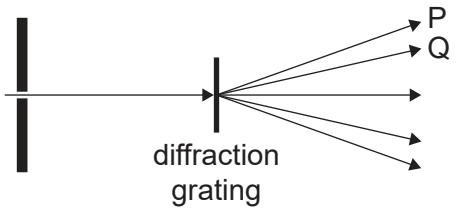
B. $T$

C. $\frac{\sqrt{6}}{6}T$

D. $\frac{T}{6}$

**30.** In two different experiments, white light is passed through a single slit and then is either refracted through a prism or diffracted with a diffraction grating. The prism produces a band of colours from M to N. The diffraction grating produces a first order spectrum P to Q.




What are the colours observed at M and P?

| | M | P |
|---|---|---|
| A. | red | red |
| B. | red | violet |
| C. | violet | red |
| D. | violet | violet |

**31.** A train is sounding its whistle when approaching a train station. Three statements about the sound received by a stationary observer at the station are:

I. The frequency received is higher than the frequency emitted by the train.

II. The wavelength received is longer than the wavelength emitted by the train.

III. The speed of the sound received is not affected by the motion of the train.

Which combination of statements is correct?

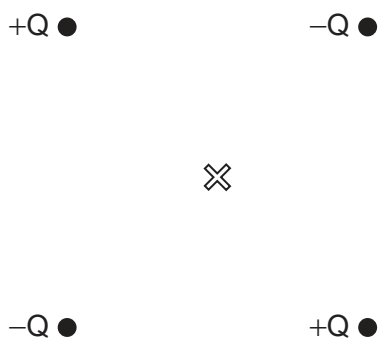
A. I and II only

B. I and III only

C. II and III only

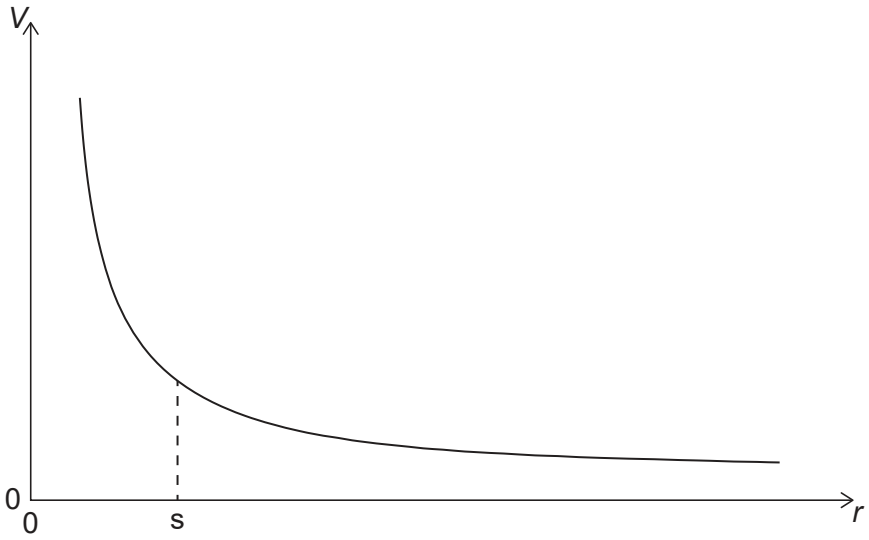
D. I, II and III

**32.** Two positive and two negative charges are located at the corners of a square as shown. Point X is the centre of the square. What is the value of the electric field $E$ and the electric potential $V$ at X due to the four charges?




| | **Electric field $E$ at X** | **Electric potential $V$ at X** |
|---|---|---|
| A. | $E = 0$ | $V = 0$ |
| B. | $E \neq 0$ | $V = 0$ |
| C. | $E = 0$ | $V \neq 0$ |
| D. | $E \neq 0$ | $V \neq 0$ |

**33.** The graph shows the variation with distance *r* of the electric potential *V* from a charge Q.




What is the electric field strength at distance s?

A. The area under the graph between s and infinity

B. The area under the graph between 0 and s

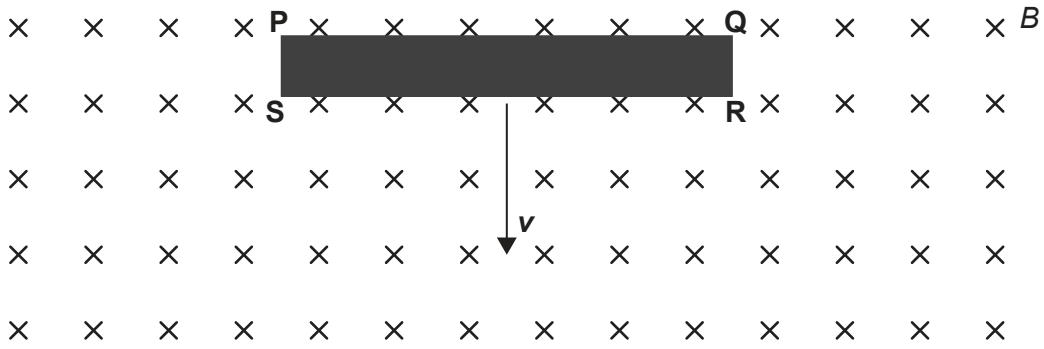
C. The gradient of the tangent at s

D. The negative of the gradient of the tangent at s

**34.** Which two features are necessary for the operation of a transformer?

| | **Feature one** | **Feature two** |
|---|---|---|
| A. | electrical connection between primary and secondary coils | input of alternating current |
| B. | magnetic interaction between primary and secondary coils | input of alternating current |
| C. | electrical connection between primary and secondary coils | input of direct current |
| D. | magnetic interaction between primary and secondary coils | input of direct current |

**35.** A conducting bar with vertices PQRS is moving vertically downwards with constant velocity $v$ through a horizontal magnetic field $B$ that is directed into the plane of the page.




Which side of the bar will have the greatest density of electrons?

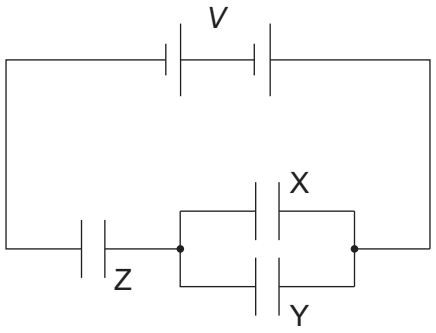
A. PQ

B. QR

C. RS

D. SP

**36.** A circuit consists of three identical capacitors of capacitance $C$ and a battery of voltage $V$. Two capacitors are connected in parallel with a third in series. The capacitors are fully charged.




What is the charge stored in capacitors X and Z?

| | Charge stored in capacitor Z | Charge stored in capacitor X |
|---|---|---|
| A. | $\frac{CV}{3}$ | $\frac{CV}{3}$ |
| B. | $\frac{CV}{3}$ | $\frac{2CV}{3}$ |
| C. | $\frac{2CV}{3}$ | $\frac{CV}{3}$ |
| D. | $\frac{2CV}{3}$ | $\frac{2CV}{3}$ |

**37.** Three correct statements about the behaviour of electrons are:

I. An electron beam is used to investigate the structure of crystals.

II. An electron beam produces a pattern of fringes when sent through two narrow parallel slits.

III. Electromagnetic radiation ejects electrons from the surface of a metal.

Which statements are explained using the wave-like properties of electrons?

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

**38.** Samples of two radioactive nuclides X and Y are held in a container. The number of particles of X is half the number of particles of Y. The half-life of X is twice the half-life of Y.

What is the initial value of $\frac{\text{activity of radioisotope X}}{\text{activity of radioisotope Y}}$?

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

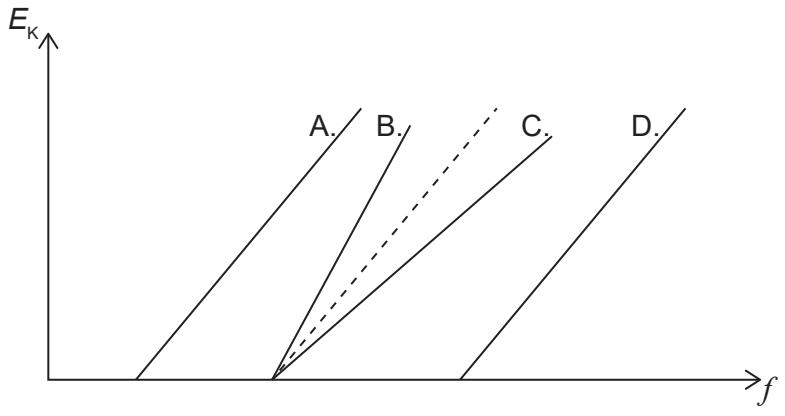
B. $\frac{1}{2}$

C. 1

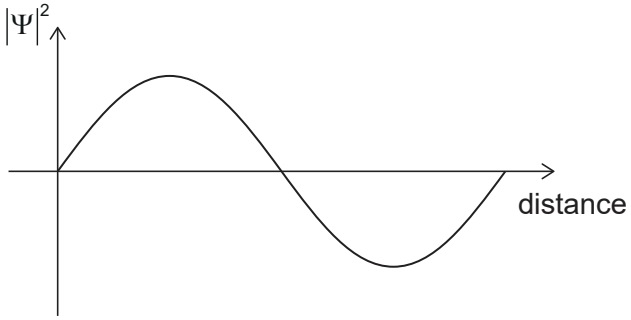
D. 4

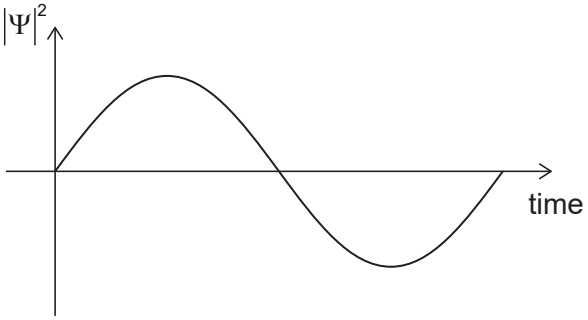
**39.** The dashed line represents the variation with incident electromagnetic frequency $f$ of the kinetic energy $E_K$ of the photoelectrons ejected from a metal surface. The metal surface is then replaced with one that requires less energy to remove an electron from the surface.

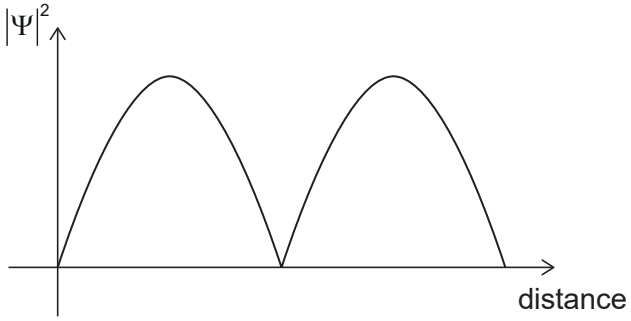
Which graph of the variation of $E_K$ with $f$ will be observed?

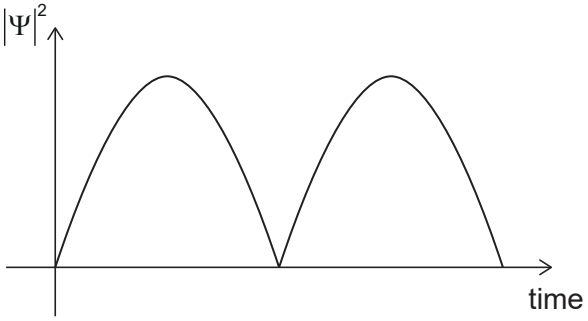


**40.** Which graph shows a possible probability density function $|\Psi|^2 = \frac{P(r)}{\Delta V}$ for a given wave function $\Psi$ of an electron?

A. 


B. 


C. 


D. 


**References:**