Diploma Programme
Programme du diplôme
Programa del Diploma

Physics
Standard level
Paper 1

25 April 2024

Zone A afternoon | **Zone B** afternoon | **Zone C** afternoon

45 minutes

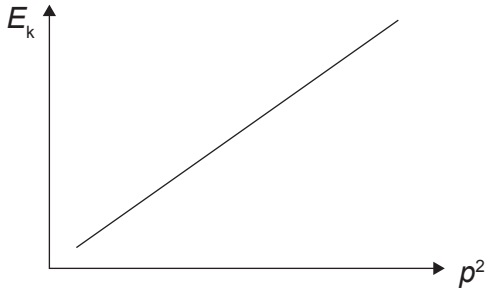
Instructions to candidates

- 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 **[30 marks]**.

2224 – 6710

22 pages

1. The graph shows the variation of kinetic energy E_k with momentum squared p^2.



What are the fundamental SI units for the gradient of the graph?

A. kg^{-1}

B. kg

C. $J m^2 s^{-2}$

D. $J m s^{-1}$

2. A cart accelerates from $(20 \pm 1)\,m\,s^{-1}$ to $(30 \pm 1)\,m\,s^{-1}$.

What is the percentage uncertainty in the change of speed of the cart?

A. 2 %

B. 4 %

C. 8 %

D. 20 %

3. Jim runs with a constant velocity *v* past Sally who is at rest. At this instant, Sally begins to chase Jim with constant acceleration *a*.

Which expression gives the time Sally will catch Jim?

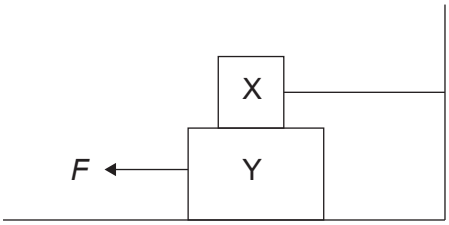
A. $\frac{v}{2a}$

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

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

D. $\frac{4v}{a}$

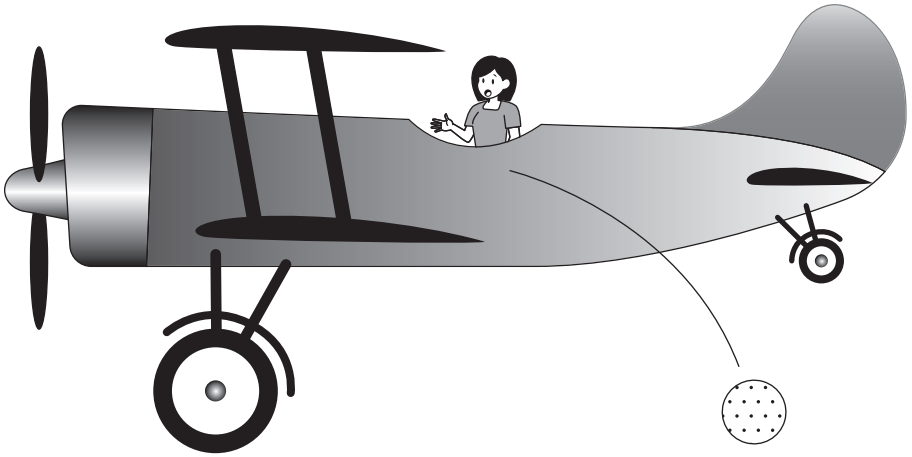
4. A block X of weight 10 N is stacked on a block Y of weight 20 N. Block X is fixed to a wall with a light string. The coefficients of static friction between the blocks and between block Y and the ground are both 0.2.



What is the value of the minimum force *F* required to move block Y and what is the tension *T* in the string immediately before block Y begins to move?

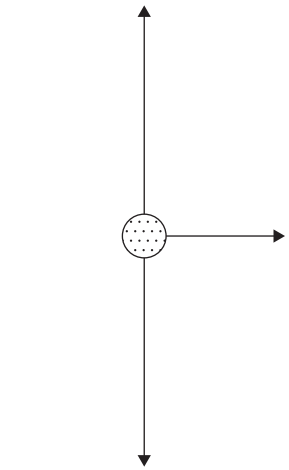
	Minimum force *F* / N	**Tension in string *T* / N**
A.	8	2
B.	8	6
C.	6	2
D.	6	6

5. A ball is thrown from an aircraft in flight.



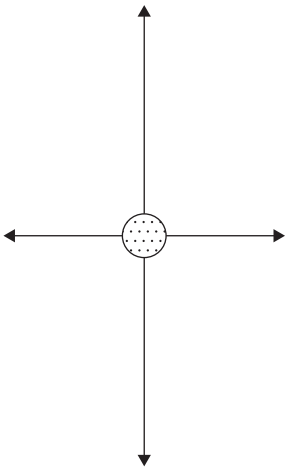
Which of the following shows the correct free-body diagram for the forces acting on the ball when terminal velocity is reached?

A.



B.

C.



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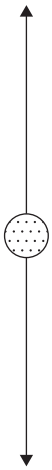
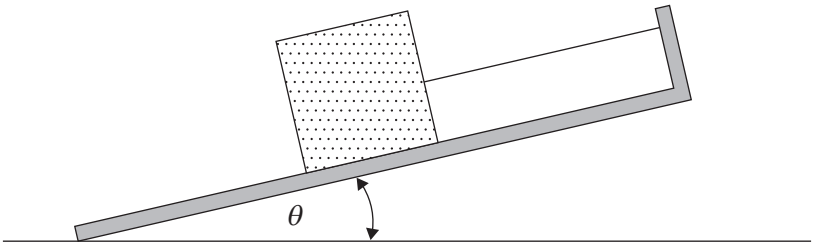


6. An object is held in position by a light string on an incline plane such that the angle θ to the horizontal is slowly increased from zero.



Which statement is **correct** about the forces acting on the object as the angle θ is increased?

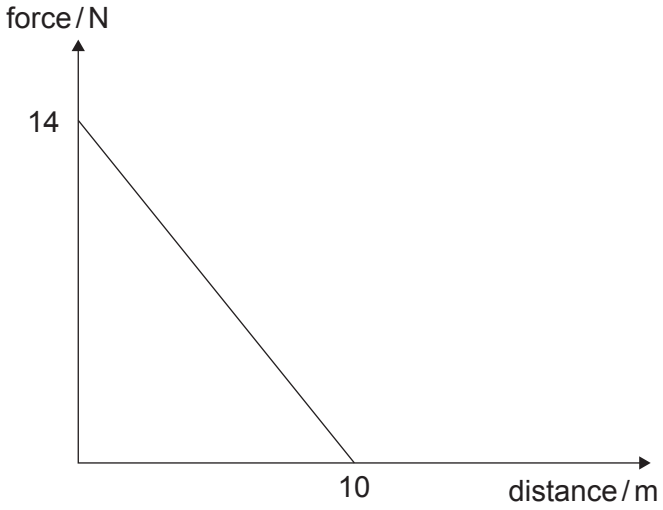
A. The tension in the string remains constant.

B. The normal force decreases.

C. The weight component parallel to the slope remains constant.

D. The weight decreases.

7. A mass of 4.0 kg moving with a velocity of $1.0\,m\,s^{-1}$ is acted on by a net force which varies with distance as shown.



What is the maximum speed of the mass?

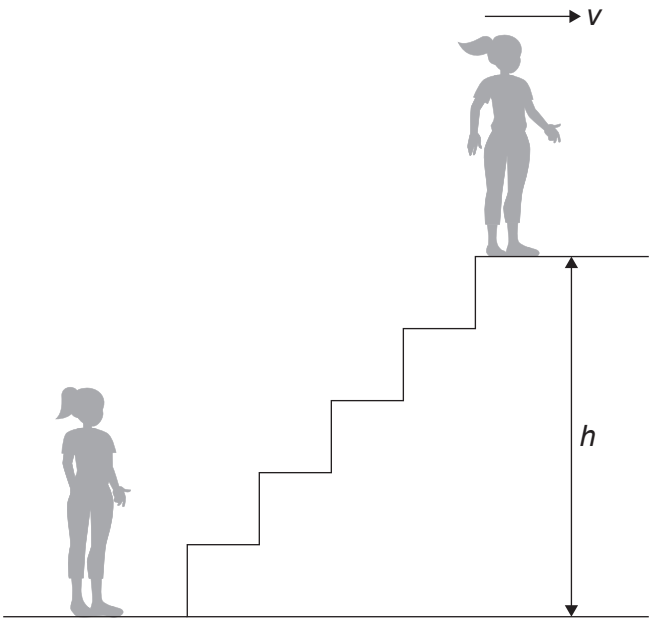
A. $\sqrt{35}\,m\,s^{-1}$

B. $6\,m\,s^{-1}$

C. $\sqrt{71}\,m\,s^{-1}$

D. $12\,m\,s^{-1}$

8. A student of mass m initially at rest takes t seconds to run up stairs of height h. At the top of the stairs the student has a velocity v.



What is the average power supplied by the student during the climb?

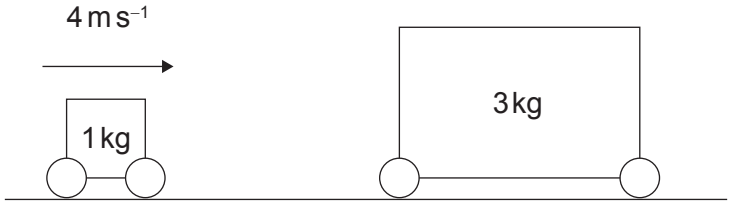
A. $\frac{mgh}{t}$

B. $\frac{m(gh+\frac{1}{2}v^2)}{t}$

C. $\frac{m(gh-\frac{1}{2}v^2)}{t}$

D. mgv

9. A cart of mass 1 kg moving at 4 m s^{-1} collides with a stationary cart of mass 3 kg.



After the collision the carts stick together.

What is $\frac{\text{kinetic energy after the collision}}{\text{kinetic energy before the collision}}$?

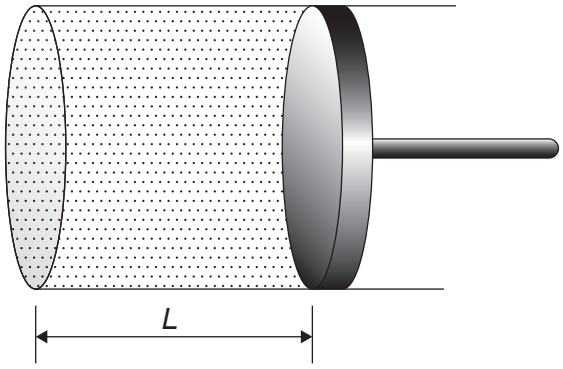
A. $\frac{1}{16}$

B. $\frac{1}{8}$

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

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

10. An ideal gas is sealed in a cylinder with a sliding piston. When the piston is a length L from the bottom of the cylinder the total force of the gas particles on the piston is F_{total} and the average force each individual particle imparts on the piston per collision is $F_{particle}$.

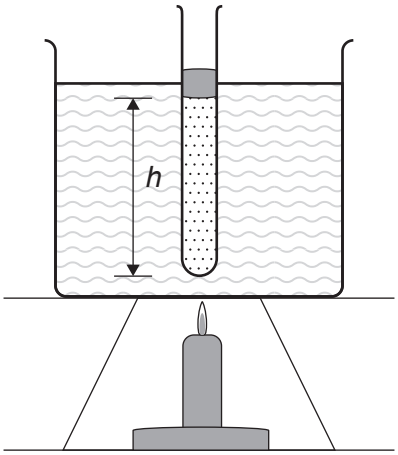


The piston length is slowly reduced to $\frac{L}{2}$ such that the temperature of the gas remains constant.

What is true about the change in F_{total} and the change in $F_{particle}$?

	Change in F_{total}	**Change in $F_{particle}$**
A.	Increase	No change
B.	Increase	Increase
C.	No change	No change
D.	No change	Increase

11. A layer of mercury traps a volume of gas in a tube. The tube is placed in a water bath and slowly heated. When the temperature of the water is 300 K the height of gas *h* in the tube is 150 mm.



What is *h* when the temperature of the water is 360 K?

A. 120 mm

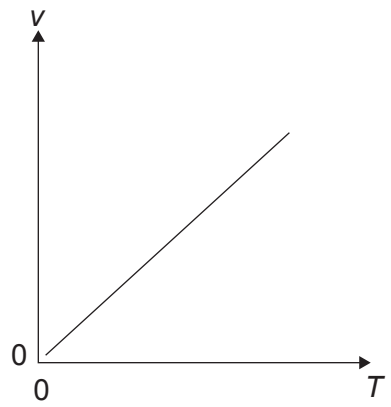
B. 180 mm

C. 300 mm

D. 360 mm

12. Which graph shows the variation of molecular speed v with absolute temperature T of an ideal gas?

A.



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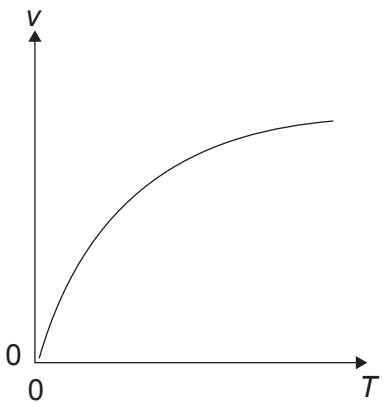
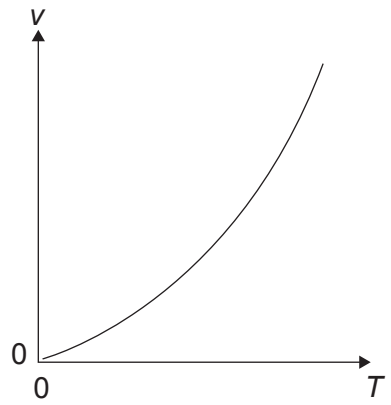


C.



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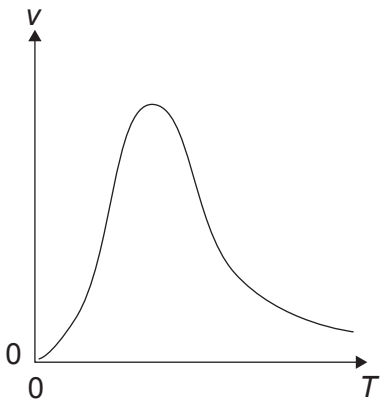
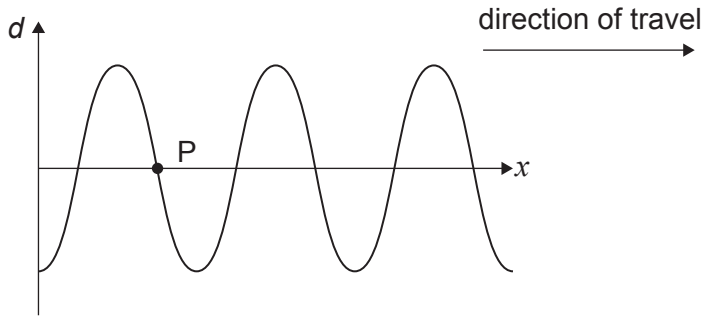
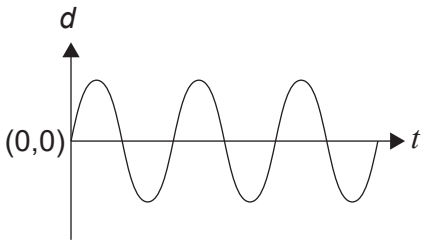
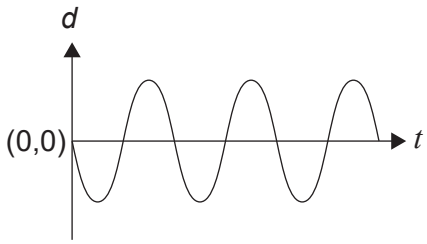


13. The graph shows the variation of displacement *d* with distance x along a transverse wave. At time $t = 0$ a point P has a displacement $d = 0$.



Which of the graphs shows the variation with time *t* of the displacement *d* of P?

A.


B.


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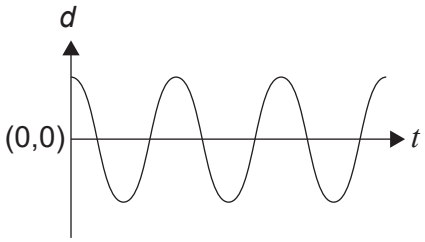

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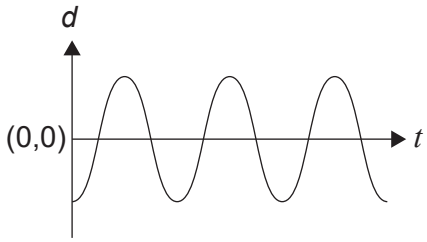


14. Which statement is **incorrect** about a standing wave?

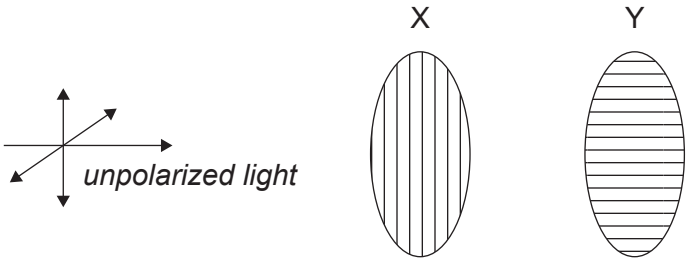
A. All points between adjacent nodes oscillate in phase.

B. The wave must always reflect out of phase at a boundary.

C. The frequency is the same at each point.

D. The wavelength is twice the distance between adjacent nodes.

15. Unpolarized light is incident on two polarizers X and Y. The transmission axis of X is vertical and that of Y is horizontal.



Polarizer Z can be placed

I. before polarizer X.

II. between polarizer X and Y.

III. after polarizer Y.

The transmission axis of Z makes an angle of 45° with those of X and Y.

At which positions for Z will no light be transmitted?

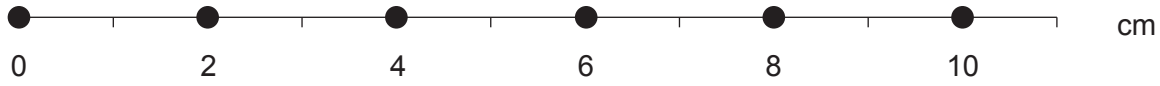
A. I and II only

B. I and III only

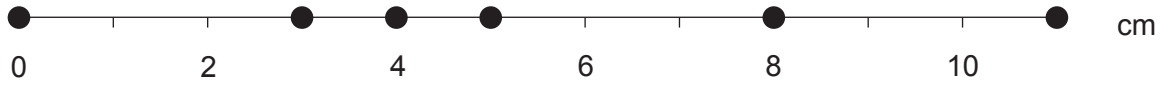
C. II and III only

D. I, II and III

16. The equilibrium positions of six particles in a medium are separated by a distance of 2 cm as shown.



The positions of these particles, when a longitudinal wave is transmitted through the medium, are now shown.



What is the wavelength of the wave?

A. 2 cm

B. 4 cm

C. 6 cm

D. 8 cm

17. Light passes from a medium into air. The critical angle is θ_c.

Which expression gives the speed of light in the medium?

A. $\dfrac{1}{c \sin\theta_c}$

B. $\dfrac{\sin\theta_c}{c}$

C. $\dfrac{c}{\sin\theta_c}$

D. $c \sin\theta_c$

18. Three statements are made about drift speed v_d in a metal wire.

I. v_d is less than the speed of light in a vacuum.

II. v_d is the average speed of positive lattice ions.

III. v_d is directly proportional to the current.

Which statements are correct?

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

19. Current I flows in a conducting wire.

What expression correctly gives the number of electrons passing through a cross section of the wire in a time t?

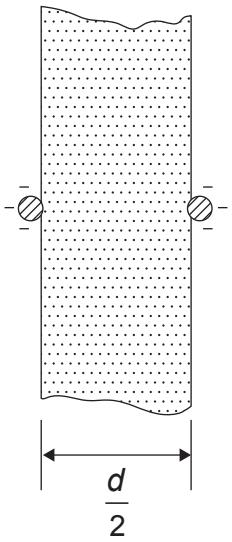
A. It

B. $\frac{I}{t}$

C. Ite

D. $\frac{It}{e}$

20. Two point charges of equal charge are separated in free space by a distance d and experience an electric force $F_{\text{free space}}$. The same point charges are now separated by a wall of concrete $\frac{d}{2}$ thick and experience an electric force F_{concrete}.



The permittivity of concrete is four times that of free space.

What is $\frac{F_{\text{concrete}}}{F_{\text{free space}}}$?

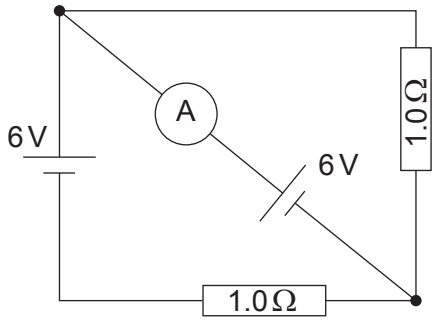
A. $\frac{1}{4}$

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

C. 1

D. 8

21. Two 1.0 Ω resistors are placed in a circuit with two 6 V cells of negligible internal resistance as shown.



What is the reading on the ideal ammeter?

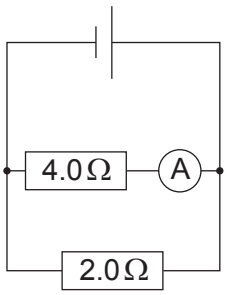
A. 2.0A

B. 3.0A

C. 6.0A

D. 12.0A

22. A 2.0 Ω and a 4.0 Ω resistor are connected in parallel to a cell with negligible internal resistance. An ammeter placed in the circuit as shown measures a current of 1.0A.



What is the current passing through the 2.0 Ω resistor?

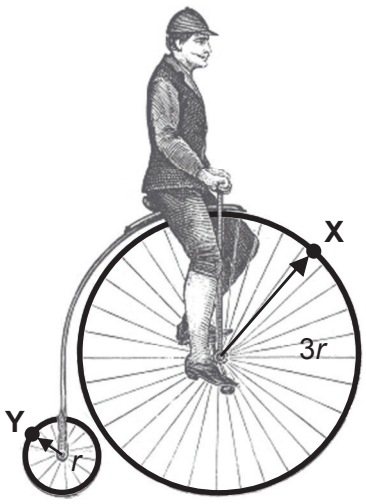
A. 0.5A

B. 1.0A

C. 2.0A

D. 4.0A

23. An old-fashioned bicycle is moving with a constant speed v. The front wheel has a radius 3 times that of the rear wheel. Points X and Y are positioned on the front and rear wheel as shown.



What is $\frac{\text{acceleration of X}}{\text{acceleration of Y}}$?

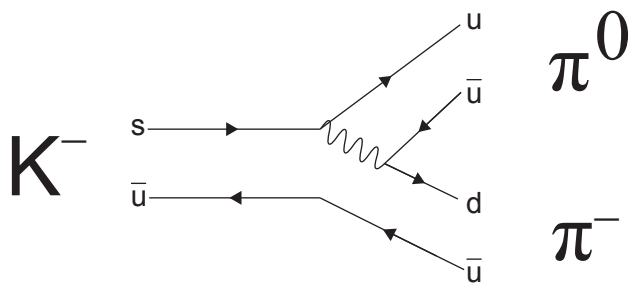
A. $\frac{1}{9}$

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

C. 3

D. 9

24. The Feynman diagram shows a possible decay of a K^- meson.



Which particle is represented by the wavy line?

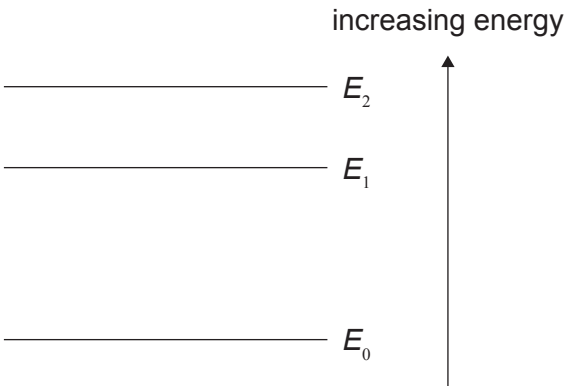
A. Gluon

B. Z^0

C. Photon

D. W^-

25. Three electron energy levels of a gas atom E_0, E_1 and E_2 are shown.



The following three claims are made about photons associated with these energy levels:

I. Transition from E_2 to E_1 will produce photons with the shortest wavelength.

II. Transition from E_2 to E_0 will produce photons with the highest frequency.

III. Three lines in the spectrum of this gas appear.

Which statements are **correct**?

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

26. A nucleus of uranium undergoes fission.

$$ {}^{1}_{0}\mathrm{n} + {}^{235}_{92}\mathrm{U} \rightarrow {}^{141}_{56}\mathrm{Ba} + {}^{x}_{36}\mathrm{Kr} + 3\,{}^{1}_{0}\mathrm{n} $$

What is correct about the number of nucleons x in the Kr nucleus and the ratio

$$ \frac{\text{binding energy per nucleon of Kr}}{\text{binding energy per nucleon of Ba}} \; ? $$

	Number of nucleons x in Kr nucleus	**$\frac{\text{binding energy per nucleon of Kr}}{\text{binding energy per nucleon of Ba}}$**
A.	92	Greater than 1
B.	92	Less than 1
C.	94	Greater than 1
D.	94	Less than 1

27. The half-life of a radioactive substance is 5 hours. At time $t = 20$ hours N nuclei are present in the sample.

What was the number of radioactive nuclei that were present at time $t = 5$ hours?

A. $3N$

B. $4N$

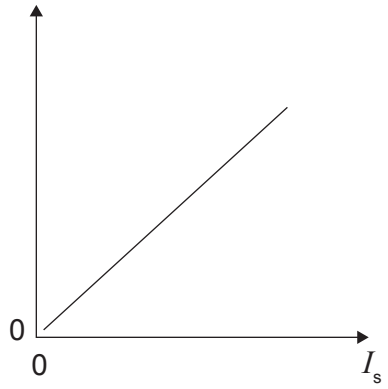
C. $8N$

D. $9N$

28. A planet has a known albedo and emissivity. The average intensity received at the surface is I_s.

Which graph describes the variation of surface temperature *T* with I_s?

A.



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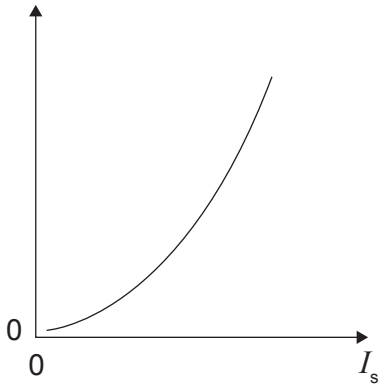
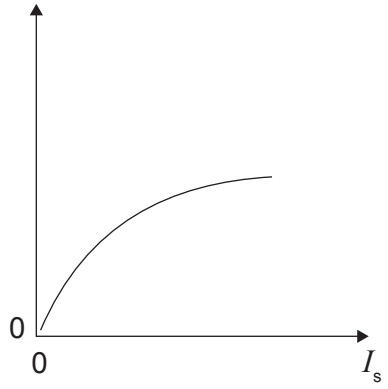


C.



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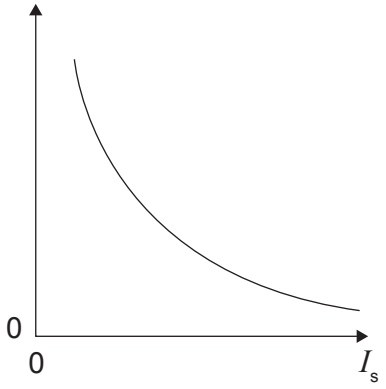

29. The wind generator equation can be used to estimate the power produced by a wind turbine from a given set of conditions.

Which assumption is **not** used in the derivation of this equation?

A. The number of blades on the turbine is a constant.

B. Speed of air particles after passing through the turbine is zero.

C. Speed of air particles approaching the turbine cross-sectional area is constant.

D. Turbulence created by the spinning turbine is negligible

30. An engine provides a thrust force F to move a vehicle at constant velocity v. The engine has an efficiency e and consumes fuel with an energy density η.

Which expression gives the rate at which the volume of fuel is being consumed by the engine?

A. $\frac{Fv}{e\eta}$

B. $\frac{Fv\eta}{e}$

C. $\frac{eFv}{\eta}$

D. $\frac{e\eta}{Fv}$

References:

23. Clu, n.d. *Penny farthing bicycle*. [image online] Available at: https://www.gettyimages.co.uk/detail/illustration/penny-farthing-bicycle-first-exercise-royalty-free-illustration/1179950344 [Accessed 16 May 2023]. Source adapted.