Diploma Programme
Programme du diplôme
Programa del Diploma

Physics
Higher level
Paper 1

Thursday 10 May 2018 (afternoon)

1 hour

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]**.

2218 – 6507

22 pages

1. A student measures the radius r of a sphere with an absolute uncertainty 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. $4\pi\frac{\Delta r}{r}$

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

2. An object is projected vertically upwards at time $t = 0$. Air resistance is negligible. The object passes the same point above its starting position at times 2s and 8s.

If $g = 10\ m\,s^{-2}$, what is the initial speed of the object?

A. 50

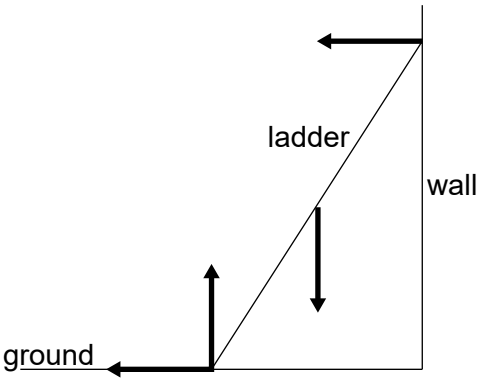
B. 30

C. 25

D. 4

3. A uniform ladder resting in equilibrium on rough ground leans against a smooth wall. Which diagram correctly shows the forces acting on the ladder?

A.



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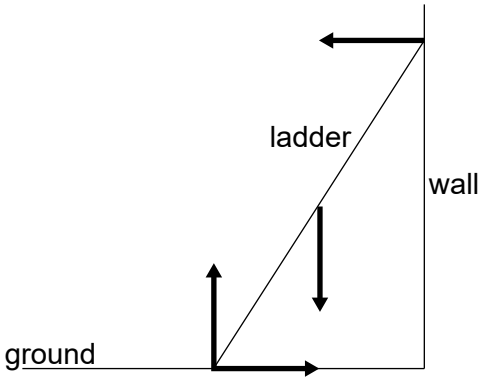

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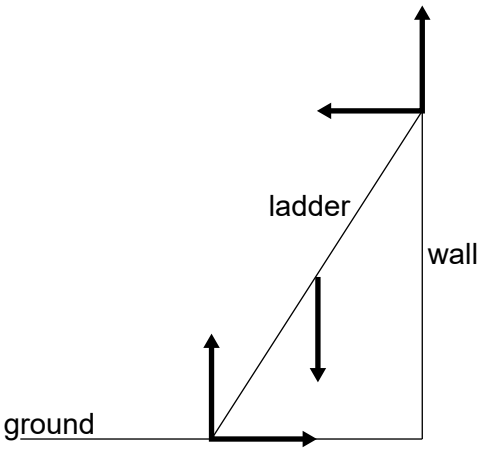

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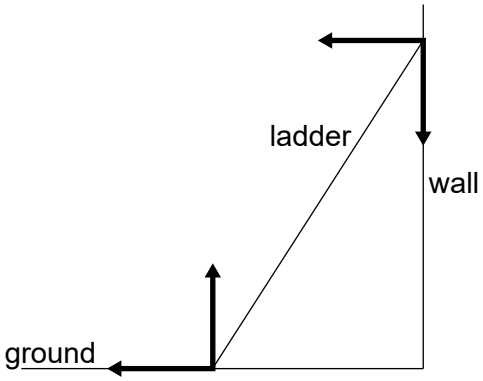


4. An object falls from rest from a height h close to the surface of the Moon. The Moon has no atmosphere.

When the object has fallen to height $\frac{h}{4}$ above the surface, what is

$$\frac{\text{kinetic energy of the object at } \frac{h}{4}}{\text{gravitational potential energy of the object at } h} ?$$

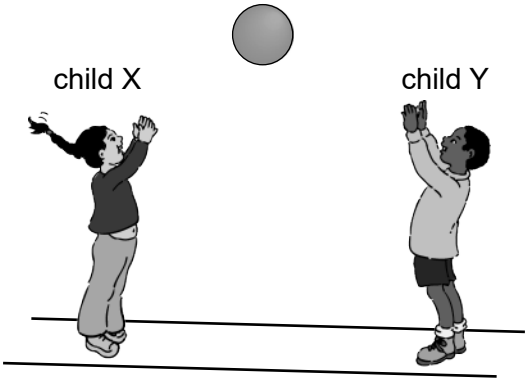
A. $\frac{3}{4}$

B. $\frac{4}{3}$

C. $\frac{9}{16}$

D. $\frac{16}{9}$

5. Child X throws a ball to child Y. The system consists of the ball, the children and the Earth. What is true for the system when the ball has been caught by Y?



[Source: https://pixabay.com/en/playing-ball-kids-boy-girl-31339/]

A. The momentum of child Y is equal and opposite to the momentum of child X.

B. The speed of rotation of the Earth will have changed.

C. The ball has no net momentum while it is in the air.

D. The total momentum of the system has not changed.

6. A parachutist of total mass 70 kg is falling vertically through the air at a constant speed of $8\,m\,s^{-1}$. What is the total upward force acting on the parachutist?

A. 0 N

B. 70 N

C. 560 N

D. 700 N

7. A stopper of mass 8 g leaves the opening of a container that contains pressurized gas.

The stopper accelerates from rest for a time of 16 ms and leaves the container at a speed of $20\,m\,s^{-1}$.

What is the order of magnitude of the force acting on the stopper?

A. 10^{-3} N

B. 10^{0} N

C. 10^{1} N

D. 10^{3} N

8. What are the units of the ratio $\frac{\text{specific heat capacity of copper}}{\text{specific latent heat of vaporization of copper}}$?

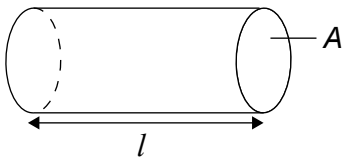
A. no units

B. k

C. k^{-1}

D. k^{-2}

9. A sealed cylinder of length l and cross-sectional area A contains N molecules of an ideal gas at kelvin temperature T.



What is the force acting on the area of the cylinder marked A due to the gas?

A. $\frac{NRT}{l}$

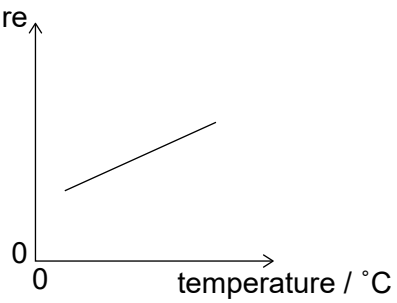
B. $\frac{NRT}{lA}$

C. $\frac{Nk_BT}{lA}$

D. $\frac{Nk_BT}{l}$

10. A fixed mass of an ideal gas is trapped in a cylinder of constant volume and its temperature is varied. Which graph shows the variation of the pressure of the gas with temperature in degrees Celsius?

A.



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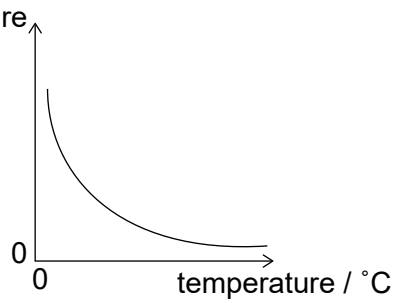

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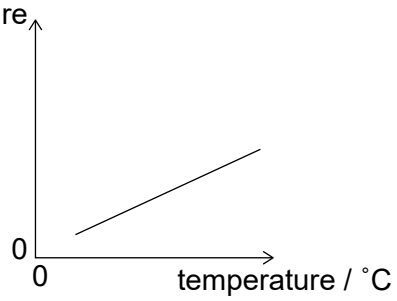

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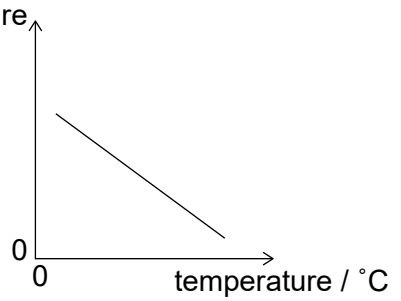
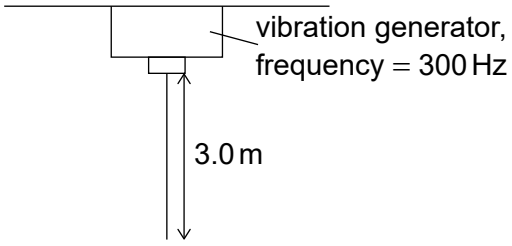


11. A first-harmonic standing wave is formed on a vertical string of length 3.0 m using a vibration generator. The boundary conditions for this string are that it is fixed at one boundary and free at the other boundary.

diagram not to scale



The generator vibrates at a frequency of 300 Hz.

What is the speed of the wave on the string?

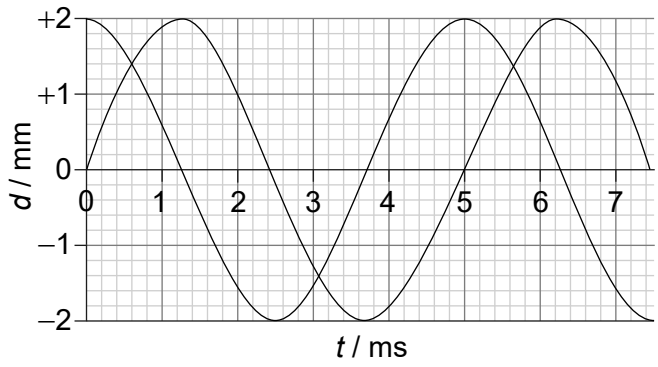
A. $0.90\,\text{km}\,\text{s}^{-1}$

B. $1.2\,\text{km}\,\text{s}^{-1}$

C. $1.8\,\text{km}\,\text{s}^{-1}$

D. $3.6\,\text{km}\,\text{s}^{-1}$

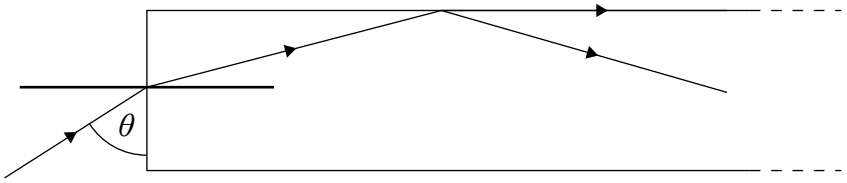
12. Two travelling waves are moving through a medium. The diagram shows, for a point in the medium, the variation with time *t* of the displacement *d* of each of the waves.



For the instant when $t = 2.0\,\text{ms}$, what is the phase difference between the waves and what is the resultant displacement of the waves?

	Phase difference	Resultant displacement / mm
A.	45°	–0.6
B.	90°	2.6
C.	45°	2.6
D.	90°	–0.6

13. A ray of light passes from the air into a long glass plate of refractive index *n* at an angle θ to the edge of the plate.



The ray is incident on the internal surface of the glass plate and the refracted ray travels along the external surface of the plate.

What change to *n* and what change to θ will cause the ray to travel entirely within the plate after incidence?

	Change to *n*	**Change to θ**
A.	increase	increase
B.	increase	decrease
C.	decrease	increase
D.	decrease	decrease

14. A system that is subject to a restoring force oscillates about an equilibrium position.

For the motion to be simple harmonic, the restoring force must be proportional to

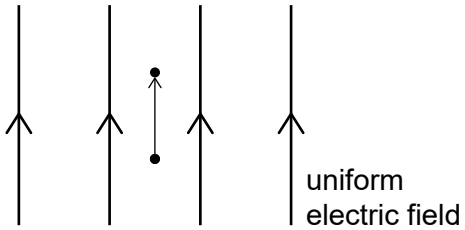
A. the amplitude of the oscillation.

B. the displacement from the equilibrium position.

C. the potential energy of the system.

D. the period of the oscillation.

15. An ion of charge $+Q$ moves vertically upwards through a small distance s in a uniform vertical electric field. The electric field has a strength E and its direction is shown in the diagram.



What is the electric potential difference between the initial and final position of the ion?

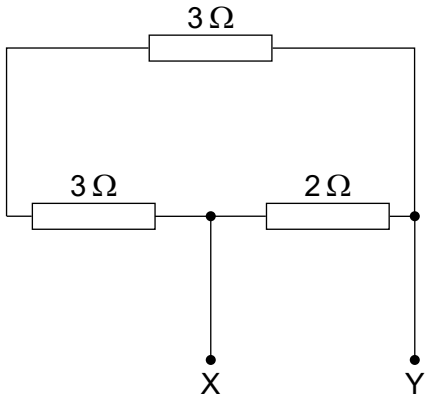
A. $\frac{EQ}{s}$

B. EQs

C. Es

D. $\frac{E}{s}$

16. Three resistors are connected as shown. What is the value of the total resistance between X and Y?



A. 1.5 Ω

B. 1.9 Ω

C. 6.0 Ω

D. 8.0 Ω

17. When an electric cell of negligible internal resistance is connected to a resistor of resistance $4R$, the power dissipated in the resistor is P.

What is the power dissipated in a resistor of resistance value R when it is connected to the same cell?

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

B. P

C. $4P$

D. $16P$

18. An object of mass m at the end of a string of length r moves in a vertical circle at a constant angular speed ω.

What is the tension in the string when the object is at the bottom of the circle?

A. $m(\omega^2 r + g)$

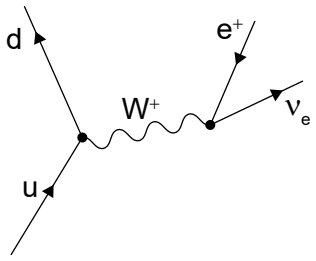
B. $m(\omega^2 r - g)$

C. $mg(\omega^2 r + 1)$

D. $mg(\omega^2 r - 1)$

19. Which Feynman diagram shows beta-plus (β^+) decay?

A.



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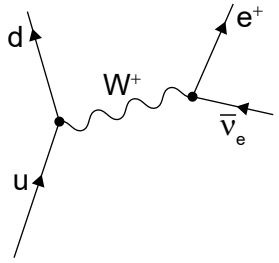

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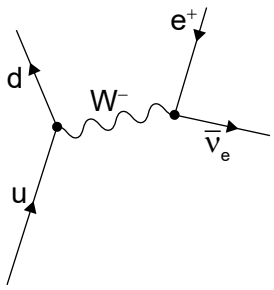

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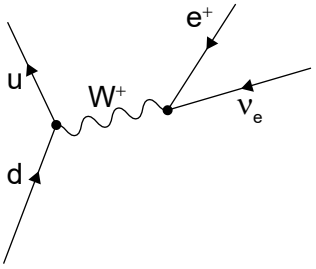


20. The average binding energy per nucleon of the $^{15}_{8}O$ nucleus is 7.5 MeV. What is the total energy required to separate the nucleons of one nucleus of $^{15}_{8}O$?

A. 53 MeV

B. 60 MeV

C. 113 MeV

D. 173 MeV

21. What is correct about the Higgs Boson?

A. It was predicted before it was observed.

B. It was difficult to detect because it is charged.

C. It is not part of the Standard Model.

D. It was difficult to detect because it has no mass.

22. What is equivalent to $\frac{\text{specific energy of a fuel}}{\text{energy density of a fuel}}$?

A. density of the fuel

B. $\frac{1}{\text{density of the fuel}}$

C. $\frac{\text{energy stored in the fuel}}{\text{density of the fuel}}$

D. $\frac{\text{density of the fuel}}{\text{energy stored in the fuel}}$

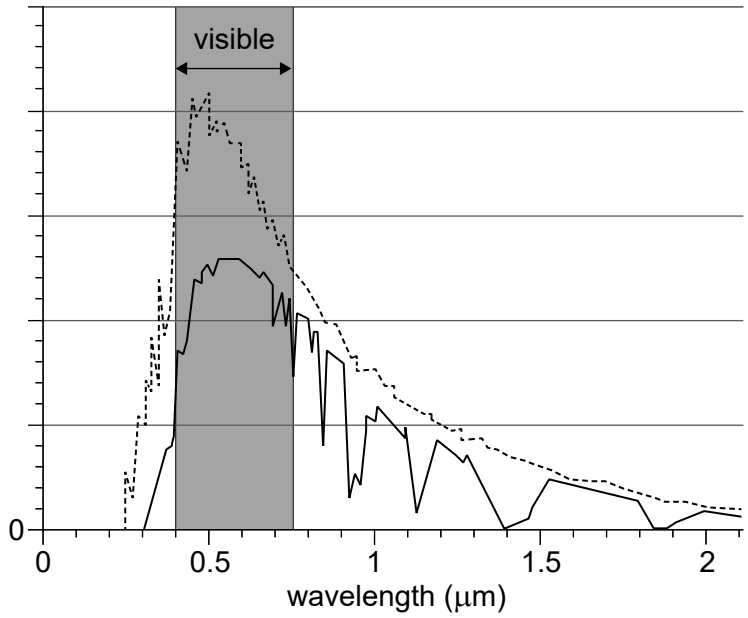
23. A nuclear reactor contains atoms that are used for moderation and atoms that are used for control.

What are the ideal properties of the moderator atoms and the control atoms in terms of neutron absorption?

	Ideal moderator atom	Ideal control atom
A.	poor absorber of neutrons	poor absorber of neutrons
B.	poor absorber of neutrons	good absorber of neutrons
C.	good absorber of neutrons	poor absorber of neutrons
D.	good absorber of neutrons	good absorber of neutrons

24. The dashed line on the graph shows the variation with wavelength of the intensity of solar radiation before passing through the Earth's atmosphere.

The solid line on the graph shows the variation with wavelength of the intensity of solar radiation after it has passed through the Earth's atmosphere.



[Source: Reproduced by permission of Martin Green, UNSW Sydney]

Which feature of the graph helps explain the greenhouse effect?

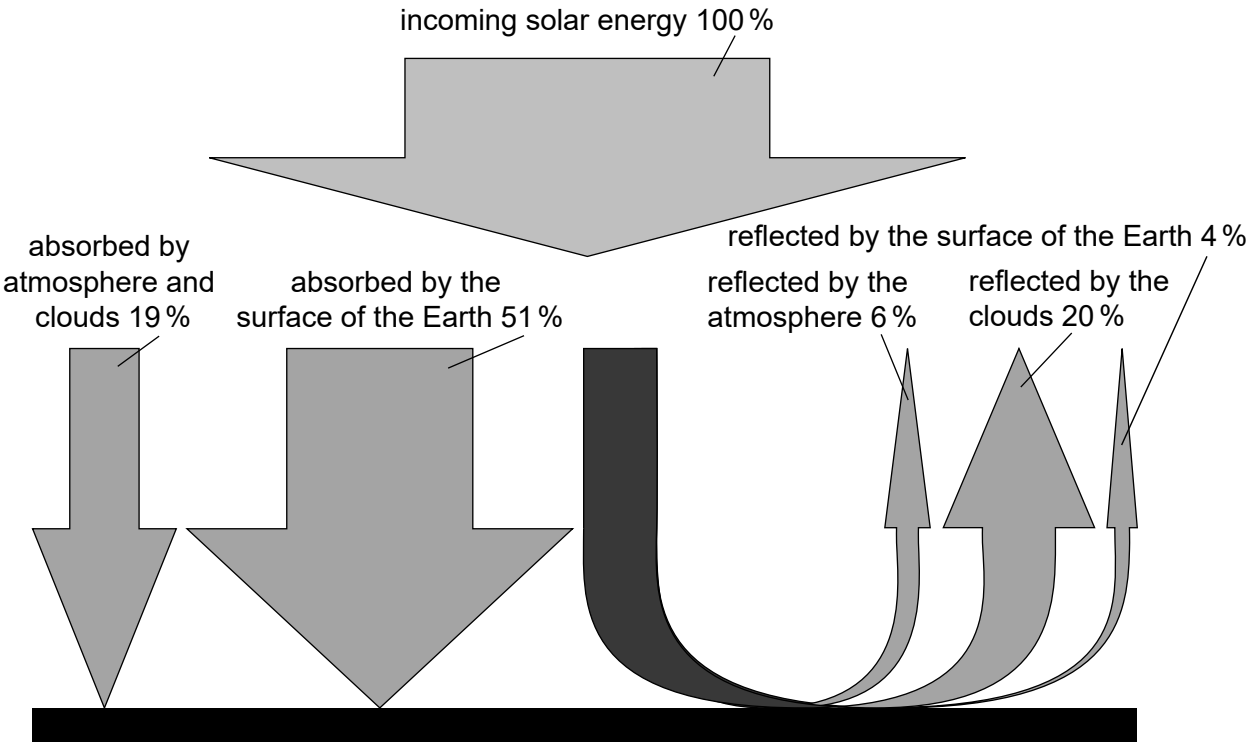
A. Infrared radiation is absorbed at specific wavelengths.

B. There is little absorption at infrared wavelengths.

C. There is substantial absorption at visible wavelengths.

D. There is little absorption at UV wavelengths.

25. The diagram shows a simple climate model for the Earth.



What does this model predict for the average albedo of the Earth?

A. 0.30

B. 0.51

C. 0.70

D. 0.81

26. A mass at the end of a vertical spring and a simple pendulum perform oscillations on Earth that are simple harmonic with time period T. Both the pendulum and the mass-spring system are taken to the Moon. The acceleration of free fall on the Moon is smaller than that on Earth. What is correct about the time periods of the pendulum and the mass-spring system on the Moon?

	Simple pendulum	Mass-spring system
A.	T	T
B.	greater than T	T
C.	greater than T	greater than T
D.	T	greater than T

27. Monochromatic light of wavelength λ in air is incident normally on a thin film of refractive index n. The film is surrounded by air. The intensity of the reflected light is a minimum. What is a possible thickness of the film?

A. $\frac{\lambda}{4n}$

B. $\frac{3\lambda}{4n}$

C. $\frac{\lambda}{n}$

D. $\frac{5\lambda}{4n}$

28. Monochromatic light is incident on 4 rectangular, parallel slits. The first principal maximum is observed at an angle θ to the direction of the incident light. The number of slits is increased to 8 each having the same width and spacing as the first 4.

Three statements about the first principal maximum with 8 slits are

I. the angle at which it is observed is greater than θ
II. its intensity increases
III. its width decreases.

Which statements are correct?

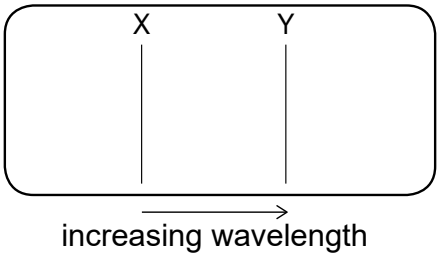
A. I and II only

B. I and III only

C. II and III only

D. I, II and III

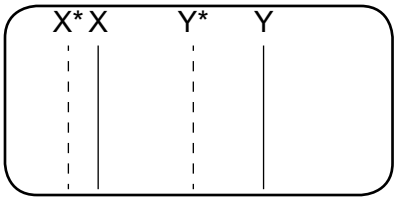
29. Two lines X and Y in the emission spectrum of hydrogen gas are measured by an observer stationary with respect to the gas sample.



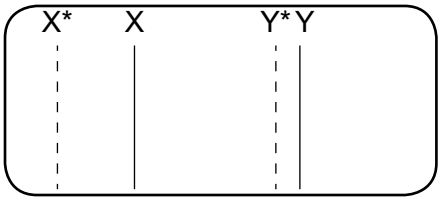
The emission spectrum is then measured by an observer moving away from the gas sample.

What are the correct shifts X* and Y* for spectral lines X and Y?

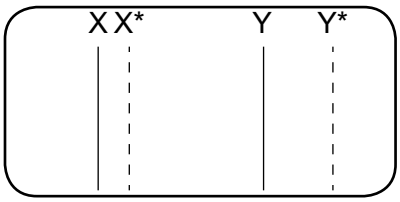
A.



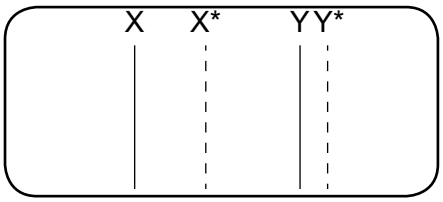
B.



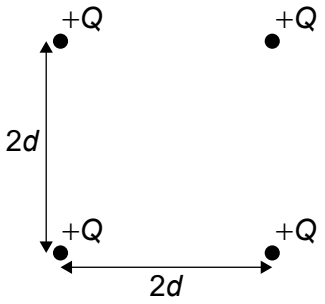
C.



D.



30. Four identical, positive, point charges of magnitude Q are placed at the vertices of a square of side $2d$. What is the electric potential produced at the centre of the square by the four charges?



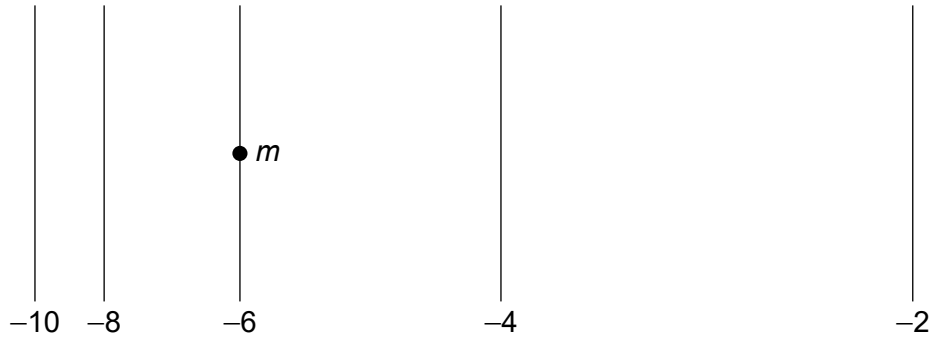
A. 0

B. $\frac{4kQ}{d}$

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

D. $\frac{2\sqrt{2}kQ}{d}$

31. The diagram shows 5 gravitational equipotential lines. The gravitational potential on each line is indicated. A point mass m is placed on the middle line and is then released. Values given in $MJ\,kg^{-1}$.



Which is correct about the direction of motion and the acceleration of the point mass?

	Direction	Acceleration
A.	to the right	decreasing
B.	to the right	increasing
C.	to the left	decreasing
D.	to the left	increasing

32. An electron of mass m_e orbits an alpha particle of mass m_α in a circular orbit of radius r. Which expression gives the speed of the electron?

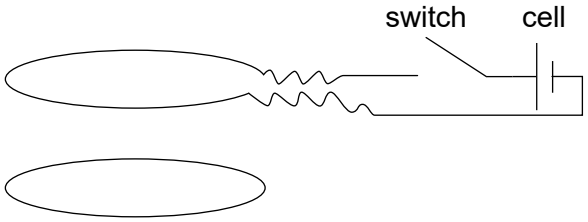
A. $\sqrt{\frac{2ke^2}{m_e r}}$

B. $\sqrt{\frac{2ke^2}{m_\alpha r}}$

C. $\sqrt{\frac{4ke^2}{m_e r}}$

D. $\sqrt{\frac{4ke^2}{m_\alpha r}}$

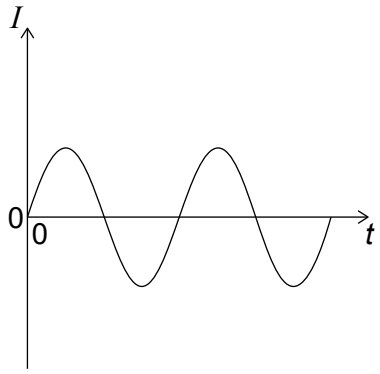
33. Two identical circular coils are placed one below the other so that their planes are both horizontal. The top coil is connected to a cell and a switch.



The switch is closed and then opened. What is the force between the coils when the switch is closing and when the switch is opening?

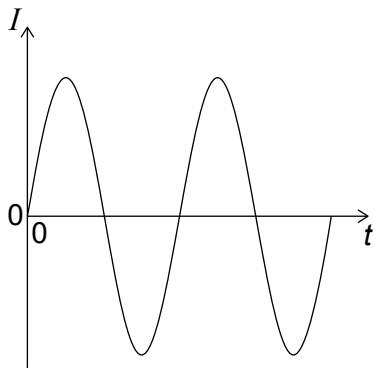
	Switch is closing	Switch is opening
A.	attractive	attractive
B.	attractive	repulsive
C.	repulsive	attractive
D.	repulsive	repulsive

34. The graph shows the variation with time *t* of the current I in the primary coil of an ideal transformer.

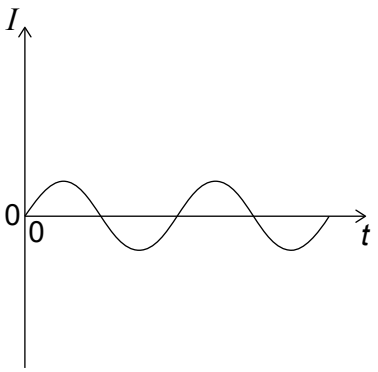


The number of turns in the primary coil is 100 and the number of turns in the secondary coil is 200. Which graph shows the variation with time of the current in the secondary coil?

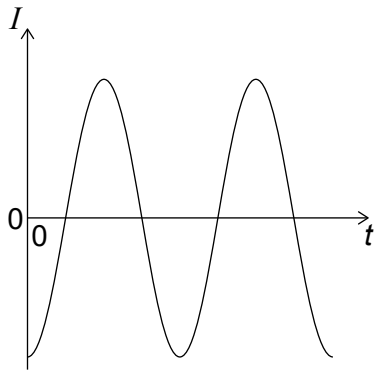
A.



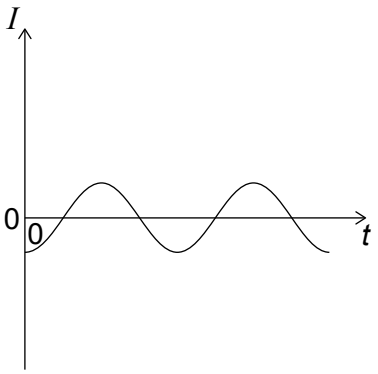
B.



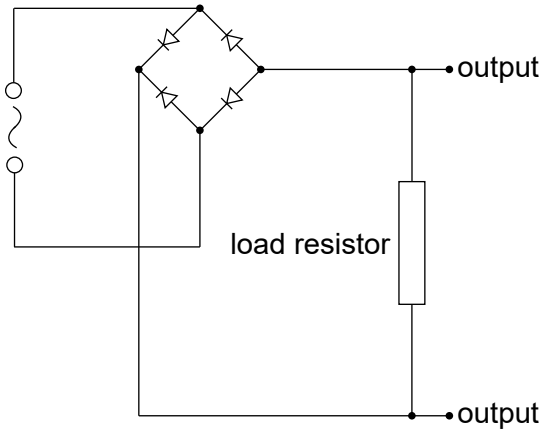
C.



D.

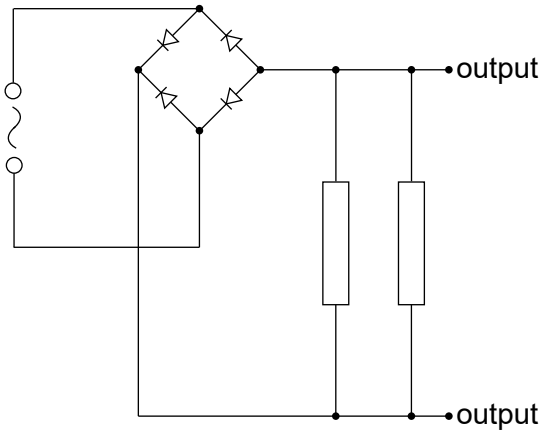


35. The diagram shows a diode bridge rectification circuit and a load resistor.

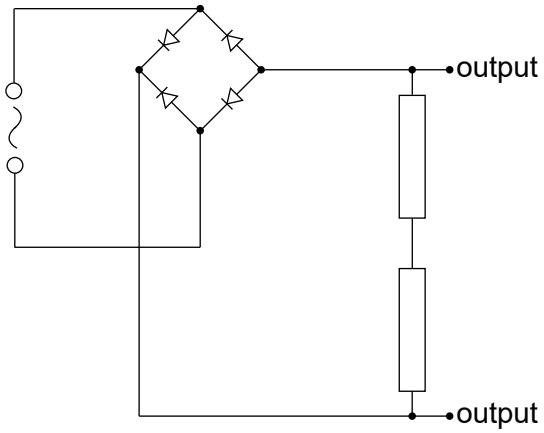


The input is a sinusoidal signal. Which of the following circuits will produce the most smoothed output signal?

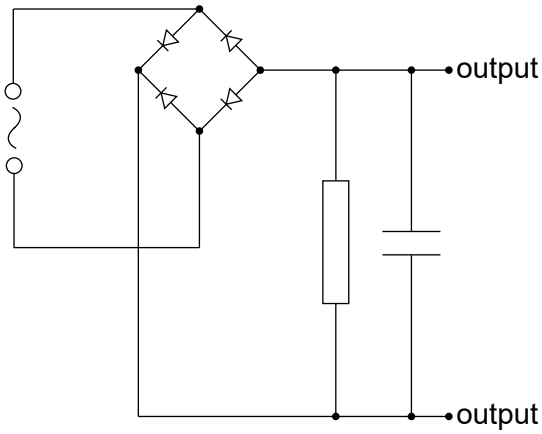
A.



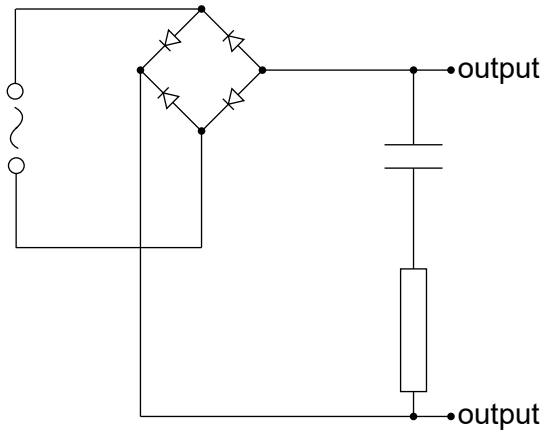
B.



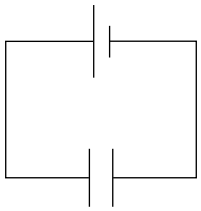
C.



D.



36. A parallel plate capacitor is connected to a cell of negligible internal resistance.



The energy stored in the capacitor is 4 J and the electric field in between the plates is $100\,\text{N}\,\text{C}^{-1}$. The distance between the plates of the capacitor is doubled. What are the energy stored and the electric field strength?

	Energy / J	Electric field strength / $\text{N}\,\text{C}^{-1}$
A.	2	50
B.	8	50
C.	2	200
D.	8	200

37. Two radioactive nuclides, X and Y, have half-lives of 50 s and 100 s respectively. At time $t = 0$ samples of X and Y contain the same number of nuclei.

What is $\frac{\text{number of nuclei of X undecayed}}{\text{number of nuclei of Y undecayed}}$ when $t = 200\,\text{s}$?

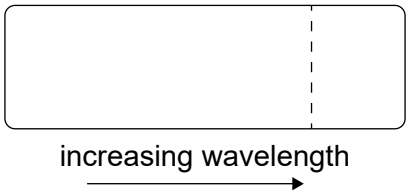
A. 4

B. 2

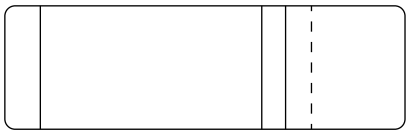
C. $\frac{1}{2}$

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

38. According to the Bohr model for hydrogen, visible light is emitted when electrons make transitions from excited states down to the state with $n = 2$. The dotted line in the following diagram represents the transition from $n = 3$ to $n = 2$ in the spectrum of hydrogen.



Which of the following diagrams could represent the visible light emission spectrum of hydrogen?

A. 

B. 

C. 

D. 

39. A particle of fixed energy is close to a potential barrier.

Which changes to the width of the barrier and to the height of the barrier will always make the tunnelling probability greater?

	Width of the barrier	Height of the barrier
A.	increase	increase
B.	increase	decrease
C.	decrease	increase
D.	decrease	decrease

40. Alpha particles with energy E are directed at nuclei with atomic number Z. Small deviations from the predictions of the Rutherford scattering model are observed.

Which change in E and which change in Z is most likely to result in greater deviations from the Rutherford scattering model?

	E	**Z**
A.	increase	increase
B.	increase	decrease
C.	decrease	increase
D.	decrease	decrease