Diploma Programme
Programme du diplôme
Programa del Diploma

Physics
Higher level
Paper 1

7 November 2024

Zone A afternoon | **Zone B** afternoon | **Zone C** 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].**

8824 – 9590

22 pages

1. The radius of a sphere is R. The absolute uncertainty in R is ΔR.

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

A. $\frac{3\Delta R}{R}$

B. $\left(\frac{\Delta R}{R}\right)^3$

C. $\frac{4\pi\Delta R}{3R}$

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

2. Astronomers have measured that the magnetic fields of some stars are of order 10^{10} T. Physicists have measured the magnetic fields of some laboratory magnets to be 1 T.

Three types of uncertainty are:

I. absolute uncertainty.

II. fractional uncertainty.

III. percentage uncertainty.

What types should the groups use to compare the precision of their measurements?

A. I and II only

B. I and III only

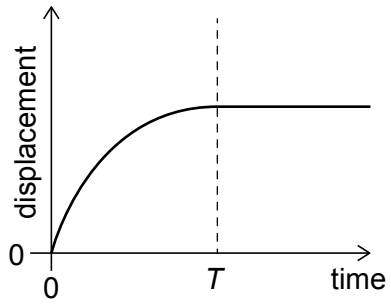
C. II and III only

D. I, II and III

3. A runner accelerates from rest and reaches a constant speed at time *T*.

What is the variation of displacement with time?

A.



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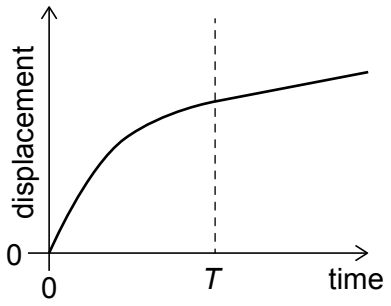

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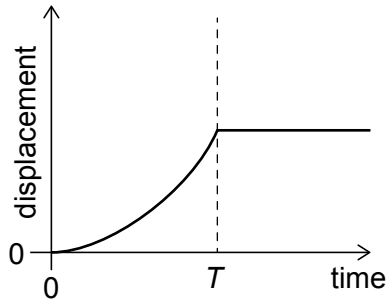

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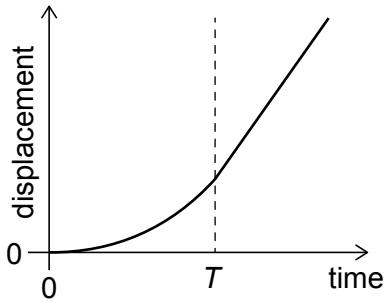


4. A balloon rises at a steady vertical velocity of $10\,m\,s^{-1}$. An object is released at rest relative to the balloon when the object is at a height 120 m above the ground. Air resistance is negligible.

What time, to the nearest second, does the object take to hit the ground?

A. 4 s

B. 5 s

C. 6 s

D. 12 s

5. When a horizontal spring is extended by a distance x, the force acting on the spring is F. The extension of the spring is directly proportional to the force.

What is the energy stored in the spring?

A. $\frac{F}{2x}$

B. Fx

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

D. $\frac{Fx^2}{2}$

6. A toy car collides with an identical toy car at rest. The cars stick together. The surface is frictionless.

Three statements about this collision are:

I. The speed of one car decreases and the speed of the other car increases.

II. Total momentum is conserved.

III. Kinetic energy is conserved.

Which statements are true?

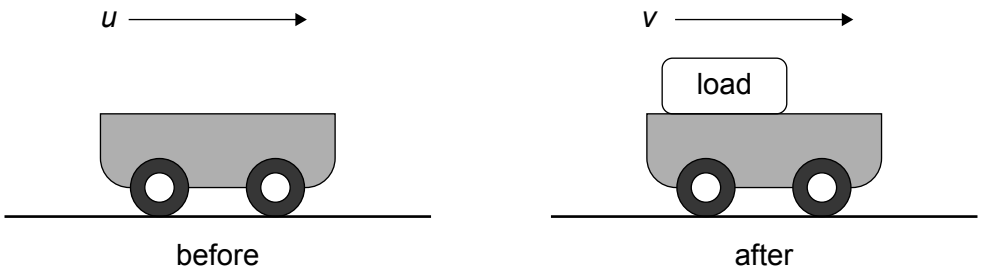
A. I and II only

B. I and III only

C. II and III only

D. I, II and III

7. A trolley of mass m is moving with speed u. A load is dropped onto the trolley so that it immediately attaches to the trolley. The speed of the trolley and the load becomes v.



What is the mass of the load?

A. $\frac{m(u-v)}{v}$

B. $\frac{m(u+v)}{v}$

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

D. $\frac{mv}{u}$

8. An object of mass m is being heated by a source of constant power P.

The rate of change of the temperature of the object is S.

What is the specific heat capacity of the object?

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

B. $\frac{mP}{S}$

C. $\frac{S}{mP}$

D. $\frac{P}{mS}$

9. An ideal gas is in a container with a movable piston. The piston compresses the gas rapidly.

The temperature of the gas increases because

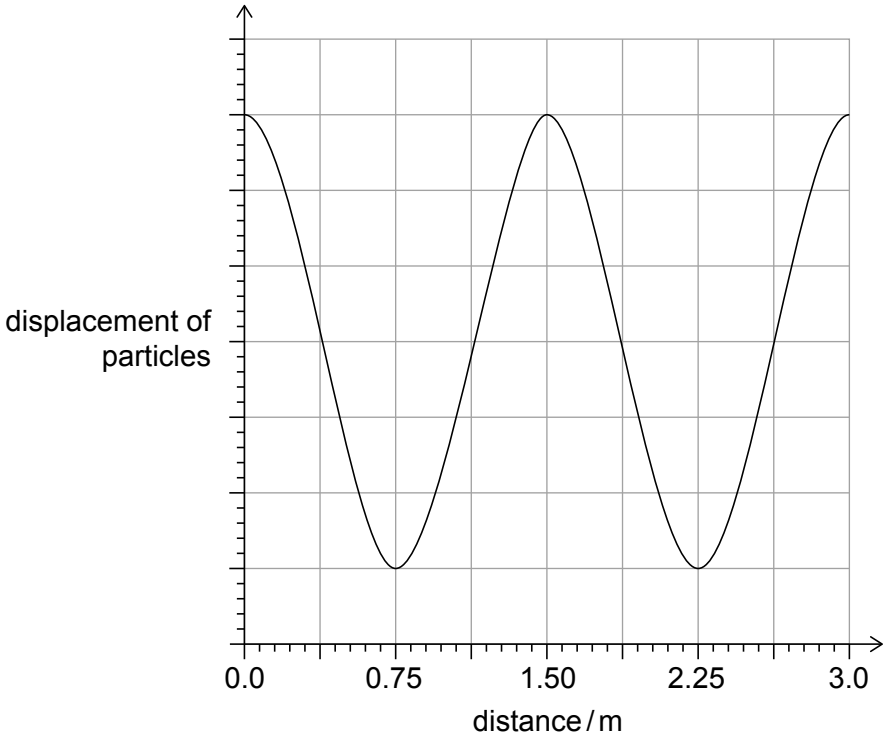
A. molecules bounce off the piston with increased speed.

B. molecules collide with the piston more frequently.

C. molecules exert a greater force on the piston.

D. the number of molecules per cubic metre has increased.

10. A travelling wave of time period 2.0 s is moving through a medium. The graph shows, for one instant, the variation with distance of the displacement of particles in the medium.



What is the speed of the wave?

A. $0.75\,m\,s^{-1}$

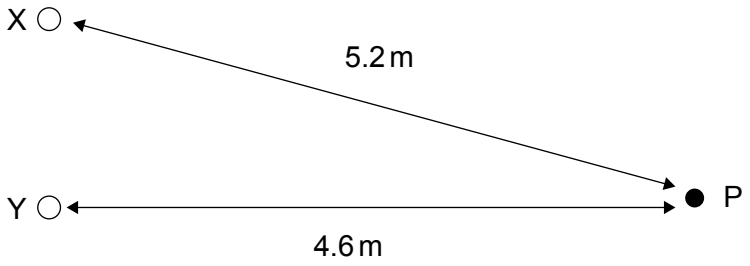
B. $1.5\,m\,s^{-1}$

C. $3.0\,m\,s^{-1}$

D. $6.0\,m\,s^{-1}$

11. Source X and source Y both emit waves of wavelength 0.40 m. There is a constant phase difference of π rad between the sources. Point P is 5.2 m from X and 4.6 m from Y. The amplitude of each wave at P is *A*.

diagram not to scale



What is the amplitude of the resultant wave at P?

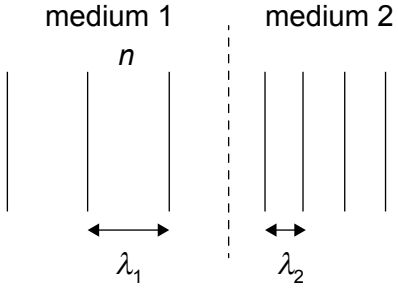
A. 0

B. *A*

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

D. 2*A*

12. An electromagnetic wave travels from medium 1 to medium 2. The wavelength of the wave in medium 1 is λ_1. The wavelength of the wave in medium 2 is λ_2. The refractive index of medium 1 is *n*.



What is the refractive index of medium 2?

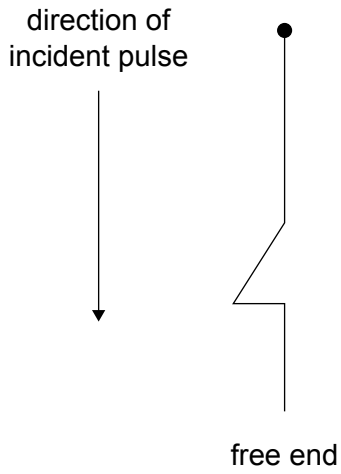
A. $\frac{\lambda_1 n}{\lambda_2}$

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

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

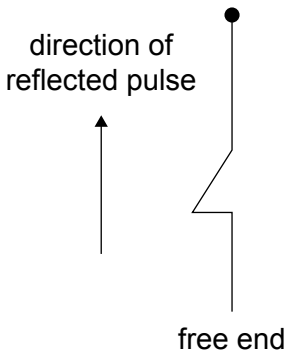
D. $\frac{\lambda_1}{\lambda_2}$

13. A single pulse travels towards the free end of a hanging vertical string. The pulse is reflected.



What is the shape of the reflected pulse?

A.



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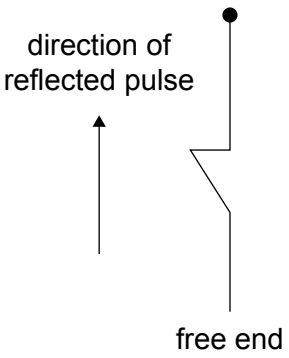

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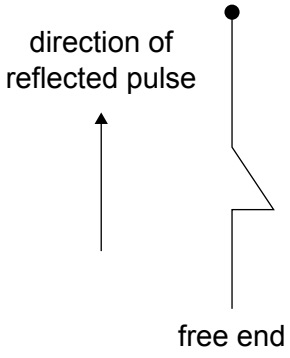

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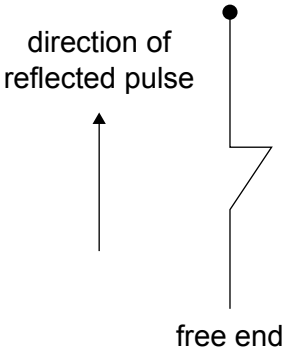


14. Electric field lines

A. can cross each other.

B. are parallel to equipotential surfaces.

C. are directed from negative to positive charges.

D. show field strength by their density.

15. What is the unit of resistivity in fundamental SI units?

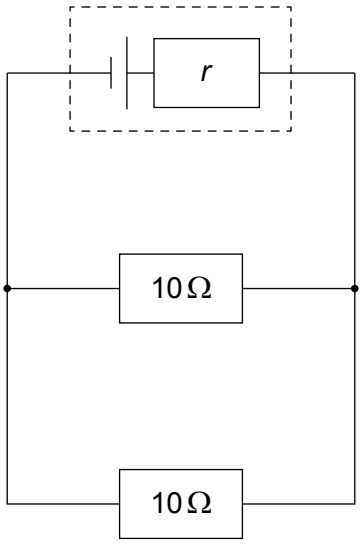
A. $kg\,m\,s^{-3}\,A^{-1}$

B. $kg\,m^{2}\,s^{-3}\,A^{-2}$

C. $kg\,m^{3}\,s^{-3}\,A^{-2}$

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

16. A cell has an emf of 17.0 V and internal resistance *r*. It is connected to two 10 Ω external resistors.



There is a current of 1.5 A in one of the external resistors.

What is the value of *r*?

A. 0.34 Ω

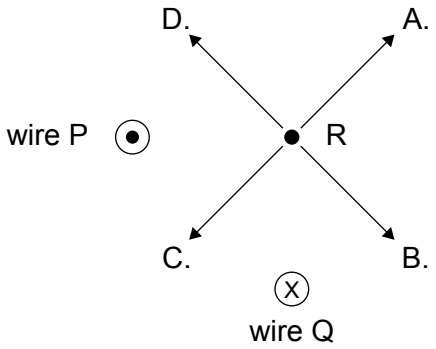
B. 0.50 Ω

C. 0.67 Ω

D. 1.3 Ω

17. P and Q are two parallel wires perpendicular to the page that carry currents of equal magnitude in opposite directions. The current in P is out of the page. R is a fixed point equidistant from P and Q.

What is the direction of the magnetic field produced at R?



18. An aircraft of mass M turns in a horizontal circle. The net force on the aircraft is F.

A second aircraft makes a horizontal turn with double the radius at the same speed. The mass of the second aircraft is $1.5M$.

What is the net force on the second aircraft?

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

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

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

D. $\frac{4}{3}F$

19. An unstable nuclide has too many protons.

What is the most likely decay of the nuclide?

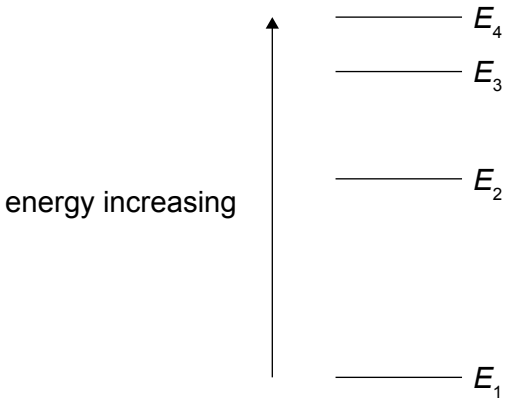
A. Alpha

B. Beta minus

C. Beta plus

D. Gamma

20. The four energy states for an atom are shown.



What is the lowest frequency of radiation that can be absorbed by the atom?

A. $\frac{E_1 - E_4}{h}$

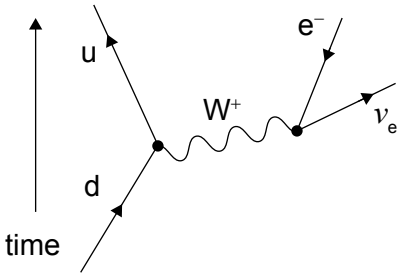
B. $\frac{E_4 - E_1}{h}$

C. $\frac{E_3 - E_4}{h}$

D. $\frac{E_4 - E_3}{h}$

21. Which Feynman diagram shows beta minus (β^-) decay?

A.



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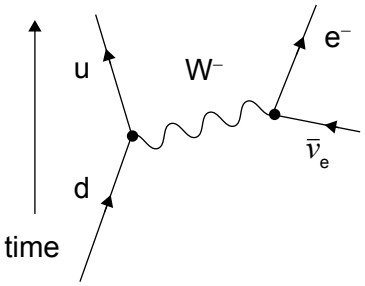

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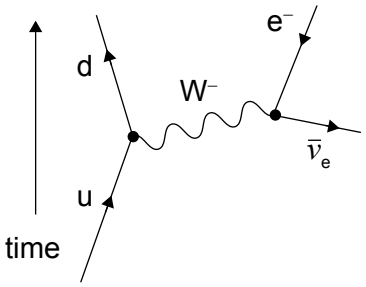

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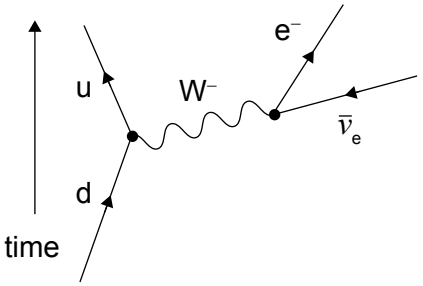


22. The Ξ^0 particle is a baryon.

What is the quark structure of this particle?

A. uus

B. uss

C. $u\bar{s}$

D. us

23. Once research is completed, scientists gather support for the validity of their work by

A. using common terminology.

B. collaborating with others.

C. improving their instrumentation.

D. obtaining a review by independent scientists.

24. Three energy sources for power stations are:

I. nuclear fuel.

II. sunlight.

III. fossil fuel.

Which energy sources are primary sources?

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

25. The surface of a planet absorbs an intensity of $400\,\mathrm{W\,m^{-2}}$ and reflects $100\,\mathrm{W\,m^{-2}}$. The surface of the planet is at equilibrium at a constant temperature.

What is the albedo of the planet surface and the radiated intensity?

	Albedo of the planet surface	**Radiated intensity / W m^{-2}**
A.	0.20	300
B.	0.20	400
C.	0.25	300
D.	0.25	400

26. An iceberg oscillates up and down in the sea with simple harmonic motion. At time $t = 0$ the iceberg is at the lowest point in its motion. At this instant its displacement is $-x_0$ relative to the equilibrium sea level. The angular frequency of the iceberg is ω.

What is the velocity of the iceberg at time t?

A. $\omega x_0 \cos \omega t$

B. $\omega x_0 \sin \omega t$

C. $-\omega x_0 \cos \omega t$

D. $-\omega x_0 \sin \omega t$

27. Light of wavelength λ is incident on a slit of width *b* and forms a diffraction pattern. The central maximum has a width of θ radians. The wavelength of the light is now changed to $\frac{2}{3}\lambda$ and the slit width is changed to $\frac{1}{6}b$.

What is the angle between the first diffraction minimum and the point of maximum intensity?

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

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

C. 2θ

D. 4θ

28. Monochromatic light of wavelength λ is incident normally on a diffraction grating of slit spacing $\frac{9}{2}\lambda$.

What is the total number of maxima that can be produced using this arrangement?

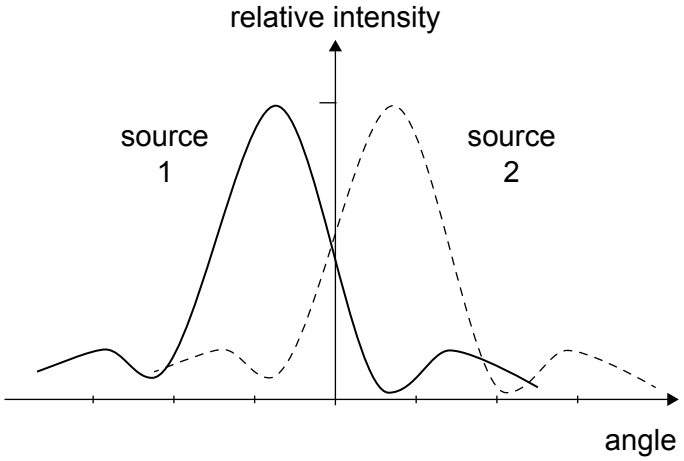
A. 4

B. 5

C. 9

D. 11

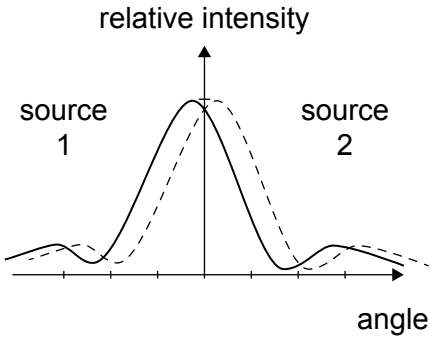
29. Source 1 and source 2 are observed by an optical system. When a green filter is used in the optical system, the two sources are just resolved. The diffraction pattern for the two sources is shown.



A blue filter is now used.

What diffraction patterns will be observed for the two sources?

A.



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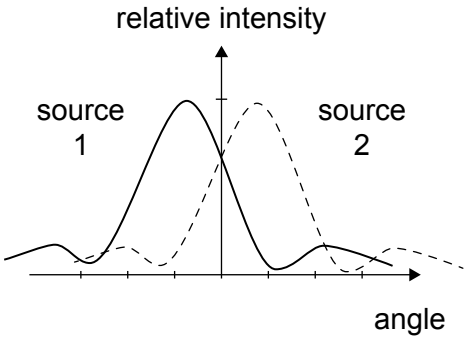

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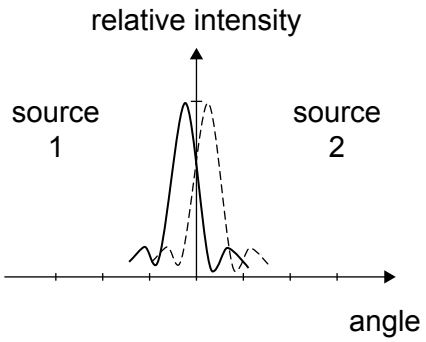

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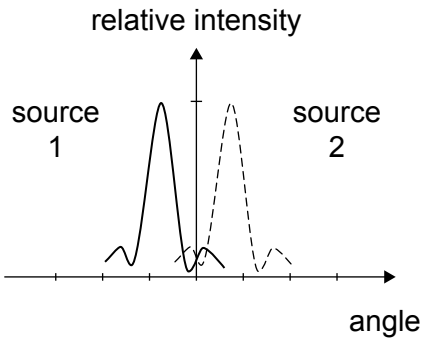
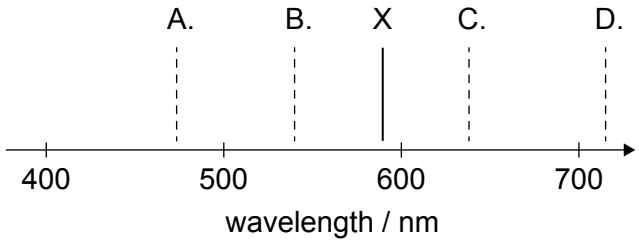
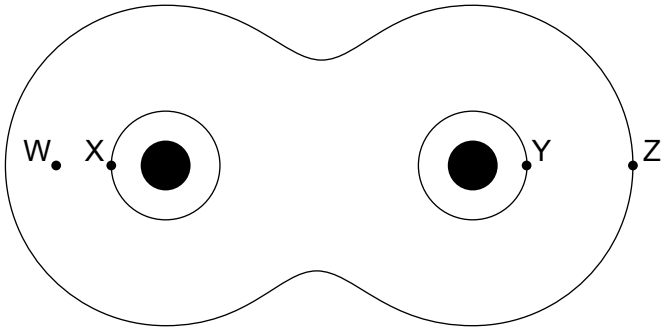


30. X shows the position of a spectral line in the emission spectrum of helium from a stationary source in a laboratory on Earth. The emission spectrum of helium from a star moving towards Earth is also observed. The speed of the star relative to Earth is 0.1 *c*.

What is the observed position of the same spectral line in the emission spectrum of helium from the star?



31. The diagram shows gravitational equipotential surfaces around two identical masses.



The greatest external work is done when a test mass is moved from

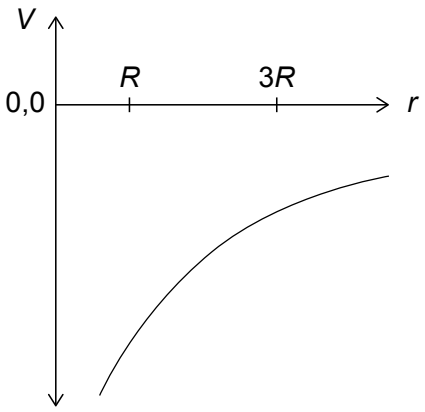
A. X to Y.

B. W to Y.

C. Y to Z.

D. W to Z.

32. The graph shows the variation of the gravitational potential V with distance r from the centre of a planet of radius R.



A mass m is placed at $r = 3R$.

What quantity when multiplied by m gives the gravitational potential energy of m due to the planet?

A. Gradient of a tangent line at $3R$

B. Area under the curve between R and $3R$

C. Gravitational potential value at $3R$

D. Difference in gravitational potential values at $3R$ and R

33. The escape speed from planet X is v_{esc}. Planet Y has twice the density and half the radius of planet X.

What is the speed required to escape the gravitational field of planet Y?

A. $\frac{v_{esc}}{4}$

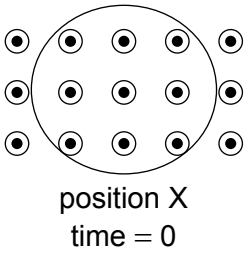
B. $\frac{v_{esc}}{2}$

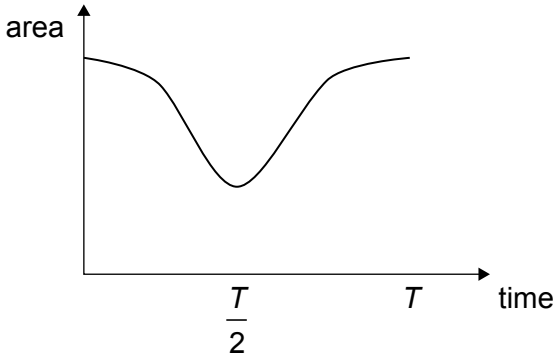
C. $\frac{v_{esc}\sqrt{2}}{2}$

D. $v_{esc}\sqrt{2}$

34. A circular coil of wire is in a region of uniform magnetic field directed out of the page, refer to **Figure 1.** The area of coil in the region varies with time as shown in the graph.

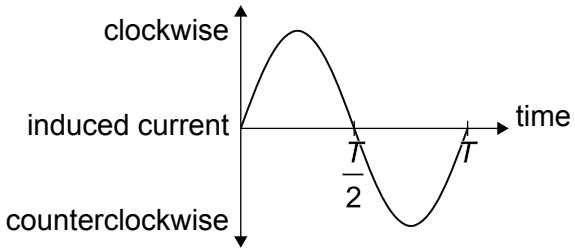
Figure 1





What is the induced current in the loop plotted with time?

A.



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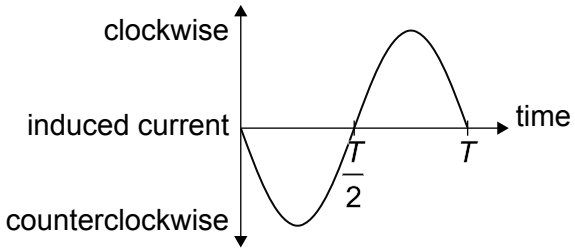
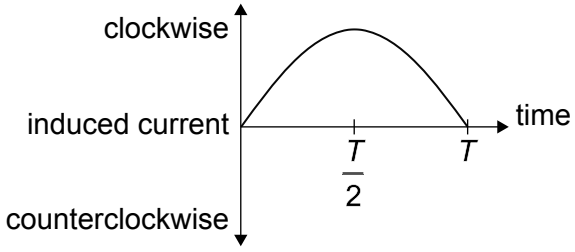
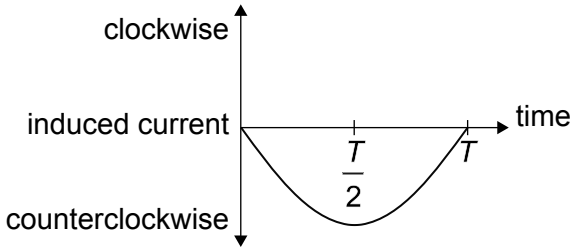


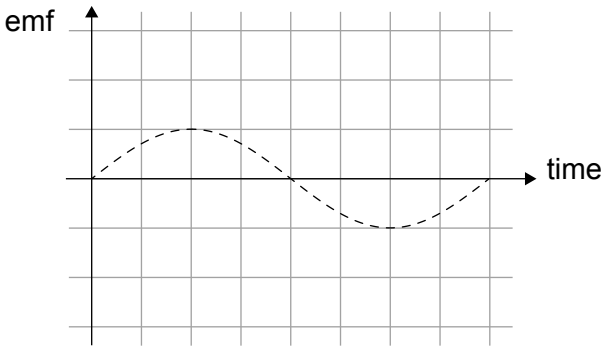
C.



D.

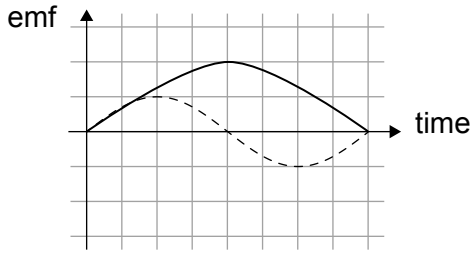


35. An alternating current (ac) generator rotates 300 times in 60 s. The dashed line shows how the induced emf varies with time.



Which graph represents the induced emf produced when the same generator rotates 400 times in 40 s? The original induced emf is shown by the dashed line.

A.



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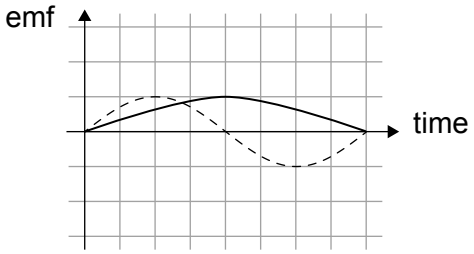

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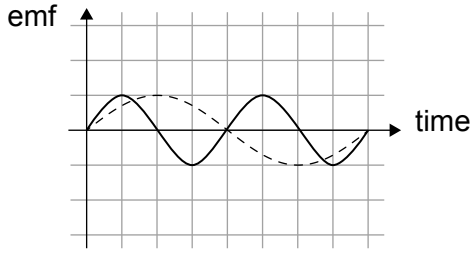
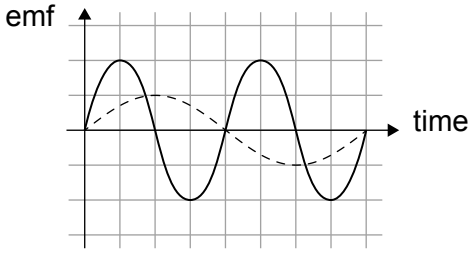
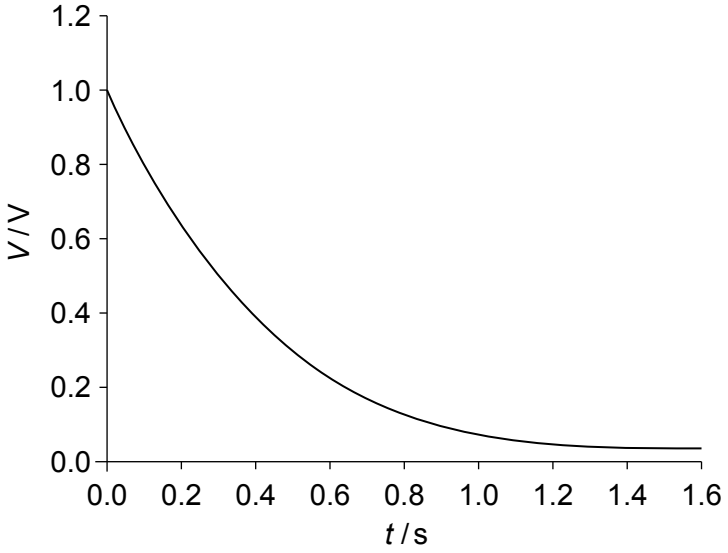


D.



36. A capacitor discharges through a resistor. The graph shows the variation with time t of the voltage V across the capacitor.

Given $\frac{1}{e}$ is 0.37.



What is the time constant τ for the circuit?

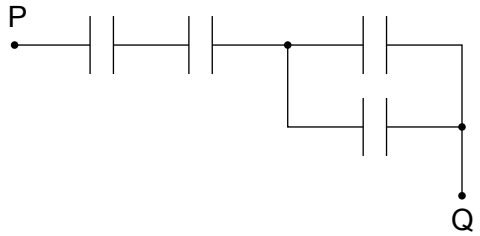
A. 0.12 s

B. 0.32 s

C. 0.44 s

D. 0.68 s

37. Four 10 μF capacitors are connected.



What is the total capacitance between P and Q?

A. 0.25 μF

B. 4.0 μF

C. 5.0 μF

D. 25 μF

38. Electrons are accelerated through a potential difference and are incident on a sample of crystal atoms causing a diffraction pattern.

When the potential difference is increased, the maxima

A. are closer together.

B. are farther apart.

C. have a similar intensity.

D. are unchanged.

39. An electron exists in an excited state for about 10^{-10} s.

What is an estimate of the minimum uncertainty in the electron's energy?

A. 10^{5} J

B. 10^{-5} J

C. 10^{5} eV

D. 10^{-5} eV

40. The radius of a nucleus of a particular nuclide X is 4.8 fm.

What is the nucleon number of X?

A. 48

B. 64

C. 128

D. 148