Section A: Fast.

1. A pendulum bob is oscillating in a vacuum, attached to a fixed point by a string above a table. The maximum height of the bob above the table is 1.3 m and the minimum height above the table is 1.1 m.

   The maximum speed of the pendulum bob is

   O 2.0 ms^{-1}
   O 3.9 ms^{-1}
   O 5.1 ms^{-1}
   O 26 ms^{-1} [OCR A-level physics]

2. Which set of S.I. prefixes are in order of increasing magnitude?

   O micro, milli, centi, kilo
   O milli, centi, micro, kilo
   O kilo, centi, milli, micro
   O centi, micro, milli, kilo [OCR A-level physics]

3. Which of the following shows the correct base units for pressure?

   O kg m^{-2}
   O kg m^{-2} s^{-2}
   O kg m^{-1} s^{-2}
   O kg m^{2} s^{-3} [OCR A-level physics]

4. A paper cone is held above the ground and dropped. It falls vertically and reaches terminal velocity before it hits the ground.

   The **resultant** force on the falling cone before it reaches terminal velocity is

   O decreasing and upwards
   O decreasing and downwards
   O increasing and upwards
   O increasing and downwards [OCR A-level physics]

5. An object is falling. The weight of the object is 4.5 N. The wind provides a horizontal force of magnitude *F* on the object. The resultant force on the object is 5.8 N, and air resistance and upthrust are negligible.

The value of *F* is

O 1.3 N
O 3.7 N
O 7.3 N
O 13 N [OCR A-level physics]

6. A solid molecular substance is supplied with energy and it starts to melt.

Which of the following pairs of quantities remains the same as the substance melts?

O Kinetic energy of molecules and internal energy of molecules.
O Potential energy of molecules and internal energy of molecules.
O Kinetic energy of molecules and temperature of substance.
O Potential energy of molecules and temperature of substance.

[OCR A-level physics]

7. A solid cylindrical glass rod has length 20.0 ± 0.1 cm and diameter 5.00 ± 0.01 cm.

What is the percentage uncertainty in the calculated volume of this rod?

O 0.1 %
O 0.2 %
O 0.7 %
O 0.9 % [OCR A-level physics]

8. A simple harmonic oscillator has a maximum speed of 24 ms^{-1} and amplitude of 5.6 cm. What is its angular frequency?

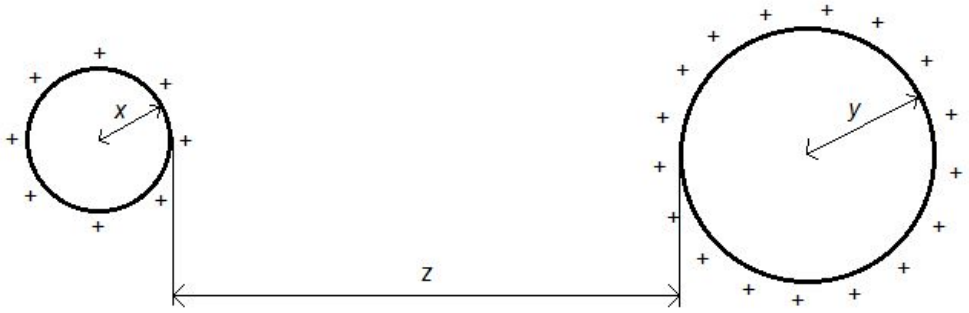
O 0.23 rad s^{-1}
O 21 rad s^{-1}
O 68 rad s^{-1}
O 430 rad s^{-1} [OCR A-level physics]

9. A car enters a roundabout of radius 20 m and accelerates uniformly from 9 ms^{-1} to 14 ms^{-1} over a period of 4.0 seconds. It then exits the roundabout.

The rate of change of the angular speed of the car while on the roundabout was

O 0.56 m s^{-2}
O 0.56 rad s^{-2}
O 0.063 rad s^{-2}
O 0.063 m s^{-2} [AQA A-level further maths]

10. The diagram below shows two uniformly charged spheres separated by a large distance *z*.

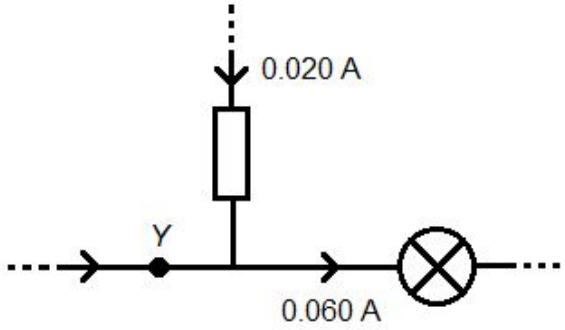


The radius of the smaller sphere is *x* and the radius of the larger sphere is *y*.

Which is the correct distance to use when determining the electric force between the charged spheres?

O *z*
O $x + y$
O $2x + 2y + z$
O $x + y + z$ [OCR A-level physics]

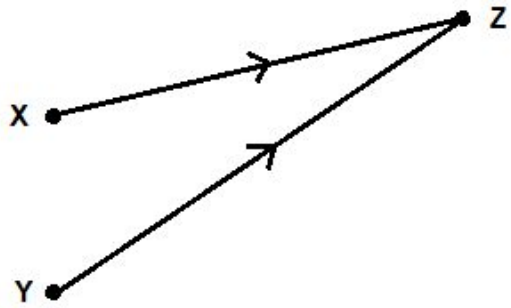
11. Part of an electrical circuit is shown below.



The direction of all the currents and the magnitude of two currents are shown. How many electrons pass through the point *Y* in 10 s?

O 1.25×10^{18}
O 2.50×10^{18}
O 3.75×10^{18}
O 5.00×10^{18} [OCR A-level physics]

12. Coherent radio waves from transmitters **X** and **Y** are emitted in phase. The waves interfere constructively at point **Z**.

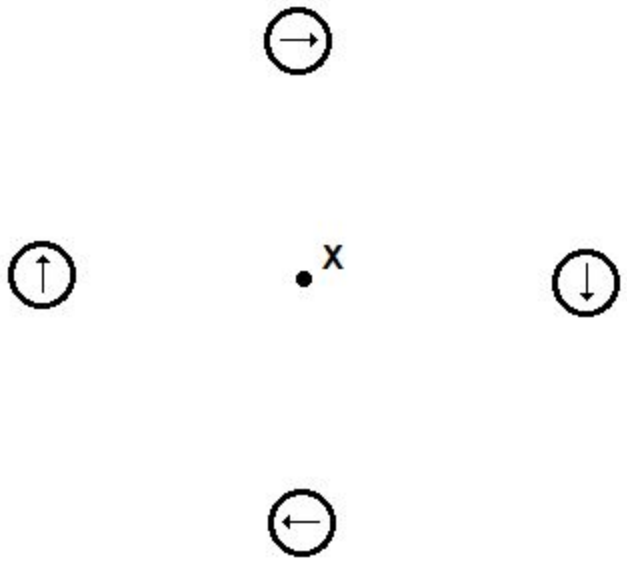


The distance **XZ** is 16.0 m and the distance **YZ** is 20.0 m. The radio waves have wavelength λ.

Which value of λ is **not** possible?

O 1.0 m
O 2.0 m
O 3.0 m
O 4.0 m [OCR A-level physics]

13. The diagram shows four magnetic compasses placed at the same distance from a point **X**.



Which of the following is most likely to be at the point **X**?

O permanent magnet, with north pole coming out of plane of paper
O current-carrying solenoid, with current flowing clockwise
O straight current-carrying wire, with current coming out of plane of paper
O straight current-carrying wire, with current going into plane of paper

[OCR A-level physics]

14. Which of the following statements is/are true about electromagnetic waves?

A They can be plane polarised.
B They can be refracted and diffracted.
C They have the same speed in any medium.

O **A** only
O **C** only
O **A** and **B** only
O **A**, **B** and **C**

[OCR A-level physics]

15. A ray of visible light is propagating through air at speed v_1, with wavelength λ_1 and frequency f_1. With an angle of incidence of 45^o, it then enters a medium with a higher refractive index and travels through the medium with speed v_2, wavelength λ_2 and frequency f_2.

Which of these statements is true?

O $v_1 = v_2$
O $\lambda_1 = \lambda_2$
O $f_1 = f_2$
O None of these [Edexcel A-level physics]

16. Kirchhoff's second law is a direct application of

O Conservation of charge
O Conservation of mass
O Conservation of energy
O Conservation of momentum [OCR A-level physics]

17. Which of these statements related to medical physics and imaging is true?

O In an ultrasound scan, a layer of gel is used to increase the reflection coefficient at the skin-gel boundary

O Bone has a larger X-ray attenuation coefficient than muscle

O The acoustic impedance of a material is the ratio of the speed of sound in the medium to its density

O In the piezoelectric effect, thermal and electrical energy are interconverted

18. A light, elastic string has force constant k, natural length L, and cross-sectional area A. The Young modulus E of the elastic material is given by

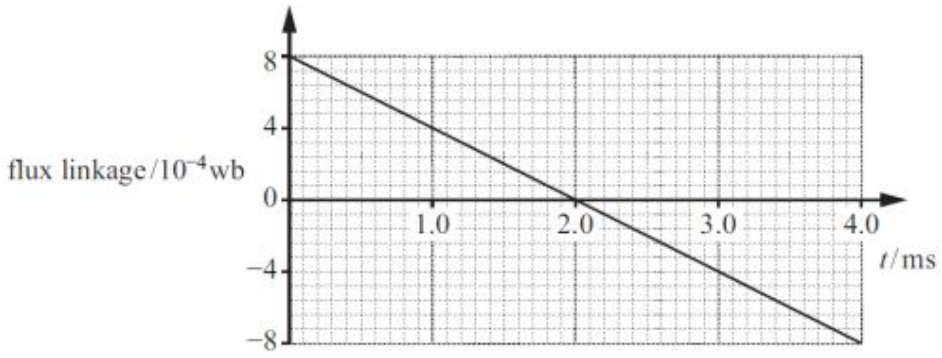
O $E = \frac{kL}{A}$

O $E = \frac{k}{AL}$

O $E = \frac{A}{kL}$

O $E = \frac{AL}{k}$

19. A coil with three turns of wire is used in an experiment. The graph shows the variation of magnetic flux linkage with time t for this coil.

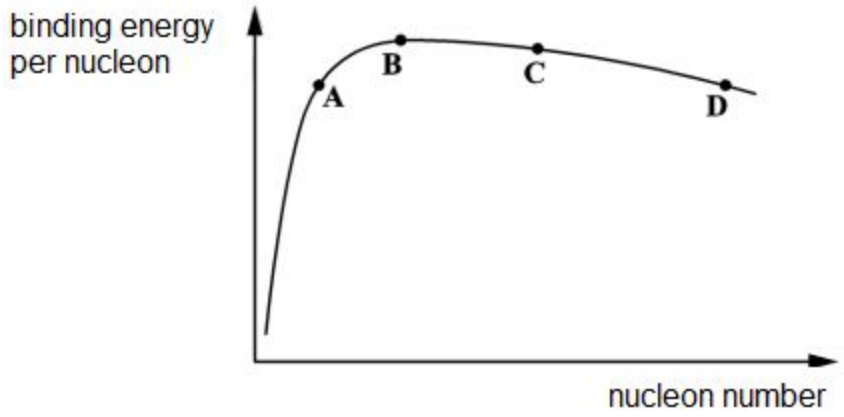


What is the e.m.f. induced across the ends of the coil?

O 0 V
O 0.20 V
O 0.40 V
O 1.2 V

[OCR A-level physics]

20. A graph of binding energy per nucleon against nucleon number is shown below.



Which nucleus has the largest magnitude of binding energy?

O **A**
O **B**
O **C**
O **D** [OCR A-level physics]

21. The potential difference across the cathode and the anode of an X-ray tube is *V*. The minimum wavelength of the X-ray photons emitted from the tube is λ_0.

Which of the following is/are true?

A λ_0 is halved when *V* is doubled.
B λ_0 is unchanged when the temperature of the cathode is increased.
C λ_0 is independent of the cathode material.

O **A** and **B** only
O **B** only
O **A** and **C** only
O **A**, **B** and **C** [OCR A-level physics]

22. Which of these statements about the photoelectric effect is true?

O The work function of a photoelectric material is the energy required to eject one electron from the lowest energy level of a surface atom

O The stopping potential is the equilibrium potential difference between two identical plates of photoelectric material when light is incident on one and electrons travel to the other

O The photoelectric current produced in the circuit increases with the intensity of the incident light

O The De Broglie wavelength of the fastest photoelectrons is less than the wavelength of the incident light

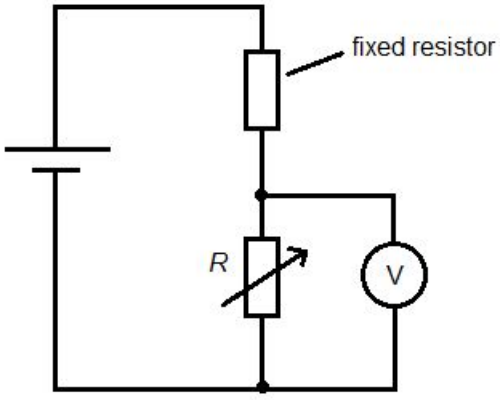
23. A rate of rotation of 72 revolutions per minute is equal to

O 3.8 rad s^{-1}
O 7.5 rad s^{-1}
O 38 rad s^{-1}
O 75 rad s^{-1} [AQA A-level further maths]

24. Which of these lists contains both scalar **and** vector quantities?

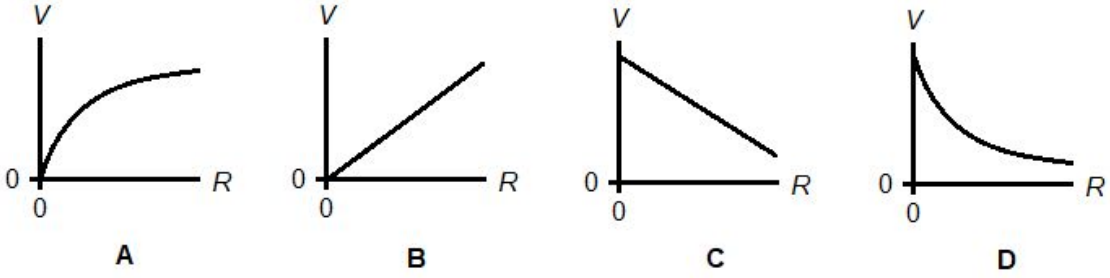
O momentum, angular speed, magnetic flux linkage
O current, Young modulus, half-life
O centripetal force, magnetic flux density, electric field strength
O capacitance, Hubble's constant, work function

25. A potential divider circuit is shown below.



The resistance of the variable resistor is *R*. The potential difference across the variable resistor is *V*.

Which of these graphs shows the correct variation of *R* with *V*?



O **A**
O **B**
O **C**
O **D** [OCR A-level physics]

26. The electric field strength at a distance of 2.0×10^{-8} m from a nucleus is 3.3×10^{8} NC^{-1}. The charge on the nucleus is

O 1.6×10^{-19} C
O 1.5×10^{-17} C
O 7.3×10^{-10} C
O 3.8×10^{-9} C [OCR A-level physics]

27. Wires **P** and **Q**, made from the same metal, are connected in **parallel** across a cell of negligible internal resistance.

Wire **P** has length *L*, diameter *d*, and the mean drift velocity of the electrons in the wire is 0.60 mm s^{-1}. Wire **Q** has length 3*L* and diameter 2*d*.

The mean drift velocity of the electrons in wire **Q** is

O 0.15 mm s^{-1}
O 0.20 mm s^{-1}
O 0.30 mm s^{-1}
O 0.60 mm s^{-1} [OCR A-level physics]

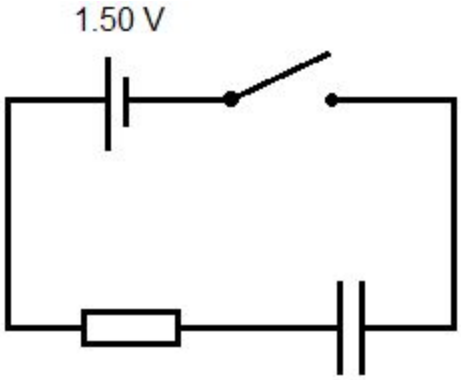
28. A capacitor is discharged through a resistor in series. The capacitor is fully charged at time $t = 0$. The time constant of the circuit is 10 s. Discharging begins at time $t = 0$.

Which row in the table below is correct?

	Current I at $t = 0$	Current I at $t = 10$ s
O	maximum	0
O	maximum	37% of the current at $t = 0$
O	0	63% of the current at $t = \infty$
O	0	37% of the current at $t = \infty$

[OCR A-level physics]

29. A capacitor is charged through a resistor.



The cell e.m.f. is 1.50 V and has negligible internal resistance. The time constant of the circuit is 10 s. The switch is closed at time $t = 0$. At time t, the potential difference across the resistor is 0.60 V.

Which expression is correct?

O $0.60 = 1.50\ e^{-0.10\,t}$
O $0.90 = 1.50\ e^{-0.10\,t}$
O $0.60 = 1.50\ e^{-10\,t}$
O $0.60 = 1.50\ (1 - e^{-10\,t})$ [OCR A-level physics]

30. Photons of wavelength 470 nm are incident on a metal surface of work function 2.3 eV. The de Broglie wavelength of the fastest photoelectrons emitted is

O 1.0 nm
O 2.1 nm
O 3.3 nm
O 8.0 nm

31. A car is travelling along a straight road at 18 ms^{-1}. The driver sees an obstacle and after a reaction time of 0.50 seconds, applies the brakes.

If the **stopping** distance of the car is 38 m, the magnitude of the deceleration of the car when the brakes are applied is

O 4.3 ms^{-2}
O 4.7 ms^{-2}
O 5.2 ms^{-2}
O 5.6 ms^{-2} [OCR A-level physics]

32. The correct option explaining the resistivity ρ of semiconductors as their temperature T varies is

O ρ increases as T increases since the metal ions vibrate with greater amplitude and collide with the conducting electrons more frequently.

O ρ decreases as T increases since the additional energy releases more electrons into the conduction band.

O ρ remains constant as T varies since resistivity is a bulk property of a particular material.

O ρ varies like any other material above a certain critical temperature, but $\rho = 0$ for any T below this temperature due to quantum effects.

33. A particle has a momentum of 30 Ns and a kinetic energy of 150 J.

The mass of the particle is

O 2 kg
O 3 kg
O 5 kg
O 6 kg [Cambridge ENGAA]

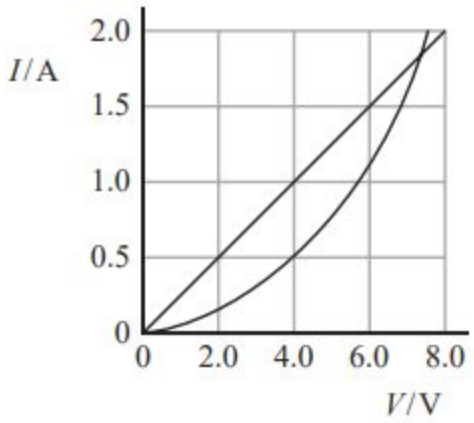
34. A 0.25 kΩ resistor is made of 50 turns of wire that is wound around a non-conducting cylinder of diameter 8.0 mm.

The resistivity of the wire is 4.2×10^{-7} Ωm.

What is the cross-sectional area of the wire?

O 1.93×10^{-9} m^2
O 2.04×10^{-9} m^2
O 2.11×10^{-9} m^2
O 2.29×10^{-9} m^2 [AQA A-level physics]

35. The IV-characteristics of a particular resistor and thermistor are shown.



The resistor and thermistor are connected in series to a 6 V battery of negligible internal resistance. The current in the circuit is

O 0.5 A
O 1.0 A
O 1.5 A
O 2.0 A [Edexcel A-level physics]

36. A light-dependent resistor (LDR) and a fixed resistor are connected in series with a 6 V battery. A voltmeter measures the p.d. across the LDR. In daylight, the voltmeter reads 3.0 V.

Which reading is most likely if the circuit is now in total darkness?

O a little above 0 V
O a little below 3 V
O a little above 3 V
O a little below 6 V [Edexcel A-level physics]

37. A lighthouse emits a beam of light. How far does this light travel in a nanosecond?

O 0.30 mm
O 300 m
O 0.30 m
O 3 pm [Cambridge ENGAA]

38. Which of the following wave properties is **not** exhibited by sound waves?

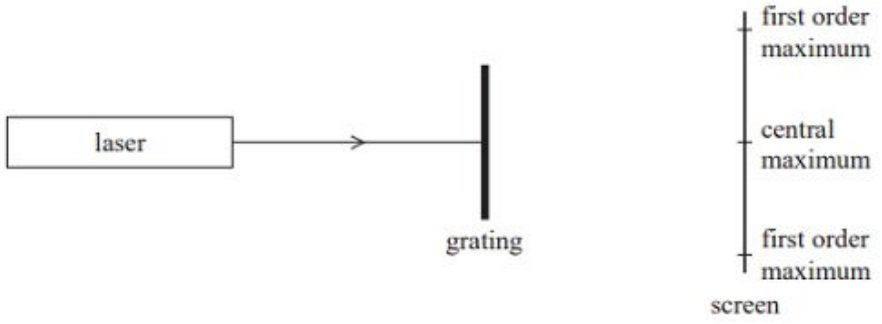
O diffraction
O interference
O polarisation
O reflection

39. A progressive wave of amplitude *a* has intensity I. This wave combines with another wave of amplitude 0.6*a* at a point in space. The phase difference between the waves is 180°.

What is the resultant intensity of the combined waves in terms of I?

O 0.16 I
O 0.4 I
O 1.6 I
O 2.6 I [OCR A-level physics]

40. A beam of light from a laser is directed at a diffraction grating. The diagram shows the positions of the central maximum and the first order maxima on a screen.



Which of the following would cause the first order maxima to be closer to the central maximum on the screen?

O moving the laser closer to the grating
O moving the screen further from the grating
O using a grating with more lines per metre
O using laser light with a higher frequency [Edexcel A-level physics]

41. There are four important attenuation mechanisms by which X-ray photons may interact when they pass through matter.

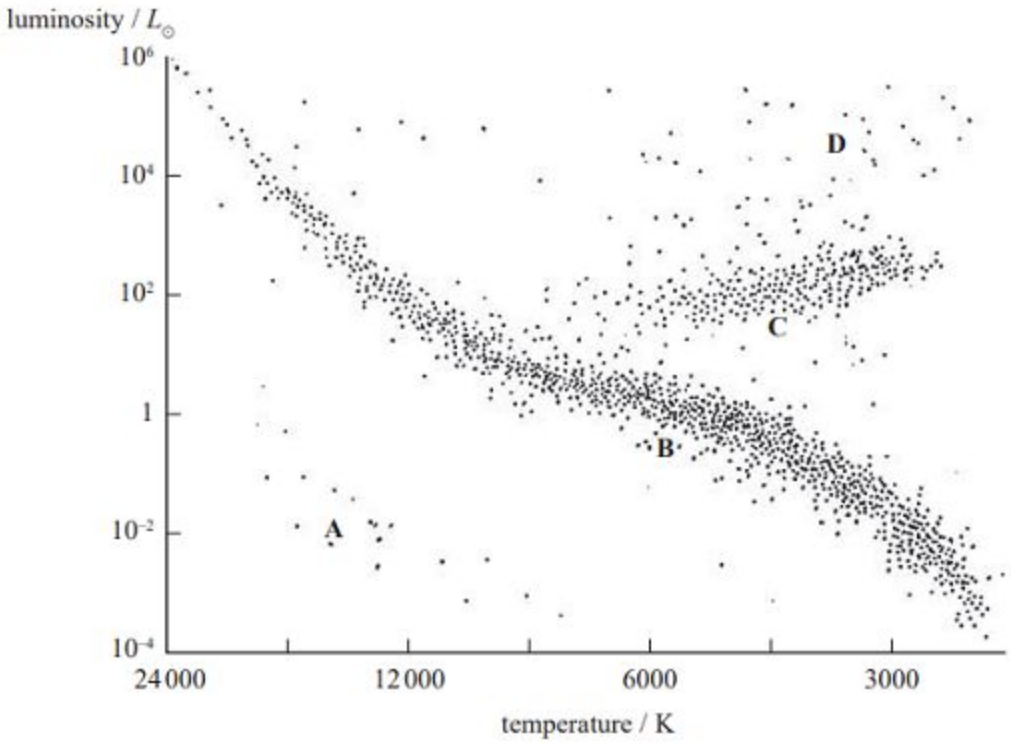
In which mechanism is the X-ray photon scattered with a longer wavelength?

O simple scattering
O Compton effect
O pair production
O photoelectric effect [OCR A-level physics]

42. Stationary waves are produced in a tube closed at one end and open at the other end. The fundamental frequency is 120 Hz. What is a possible frequency of a harmonic for this tube?

O 60 Hz
O 240 Hz
O 360 Hz
O 480 Hz [Cambridge ENGAA]

43. Four regions **A**, **B**, **C** and **D** are labelled on the Hertzsprung-Russell diagram.



Which region includes the position of the Sun?

O **A**
O **B**
O **C**
O **D**

[Edexcel A-level physics]

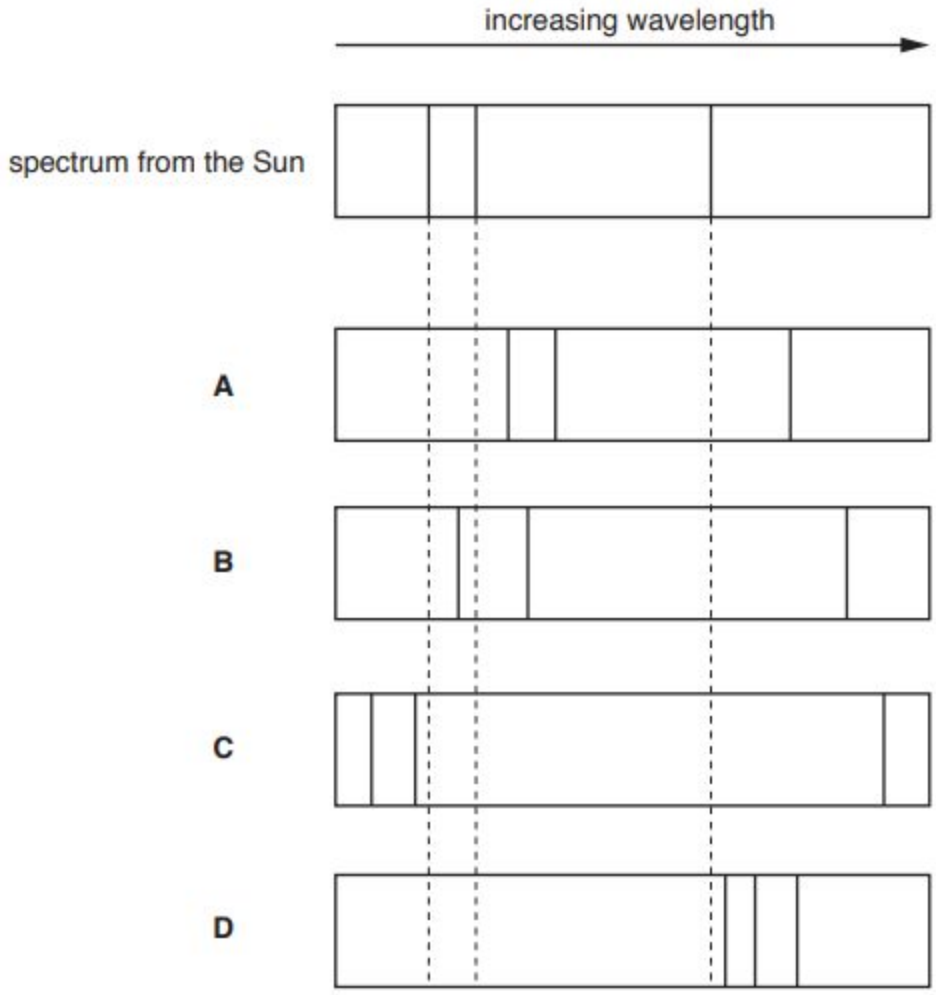
44. An electron has a de Broglie wavelength equal to the wavelength of X-rays. What is the **best** estimate of the momentum of this electron?

O 10^{-30} kg ms^{-1}
O 10^{-27} kg ms^{-1}
O 10^{-23} kg ms^{-1}
O 10^{-18} kg ms^{-1}

[Edexcel A-level physics]

45. Part of the line spectrum for light from the Sun is shown below.

Which spectrum best shows light from a similar star to the Sun?



O **A**
O **B**
O **C**
O **D**

[OCR A-level physics]

46. Which lepton is emitted in the decay of an up quark **and** is affected by a magnetic field?

O neutrino
O electron
O positron
O antineutrino [Edexcel A-level physics]

47. Which of these is **not** an assumption made when modelling a gas as ideal?

O All the particles move with equal kinetic energy but in random directions.

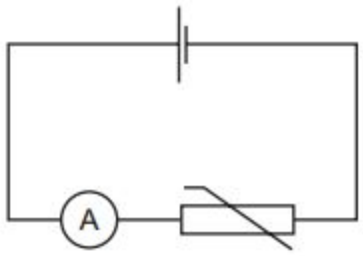
O All collisions between particles are perfectly elastic.

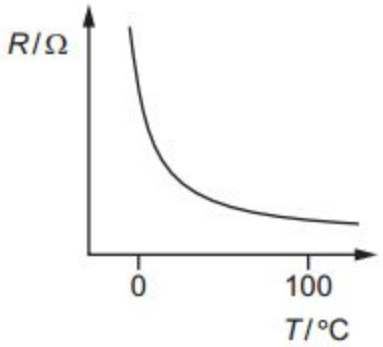
O The time between particle collisions is negligible compared to the duration of any collision.

O There are no forces acting between the particles except contact forces due to collisions.

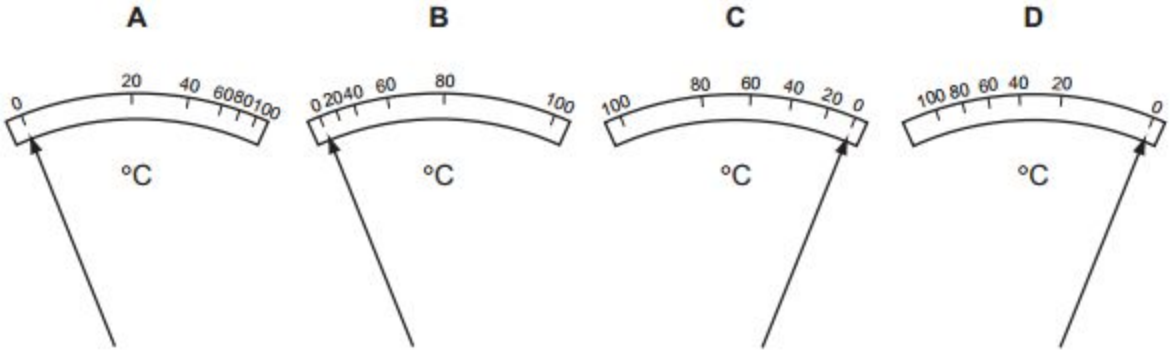
48. An analogue ammeter is to be recalibrated as a thermometer by connecting to a circuit in series with a cell of negligible internal resistance and an NTC thermistor.

The circuit is shown on the left and the variation of temperature with the resistance of the thermistor is shown on the right.





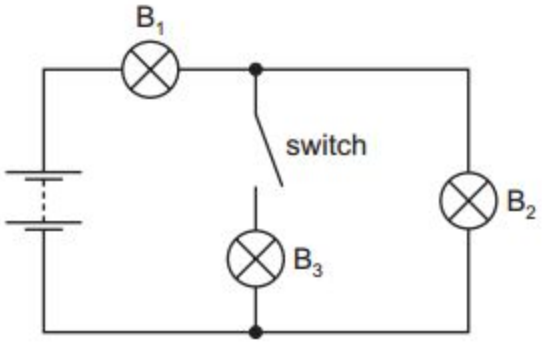
Which diagram could represent the temperature scale on the ammeter?



O **A**
O **B**
O **C**
O **D**

[OCR A-level physics]

49. B_1, B_2 and B_3 are three identical filament lamps connected in a circuit as shown.



The cell has negligible internal resistance. Initially the switch is closed. When the switch opens, which row correctly describes bulbs B_1 and B_2?

	Brightness of B_1	Brightness of B_2
O	increases	increases
O	increases	decreases
O	decreases	increases
O	decreases	decreases

[OCR A-level physics]

50. A child drinks milk of density ρ through a vertical straw. Atmospheric pressure is p_0 and the child is capable of reducing the pressure at the top of the straw through suction by 10%. The acceleration of free-fall is g.

The maximum length of the straw that would enable the child to drink the milk is

O $\dfrac{p_0}{10\rho g}$

O $\dfrac{9p_0}{10\rho g}$

O $\dfrac{p_0}{\rho g}$

O $\dfrac{10p_0}{\rho g}$

[OCR A-level physics]

51. The total quark composition of the nucleons in a $^{7}_{3}$Li nucleus is

O 10 up quarks, 11 down quarks
O 11 up quarks, 10 down quarks
O 7 up quarks, 7 down quarks, 7 strange quarks
O 7 anti-up quarks, 7 anti-down quarks, 7 anti-strange quarks

52. A rectangular building with sides 50 m and 100 m long has a flat roof on top of it. The roof has a mass per unit area of 100 kg m^{-2}. The walls are 10 cm thick.

The ultimate tensile stresses, σ_{max}, of some materials are

Dry wood: 48.3 N mm^{-2}
Concrete: 300 N mm^{-2}
Brick: 7 N mm^{-2}

What materials, if any, could be used for the walls to support the roof?

O Concrete only
O Dry wood or concrete only
O All of these materials
O None of these materials [Oxford PAT]

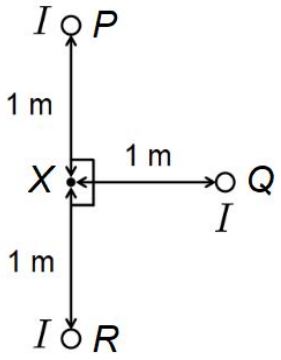
53. A light ray passes through a tall stack of many extremely thin transparent plates with an angle of incidence at the top plate of θ. The refractive index of the top plate is 1.20 and the refractive index of each successive plate is c times that of the previous plate, where c is a constant known to be greater than 1.00 but less than 1.20.

When the light ray has traversed through the full stack of plates, the angle of refraction will be

O slightly greater than 0°
O approximately 56°
O slightly less than 90°
O between 48° and 56° [Oxford PAT]

54. The magnitude of the magnetic flux density **B** at a point located at a distance *r* from a straight conducting wire carrying a current *I* is proportional to *I* and inversely proportional to *r*. When *I* = 1 A and *r* = 1 m, the magnitude of the magnetic field at that point is *B*.

In the case where **three** parallel wires *P*, *Q* and *R* carrying identical currents *I* flowing out of the plane of the paper as shown below, which option correctly describes the magnetic field at point *X*?



O Magnitude: *BI*, direction: downwards
O Magnitude: *BI*, direction: upwards
O Magnitude 3*BI*, direction: out of the plane of the paper
O Magnitude 3*BI*, direction: into the plane of the paper

[Cambridge ENGAA]

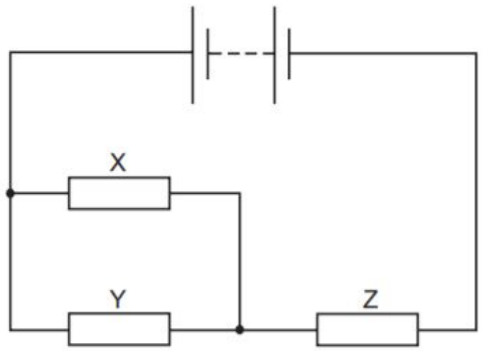
55. A rock falling vertically experiences an air resistance force of 12 N at an instant when its acceleration is 2.0 ms^{-2} downwards.

Taking gravitational field strength as 10 N kg^{-1}, what is the mass of the rock?

O 1.0 kg
O 1.5 kg
O 10 kg
O 12 kg

[OCR A-level physics]

56. The diagram shows a circuit containing a battery of negligible internal resistance and three identical resistors X, Y and Z.



The total power supplied by the battery is 18 W. What is the power dissipated as heat in resistor X?

O 1.5 W
O 2.0 W
O 3.0 W
O 6.0 W [Cambridge ENGAA]

57. Three detectors X, Y and Z are separated by large distances. Each of the detectors records a seismic wave from the same earthquake whose epicentre (source) is very close to the surface of the Earth.

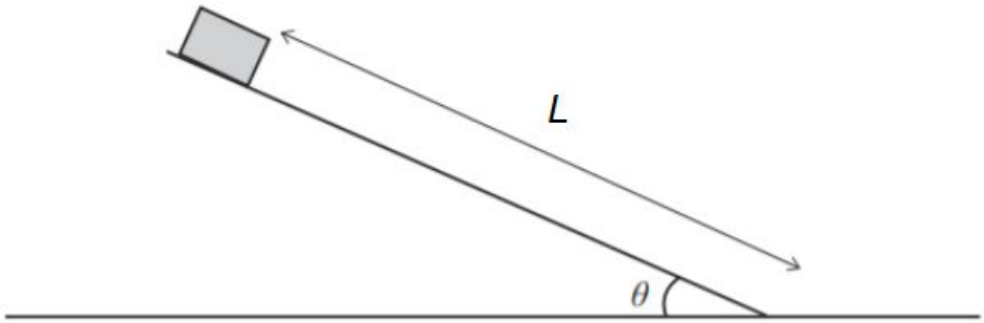
The wave travels out from the epicentre at 4.0 km s^{-1}. Detectors X and Y start to detect the wave at the same time, but detector Z starts to detect it one minute later.

Which of the following statements **must** be correct?

1 The epicentre is at the midpoint of the line XY.
2 Z is equidistant from X and Y.
3 Z is no more than 240 km away from X and from Y.

O **1** and **2** only
O **2** and **3** only
O **1** and **3** only
O None of them [Cambridge NSAA]

58. A block of mass *m* slides a distance *L* down a slope that is inclined at angle *θ* to the horizontal, as shown:



The block experiences a friction force of magnitude *kR*, where *R* is the reaction force exerted on the block and *k* is a constant such that 0 < *k* < tan *θ*. The block starts from rest at the top of the slope and slides down a distance *L* to the bottom, where its potential energy is zero.

What fraction of the initial potential energy at the top has become kinetic energy as the block reaches the bottom?

O $1 - k$

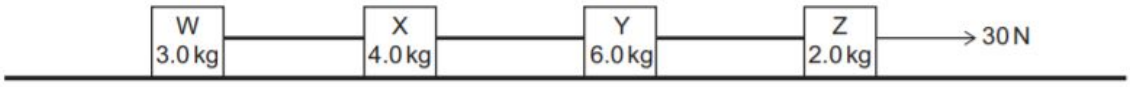
O $\dfrac{1}{1-k}$

O $1 - k\sin\theta$

O $1 - \dfrac{k\cos\theta}{\sin\theta}$

[Cambridge NSAA]

59. The diagram shows four objects W, X, Y and Z, of masses 3.0 kg, 4.0 kg, 6.0 kg and 2.0 kg respectively, connected by light, inextensible rods. The objects are pulled along a smooth, horizontal surface by a constant force of 30 N in the direction indicated.



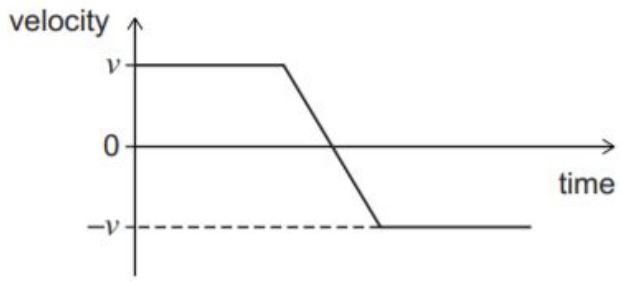
What is the tension in the rod connecting X and Y?

O 10 N
O 12 N
O 14 N
O 16 N

[Cambridge ENGAA]

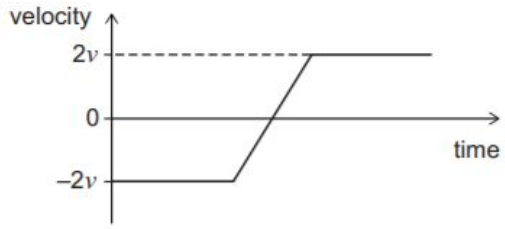
60. Two solid spheres *X* and *Y* have masses *m* and 2*m* respectively. They travel in opposite directions towards each other along the same line with speeds *v* and 2*v* respectively and collide head on.

The graph shows the variation of velocity with time for sphere *X* before, during, and after the collision.

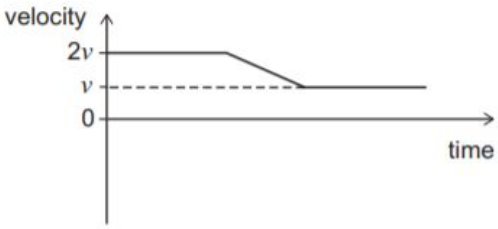


Which sketch shows the variation of velocity with time for sphere *Y*?

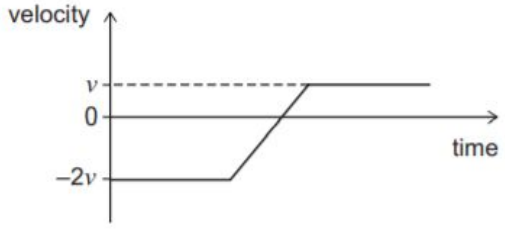
A



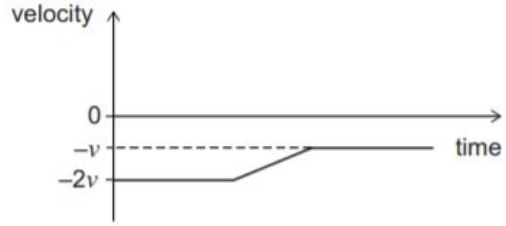
B



C



D



O **A**
O **B**
O **C**
O **D**

[Cambridge NSAA]

61. A helium balloon is held by a light taut inextensible string in the middle of the back of a very powerful truck. The back of the truck is sufficiently large that the balloon cannot hit the sides if it sways forwards or backwards on the string.

The truck now accelerates rapidly forwards. What happens to the balloon?

(The back of the truck is completely enclosed with no airflow from the outside.)

O The balloon sways forwards.
O The balloon sways backwards.
O The balloon does not move.
O The balloon falls to the floor of the truck. [Cambridge ENGAA]

62. The existence of the Chandrasekhar limit a direct result of

O The Schwarzchild radius of a black hole being less than the radius of the white dwarf of the same mass

O The mass of a star in its red giant phase being higher than the mass of the same star in its protostar stage

O The electron degeneracy pressure being constant despite variation in stellar mass

O The neutron degeneracy pressure being constant despite increased density at the core of a red supergiant

63. Two identical cylindrical pipes of length 20 cm are closed at one end and open at the other. A musician can produce a sound by blowing gently across the top of their pipe. The frequency of the sound changes if there is some water filling up the bottom of the pipe.

The musician plays a chord which requires the frequencies of the sounds to be in the ratio 3 : 4, which is done by pouring water to a depth of *h* into **one** pipe.

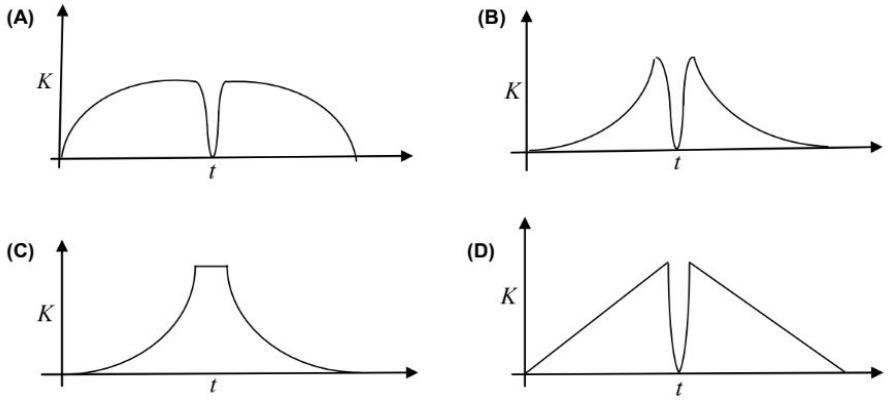
(Assume only the fundamental frequency is played. Ignore end effects.)

What is the value of *h*? [Cambridge NSAA]

O 5 cm
O 7 cm
O 10 cm
O 14 cm

64. A tennis ball is dropped on a horizontal smooth surface. It bounces back to its original position after hitting the surface.

Which graph most appropriately describes the variation of the ball's kinetic energy *K* with time *t* ?



(Assume the force on the ball during its collision obeys Hooke's law.)

O **(A)**
O **(B)**
O **(C)**
O **(D)** [IIT JEE Advanced]

65. Two electromagnetic waves P and Q travel in a vacuum and the ratio of their wavelengths is:

$$\frac{\text{wavelength of P}}{\text{wavelength of Q}} = 1.0 \times 10^{8}$$

Which row in the table shows the ratio of their speeds, the ratio of their frequencies, and identifies the possible natures of P and Q?

	$\frac{\text{frequency of P}}{\text{frequency of Q}}$	*nature of P*	*nature of Q*
O	1.0×10^{-8}	microwave	X-ray
O	1.0×10^{-8}	infrared	microwave
O	1.0×10^{8}	visible light	gamma ray
O	1.0×10^{8}	radio wave	ultraviolet

[Cambridge ENGAA]

66. The secondary coil of an ideal, 100% efficient transformer is connected to a resistor by cables of total resistance 1500 Ω. The current in the primary coil is 4.0 A.

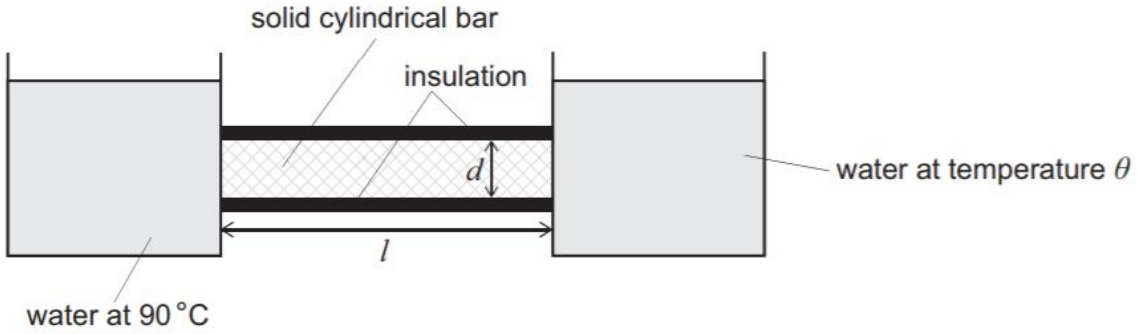
There are 240 turns in the primary coil and 4800 turns in the secondary coil.

What is the power produced as heat in the cables?

O 64 W
O 330 W
O 6.4 kW
O 24 kW

[Cambridge ENGAA]

67. Two tanks of water are connected by a solid cylindrical copper bar of length l and diameter d. The bar is insulated. One tank contains water at 90 °C and the other tank contains water at temperature θ.



For which of the following conditions is thermal energy conducted along the bar at the lowest rate?

O l = 0.80 m, d = 4 cm, θ = 40 °C
O l = 0.40 m, d = 4 cm, θ = 20 °C
O l = 0.80 m, d = 8 cm, θ = 20 °C
O l = 0.40 m, d = 8 cm, θ = 40 °C [Cambridge ENGAA]

68. The kinetic energy of an object of mass 4.0 kg, travelling in a straight line, increases from 32 J to 200 J in 3.0 seconds due to a constant resultant force.

What is the value of this resultant force?

O 2.0 N
O 4.0 N
O 8.0 N
O 24.0 N [Cambridge ENGAA]

69. The mean drift velocity of ions in an electrolyte is directly proportional to the (all else equal)

O potential difference across the ends
O length of the electrolyte container
O concentration of ions in solution
O magnitude of charge on each ion

70. An astronaut on the Moon fires a bullet from a gun vertically upwards. The bullet has a mass of 5.0 g and is fired with a muzzle velocity of 240 ms^{-1}.

The mass and radius of the moon is 7.4×10^{22} kg and 1700 km respectively. Find the maximum height of the bullet above the surface of the moon.

(You may **not** assume a uniform gravitational field. Neglect the gravitational influence of the Earth and the Sun.)

O 12 km
O 15 km
O 17 km
O 20 km

71. Which of these mechanical properties is **not** a bulk (intensive) quantity?

O ultimate tensile strength
O compliance
O Young modulus
O yield stress

72. The psi is an everyday unit of pressure. It is defined as the pressure exerted by a mass of one pound (lb) over an area of one square inch (in).

A bicycle pump is advertised as having a maximum pressure of 120 psi (relative to atmospheric pressure).

Express 120 psi in S.I. units is

(Given: 1 lb = 0.454 kg, 1 inch = 2.54 cm; round the answer to 2 s.f.)

O 84 kPa
O 830 kPa
O 1.6 MPa
O 2.1 MPa

73. The gradient of a graph of gravitational potential, *V*, against distance from the centre of mass, *r*, of a spherical planet of uniform density represents the

O mass of the planet

O $\frac{1}{G}$, where *G* is the gravitational constant

O magnitude of the gravitational field strength

O gravitational potential energy [OCR A-level physics]

74. A neutron is absorbed by a uranium-235 nuclide. The resulting nuclide undergoes fission to produce a bromine-88 nuclide, a lanthanum-145 nuclide and some neutrons.

The lanthanum-145 (^{145}La) nuclide is radioactive and undergoes β^- decay.
How many neutrons are emitted in the fission reaction and how many protons are there in the nuclide formed by the decay of lanthanum-145?

(Element symbols and proton numbers: uranium (U) = 92, bromine (Br) = 35)

	neutrons emitted in fission	*protons in* ^{145}La *decay product*
O	2	56
O	2	57
O	3	57
O	3	58

75. The nucleus of the ion Q^{2+} contains *x* neutrons and *x* – 3 protons.

How many electrons does the neutral Q **atom** contain?

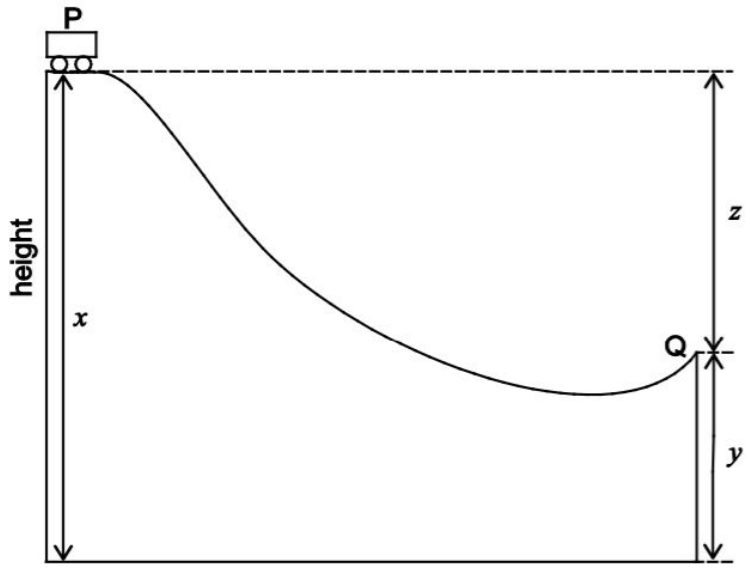
O *x*

O *x* – 1

O *x* – 3

O *x* – 5 [Cambridge NSAA]

76. The diagram shows a truck on a section of a roller coaster ride.



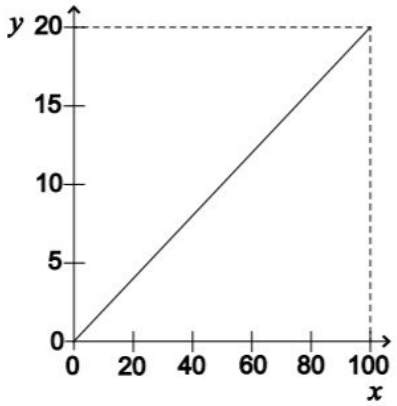
The truck is launched from position P as shown, and moves along frictionless rails towards position Q. The values of the Earth's gravitational field strength and the initial speed of the truck are known.

Which single additional piece of information is needed to be able to calculate the speed of the truck at Q?

(Assume air resistance is negligible and the truck has no internal power source.)

O mass of the truck
O distance *x*
O distance *z*
O distance from P to Q along the rails

77. Consider this graph of two physical quantities *x* and *y*.



Which of the following could the graph **not** represent (assuming axes are indicated in S.I. units) ?

O The variation of the acceleration (y-axis) of a body of mass 5.0 kg with the resultant force acting on the body (x-axis).

O The variation of the current (y-axis) through a 5.0 Ω resistor with the applied voltage (x-axis).

O The variation of the kinetic energy (y-axis) of a body of mass 0.4 kg with the square of its speed (x-axis).

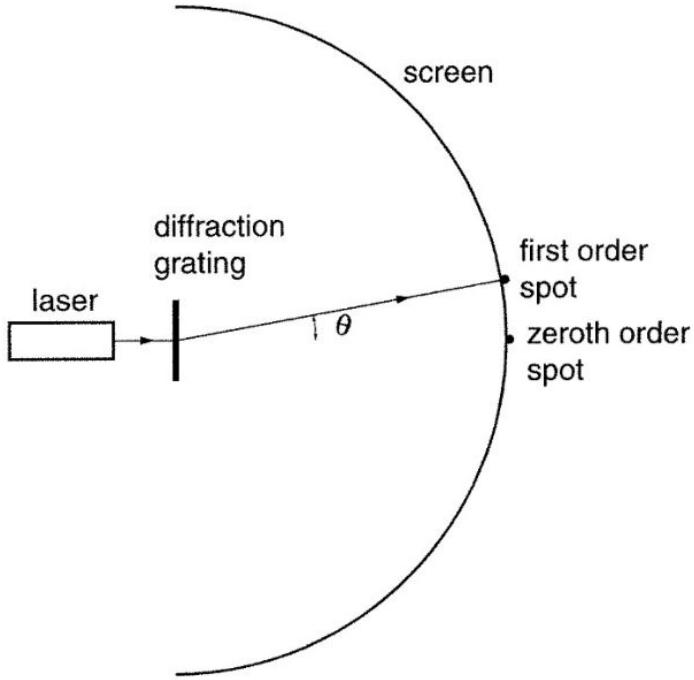
O The variation of the wavelength (y-axis) of waves with a speed of 0.2 ms^{-1} with their frequency (x-axis)

78. In 2020, NASA measured the value of the Hubble constant as 73 km s^{-1} Mpc^{-1}.

The implied expansion timescale (i.e. extrapolated age) of the universe is

O 12.7 billion years
O 13.0 billion years
O 13.4 billion years
O 13.6 billion years

79. A parallel beam of red light of wavelength 630 nm from a laser is incident normally on a diffraction grating. A semi-circular screen subtending an angle of 180° is centred at the point of diffraction, oriented normal to the plane of the diffracted laser light as shown.



The grating has 300 lines per millimetre. How many spots appear on the screen?

(Assume all spots are of sufficient intensity to be viewed correctly.)

O 5
O 6
O 10
O 11

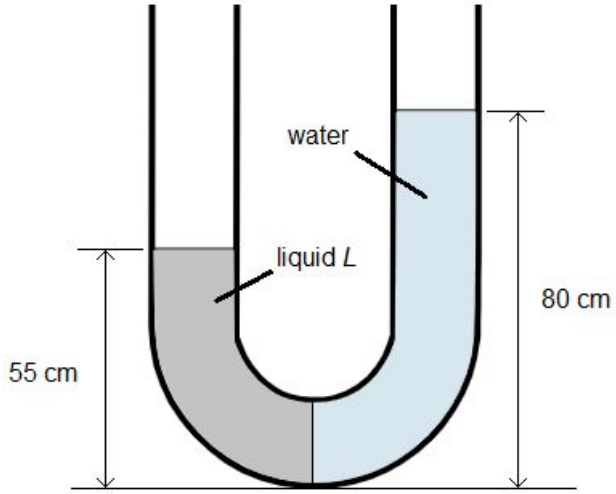
80. One mole of a monatomic ideal gas is at temperature 300 K and pressure 100 kPa. It is then compressed isothermally to half its initial volume.

The percentage increase in the root-mean-square speed of the particles in the gas is

O 0%
O 4%
O 29%
O 50%

Section B: Standard.

1. Water (density: 1000 kg m^{-3}) and an unknown liquid *L* are poured into separate ends of a frictionless U-shaped tube. The fluids do not mix and reach equilibrium with the levels of the water and *L* above the bottom of the tube at 80 cm and 55 cm respectively, and the boundary between the fluids at the midpoint:



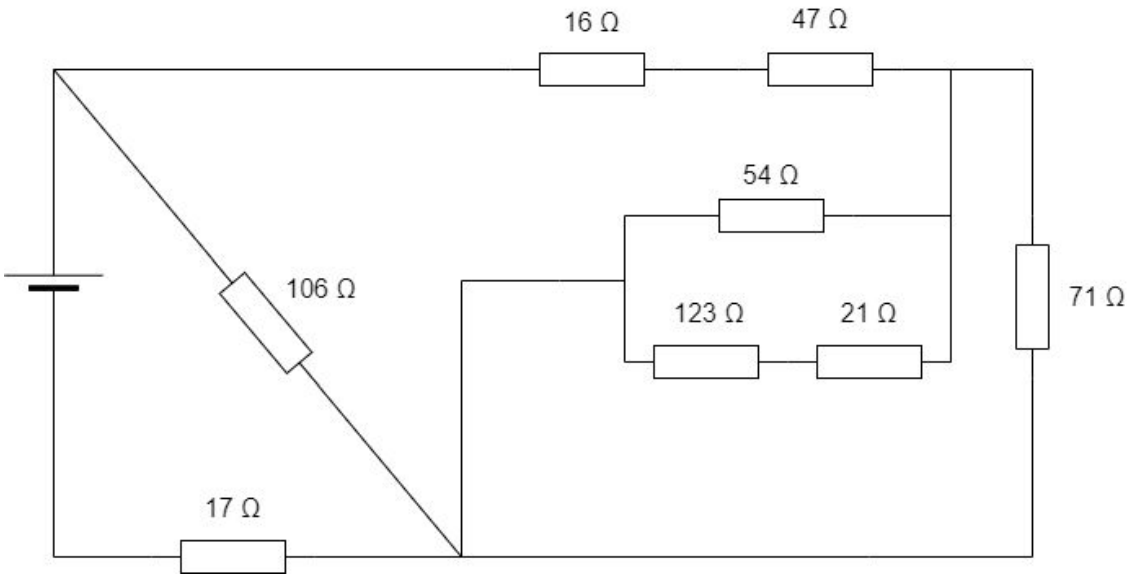
The density of liquid *L* is

O 310 kg m^{-3}
O 690 kg m^{-3}
O 1500 kg m^{-3}
O 3200 kg m^{-3}

2. The area under a stress-strain curve for a particular material represents the

O Young modulus of the material
O Elastic potential energy stored per unit volume of material
O Extension per unit cross-sectional area of material
O Energy lost to the surroundings as heat

3. What is the equivalent resistance of the following resistor circuit?



O 54.9 Ω
O 60.1 Ω
O 65.2 Ω
O 78.0 Ω

4. A transverse wave with an amplitude of 4.0 cm and a frequency of 10 Hz travels along a rope at a speed of 2.4 ms^{-1} .

What is the total distance travelled by a particle in the rope in a time of 20 s?

O 32 m
O 48 m
O 80 m
O 96 m [Cambridge ENGAA]

5. A ball rolls on a smooth horizontal table and collides with a fixed vertical wall.

Immediately before the collision, the ball moves with speed 7 ms^{-1} at an angle of 40^0 to the wall. Immediately after collision, the ball moves with speed 5 ms^{-1} at an angle of 26^o to the wall.

Which of these statements is true?

O This collision is elastic.
O The surface of the wall is smooth.
O The total force exerted by the wall acts perpendicular to the wall.
O Momentum is transferred through the wall to the Earth.

[AQA A-level further maths]

6. A ripple tank was used to investigate the relationship between the speed of a surface water wave v and the depth of the tank d.

It is thought that the relationship between the variables is of the form $v = k\,d^{\,n}$, where k and n are constants. When a graph of ln v on the y-axis against ln d on the x-axis was plotted, the line of best fit had a gradient of 0.5.

The relationship between v and d, based on this data, is of the form

O $v = 2\,d^{\,k}$, where k has no units
O $v = k\,d^{\,2}$, where k has units of $ms^{-1/2}$
O $v = k \ln d$, where k has units of ms^{-1}
O $v = k\sqrt{d}$, where k has units of $m^{1/2}s^{-1}$

7. The diameter of the Sun is known to be $(1.39 \pm 0.04) \times 10^6$ km and its surface temperature is (5770 ± 9) K.

If the Stefan-Boltzmann constant is known to be 5.67×10^{-8} W m^{-2} K^{-4} correct to 3 significant figures, then the calculated luminosity of the Sun and its associated uncertainty is

O $(3.81 \pm 0.24) \times 10^{26}$ W
O $(3.81 \pm 0.25) \times 10^{26}$ W
O $(1.53 \pm 0.09) \times 10^{27}$ W
O $(1.53 \pm 0.10) \times 10^{27}$ W

8. A radio transmitter transmits a signal at 600 MHz to a receiver 1 km away. In an attempt to double the strength of the signal at the receiver, a second antenna is added at the transmitter, 1 m away alongside the original one, and fed by the same signal.

An engineer notes that instead of improving reception, diffraction effects might actually make reception much worse.

Which of the following provides a valid argument to either support or refute the engineer's prediction?

O Diffraction effects would not be a problem because the waves are too low frequency to produce diffraction effects.

O Diffraction effects would not be a problem as the transmitting antennas are too far apart to produce diffraction effects.

O Diffraction effects will occur, but the maxima would be sufficiently close together that this would not be a problem.

O Diffraction effects could be a problem because the distance between the transmitting antennas is comparable to the wavelength.

[Cambridge ENGAA]

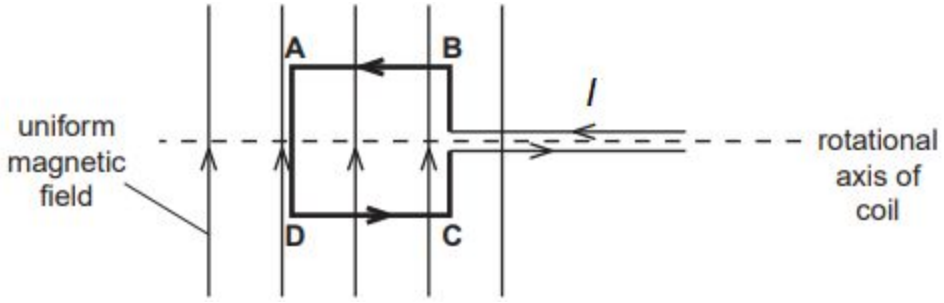
9. The *Digest of UK Energy Statistics (2015)* reports that in the UK in 2014 the total amount of electricity generated was 3.4×10^5 GW h, and it also states that total electricity consumption was 3.0×10^5 GW h.

Which of the following is the main reason for the difference between the figures quoted for generation and consumption?

O Power stations in the UK are on average only about 88% efficient.
O Electrical appliances in the UK are on average only about 88% efficient.
O About 12% of the electricity generated is lost in the distribution network.
O The data on consumption are incomplete.

[Cambridge ENGAA]

10. A current-carrying rectangular coil is placed in a uniform magnetic field.



Initially the plane of the coil is parallel to the magnetic field which is also at right angles to the section **AB** of the coil.

Which of these would increase the torque of the coupled forces acting on **AB** and **CD** in the subsequent motion?

1 Increase the length of the wire in the section **AB** and **CD**

2 Increase the length of the wire in the section **AD** and adjust **BC** to maintain a rectangular coil

3 Increase the magnitude of the current *I*

O **1** and **2** only
O **1** and **3** only
O **2** and **3** only
O **1**, **2** and **3**

[OCR A-level physics]

11. A mass m is attached to one end of a light spring of force constant k and the other end is fixed at a position vertically above the mass. The mass is pulled down and then released at time $t = 0$. The mass performs simple harmonic motion in a vertical line.

At any time t, the displacement of the mass above the equilibrium position is x.

Which, if any, of the following statements is/are true?

1 The sum of the kinetic energy of the mass and the elastic potential energy stored in the spring at any time t is constant.

2 When $x = 0$, the spring is at its natural unstretched length and therefore exerts no thrust or tensile force.

3 At any time t, the velocity of the mass is opposite and proportional to x.

O **1** and **2** only
O **1** and **3** only
O **2** and **3** only
O None of them

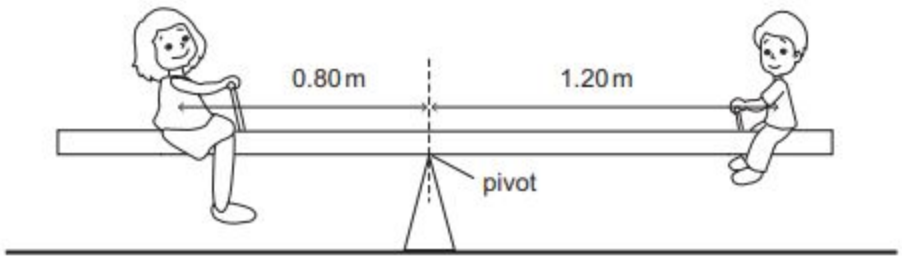
12. A car is driving along a road and approaches a 49 m long bridge and begins accelerating at 0.80 ms^{-2} when it enters the bridge. The car reaches the end of the bridge with a speed of 26 ms^{-1}.

The time taken to drive across the bridge was

O 1.8 s
O 1.9 s
O 4.0 s
O 4.4 s

[AQA A-level maths]

13. A plank of non-uniform density which has a mass of 15 kg is used to make a see-saw. A pivot is placed under the centre of the plank:

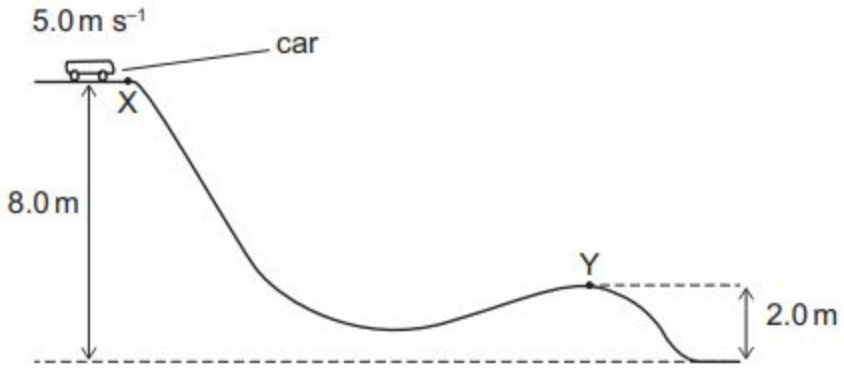


A boy of mass 35 kg sits at one end of the plank with his centre of gravity 1.20 m from the pivot. The see-saw balances when a woman of mass 60 kg sits on the plank on the other side of the pivot. Her centre of gravity is 0.80 m from the pivot.

The position of the centre of gravity of the plank is

O 0.20 m to the left of the pivot
O 0.20 m to the right of the pivot
O 0.40 m to the left of the pivot
O 0.40 m to the right of the pivot [Cambridge ENGAA]

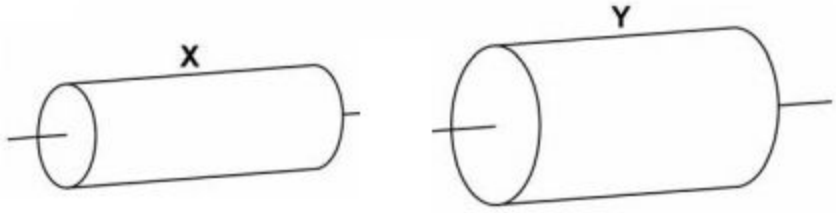
14. A car of mass 200 kg on a fairground ride travels at a speed of 5.0 ms^{-1} at point *X*. The car is allowed to move down a sloping section of track without any energy input. The heights above the ground of points *X* and *Y* are shown. When the car reaches point *Y* its speed is 9.0 ms^{-1}.



How much energy is transferred in overcoming resistive forces as the car travels from *X* to *Y*? (Assume g = 10 N kg^{-1}.)

O 3900 J
O 6400 J
O 7900 J
O 10400 J [Cambridge ENGAA]

15. The two resistors **X** and **Y** shown below are both uniform cylinders of equal length made from the same conducting putty material.



The diameter of **Y** is twice that of **X**. The resistance of **Y** is *R*.

If **X** and **Y** are connected in **parallel**, the total resistance is

O 4/3 *R*
O 4/5 *R*
O 3*R*
O 4*R* [AQA A-level physics]

16. Two radioactive sources *X* and *Y* have half-lives of 4.8 hours and 8.0 hours respectively. Both decay directly to form only stable isotopes. The activity of a sample of the source *X* is 320 Bq, and the activity of a sample of the source *Y* is 480 Bq. The two samples are now combined into a single substance. What is the activity of the combination of *X* and *Y* 24 hours later?

O 25 Bq
O 50 Bq
O 55 Bq
O 70 Bq [Cambridge ENGAA]

17. An incandescent bulb has a thin filament of tungsten that is heated to high temperature by passing an electric current. The hot filament emits black-body radiation. The filament is observed to break up at random locations after a sufficiently long time of operation due to non-uniform evaporation of tungsten from the filament.

If the bulb is powered at constant voltage, which of these is true?

O The temperature distribution over the filament is uniform

O The resistance over small sections of the filament decreases with time

O The filament emits more light at a lower band of frequencies before it breaks up

O The filament consumes less electrical power towards the end of the life of the bulb

[IIT JEE Advanced]

18. A student wants to carry out an experiment to determine the input power to a small electric motor without using electrical meters. The motor is used to lift light loads at steady speeds and works at its maximum power at all times. The efficiency of the motor is known to be 15%. They plan to follow this method:

- Attach a slot mass of 100 g to the motor
- Use the motor to slowly lift the mass through a vertical height of 1.00 m at a constant speed
- Record the time taken (*t* s) for this to happen using a stopwatch and slow-motion camera to improve accuracy
- Add another 100 g mass and repeat for various masses
- Plot a graph of *m* in kg (*y*-axis) against *t* in s (*x*-axis) and obtain the gradient of the best fit line and calculate associated uncertainty
- Use the formula $P_{input} = (g/0.15) *$ gradient to estimate the power input.

Which of the following comments about this method are true?

1 The power input obtained will be an underestimate of the true value.

2 The largest source of uncertainty in this method is due to the slot masses used (typical uncertainty: 5%)

3 The formula derived to calculate the power input is valid only when the motor is lifting the masses at a low speed.

O **1** and **2** only
O **1** and **3** only
O **2** and **3** only
O **1**, **2** and **3**

19. The base S.I. units of resistivity, are

O kg m^3 A^{-2} s^{-3}
O kg A^2 s^{-3} m^{-3}
O kg m^2 A^{-1} s^{-3}
O kg A s^{-3} m^{-2}

20. A liquid at 30 °C is poured very slowly into a copper beaker which is at a temperature of 110 °C. The boiling point of the liquid is 80 °C.

It is found that the first 5 grams of the liquid completely evaporates. After pouring in another 80 grams, the equilibrium temperature is measured to be 50 °C.

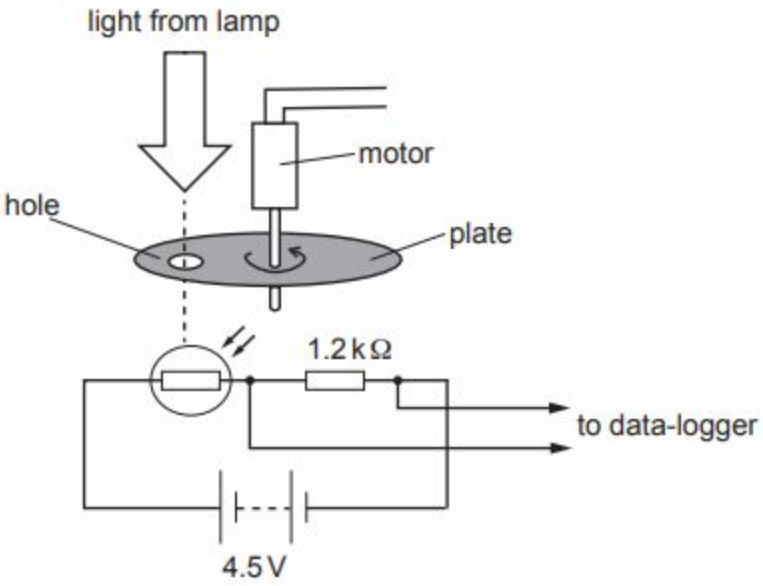
Find the value of

$$\frac{\text{specific latent heat of vaporisation of the liquid}}{\text{specific heat capacity of the liquid}}$$

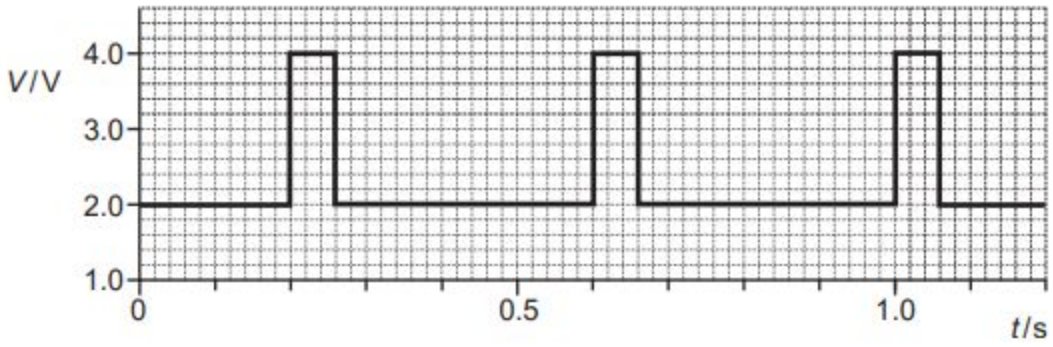
(Neglect heat exchange with the surroundings. Use a consistent system of units.)

O 64 K
O 118 K
O 225 K
O 270 K [IIT JEE Advanced]

21. A metal circular plate is rotated at a constant frequency by an electric motor. The plate has a small hole close to its rim.



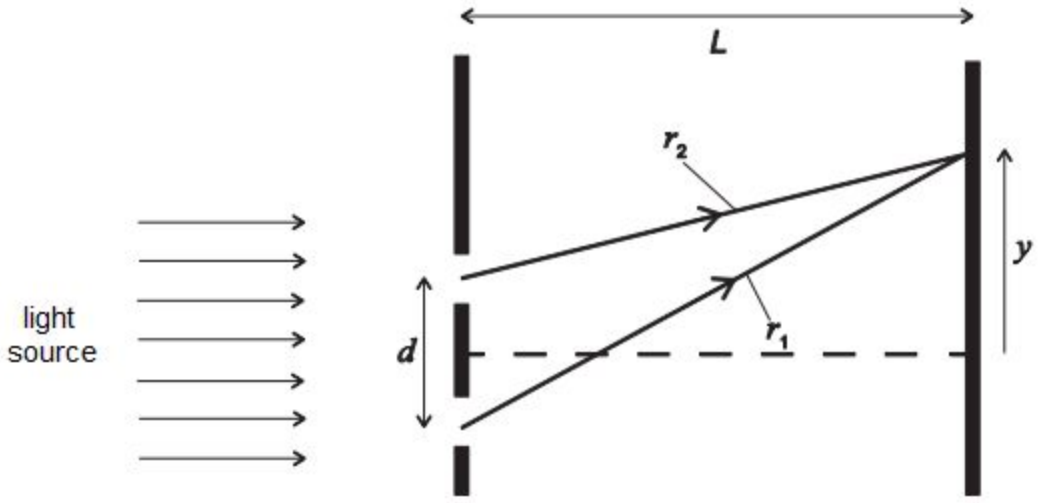
A light-dependent resistor (LDR) and a fixed resistor of resistance 1.2 kΩ are connected in series to a battery. The battery has e.m.f. 4.5 V and has negligible internal resistance. The potential difference *V* across the resistor is monitored using a data-logger. The graph shows the variation of *V* with time *t*.



Which of the following is true?

O The angular frequency of the rotating plate is about 16 rad s^{-1}.
O The resistance of the LDR when exposed to the lamp is 450 Ω less than its resistance when it is shielded from the lamp.
O Both of the above.
O None of the above.

22. The diagram shows the geometry for two slit diffraction of light, with the slits on the left and the viewing screen on the right, with slit separation *d* and distance *L* such that *d* << *L*;



The pair of slits is illuminated by coherent laser light of wavelength λ = 600 nm. A diffraction pattern appears on the viewing screen.

A thin piece of transparent material, thickness 300 nm and in which the speed of light is half that in air, is now placed immediately behind **one** of the two slits.

What happens to the diffraction pattern and why?

O The diffraction pattern is unchanged because the light is still coherent.

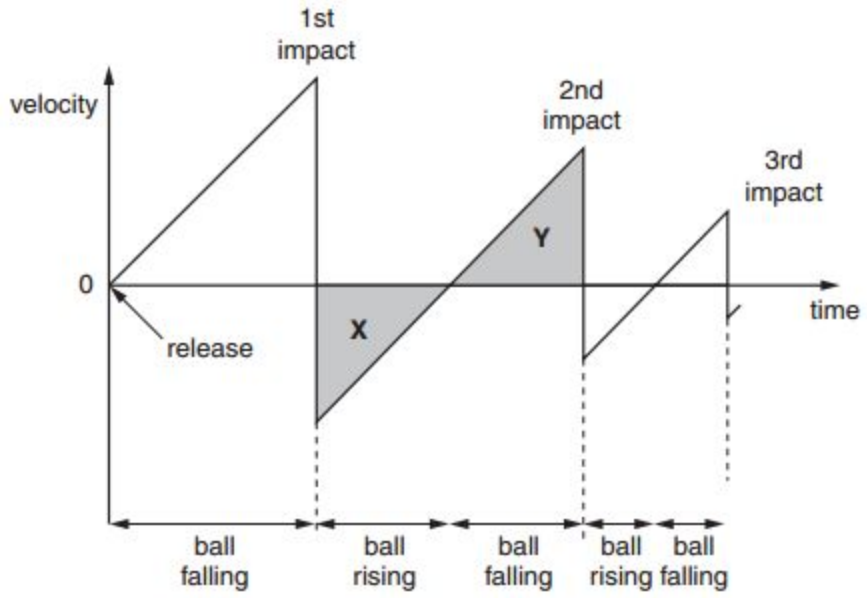
O The diffraction pattern disappears because the light from the two slits is no longer in phase.

O The complete diffraction pattern shifts in the *y*-direction because the path difference required for a maxima to appear has changed.

O Each maximum is replaced by two because the material halves the wavelength of the light coming from it.

[Cambridge ENGAA]

23. A ball is released from rest above a horizontal surface. The graph shows the variation of time with its velocity.



Areas **X** and **Y** are equal because

O the ball's acceleration is the same during its upward and downward motion.

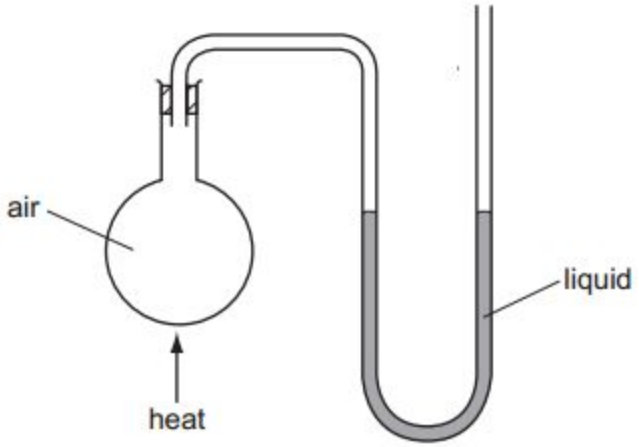
O the speed at which the ball leaves the surface after its impact is equal to the speed at which it returns to the surface for the next impact.

O for any particular impact, the speed at which the ball hits the surface is equal to the speed at which it leaves the surface.

O the ball rises and falls through equal distances between impacts.

[OCR A-level physics]

24. The diagram shows a flask connected to a U-tube containing liquid. The flask contains air at atmospheric pressure.



The flask is now gently heated and the liquid level in the right-hand side of the U-tube rises through a distance h. The density of the liquid is ρ.

The increase in the pressure of the air in the flask is

O 0

O $\frac{1}{2}\rho hg$

O ρhg

O $2\rho hg$

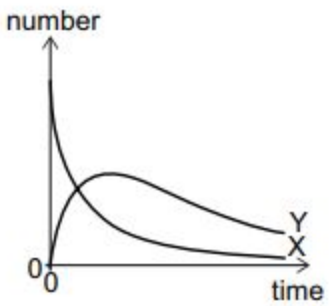
[OCR A-level physics]

25. A sample of a radioactive isotope X decays to one other radioactive isotope Y. Y has a half-life that is double that of X. Initially only X is present.

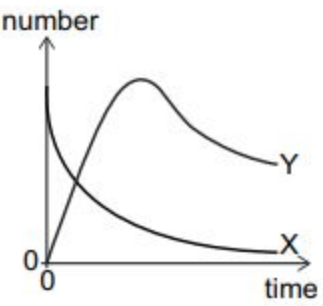
Which graph could represent how the numbers of nuclei of X and Y that are present in the sample vary with time?

(All graphs cover the same period of time.)

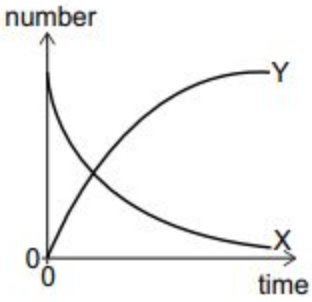
A



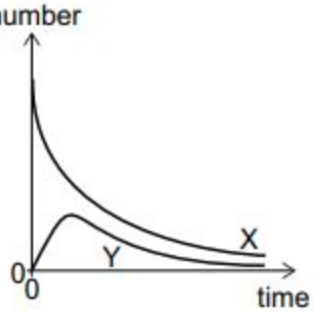
B



C



D



O **A**
O **B**
O **C**
O **D**

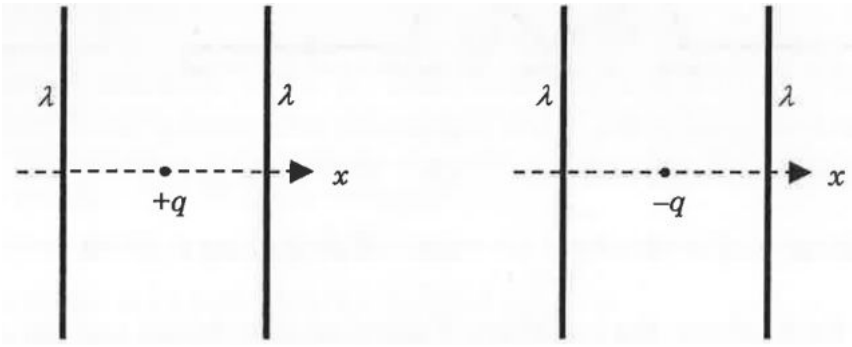
[Cambridge NSAA]

26. A nuclear power plant supplying electrical power to a city uses uranium-235 of half life T years as fuel. The amount of fuel at the beginning is such that the total power requirement of the city is 12.5% of the electrical power available from the plant at that time.

For how many years is this power plant able to meet the energy requirements of this city? (Assume the city's power consumption remains constant.)

O T years
O $3T$ years
O $6T$ years
O $8T$ years [IIT JEE Advanced]

27. The figures below depict two situations in which two long static positive line charges of charge density λ C m^{-1} are fixed parallel to each other. In their resulting electric field, point charges $+q$ and $-q$ (where $q > 0$) are kept in equilibrium between them.



You are given that the electric field strength at a distance x from **one** line charge in isolation is equal to $\frac{\lambda}{2\pi\varepsilon_0 x}$.

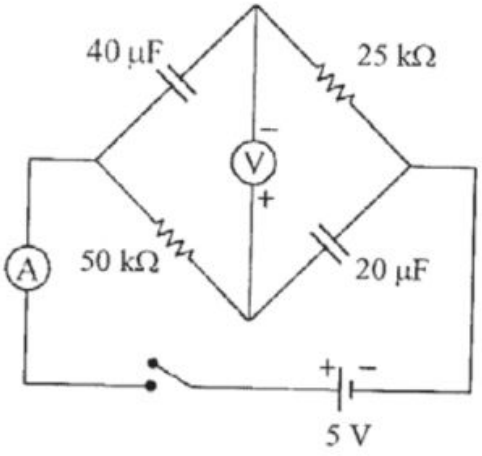
If the point charges are given a **small** displacement about their equilibrium positions, then which row of the table describes their subsequent motion?

(The point charges are confined to move in the x-direction only. Neglect resistive forces.)

	motion of charge +q	*motion of charge -q*
O	executes simple harmonic motion	continues moving in direction of its displacement
O	executes simple harmonic motion	executes simple harmonic motion
O	continues moving in direction of its displacement	continues moving in direction of its displacement
O	continues moving in direction of its displacement	executes simple harmonic motion

[IIT JEE Advanced]

28. In the RC circuit below, the switch is pressed closed at time t = 0 seconds:



(All capacitors are initially fully discharged. The polarity of the voltmeter is as shown, with a positive reading if the potential at the + terminal is greater than that at the - terminal.)

Which of these is **false**?

O The voltmeter displays +5 V as soon as the switch is pressed, and displays -5 V after a long time

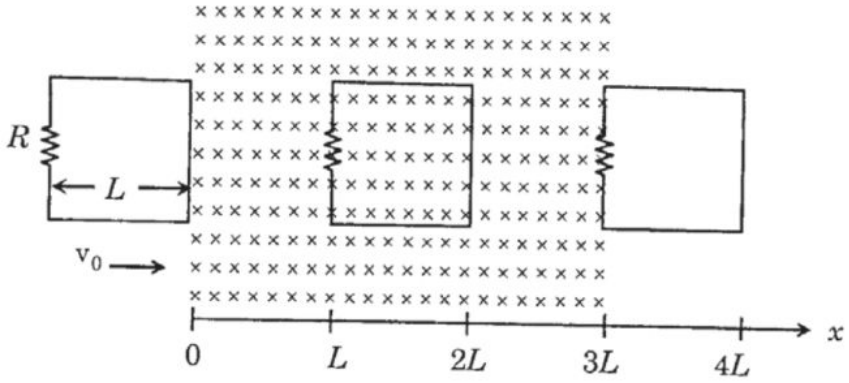
O The voltmeter will display 0 V at $t = \ln 2$

O The current in the ammeter becomes $1/e$ of its initial value at t = 1

O The current in the ammeter becomes zero after a long time

[IIT JEE Advanced]

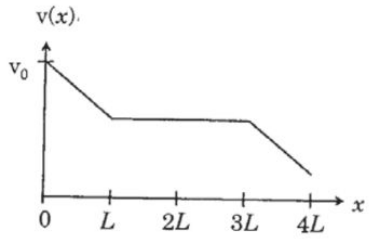
29. A rigid square wire of side length L and resistance R is moving along the x-axis in the plane of the paper. At time $t = 0$, the leading edge of the square enters a uniform magnetic field region pointing into the plane of the paper as shown.

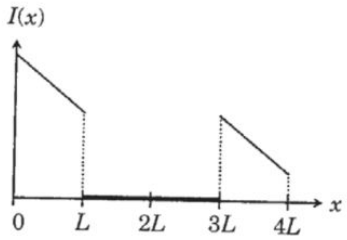


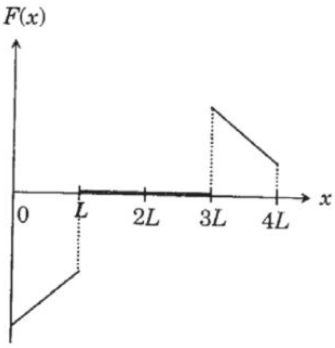
For a sufficiently large initial speed v_0 into the magnetic field, the loop crosses the region and emerges at the other side. Let x be the position of the leading edge of the loop on the length-scale shown. Let v, I and F be the velocity of the loop, current in the loop and force exerted on the loop respectively.

(Positive values of I represent currents directed anti-clockwise. Neglect gravity.)

Which graph, if any, of v, I or F as a function of x could be correct?

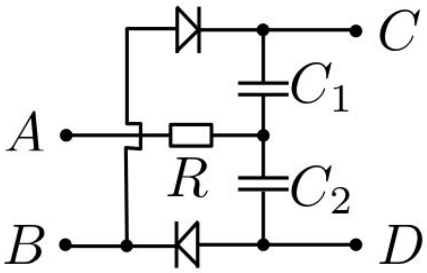






O the graph of $v(x)$
O the graph of $I(x)$
O the graph of $F(x)$
O none of them [IIT JEE Advanced]

30. Consider the circuit below.



Terminals *A* and *B* are connected across mains voltage at time $t = 0$, providing **alternating** current at 50 Hz between peaks and troughs of ± 340 V. When the capacitors are fully charged, the mains supply is disconnected at $t = T$.

(Assume the capacitors and diodes are rated to not break down at this voltage. Terminal *A* is connected to the **negative** terminal of the mains supply.)

For all times $0 < t < T$, which of these is true?

O The two capacitors alternate between charging and retaining their charge, and the charging cycles are **in phase** with each other.

O The two capacitors alternate between charging and retaining their charge, and the charging cycles are **180° out of phase** with each other.

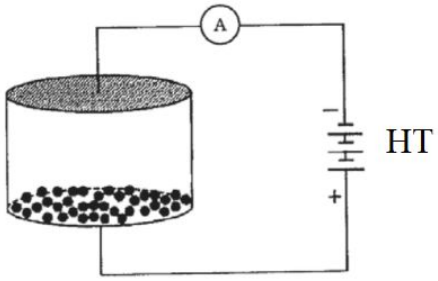
O When the capacitors are fully charged, the terminal *CD* acts as a d.c. source of e.m.f. 340 volts.

O When the capacitors are fully charged, the terminal *CD* acts as an a.c. source with e.m.f. of amplitude 680 volts.

[Cambridge NSAA]

31. *[There are **two** parts to this question]*

An evacuated cylindrical chamber of height h consisting of two parallel metal conducting plates. At time *t* = 0, a high-voltage (HT) source is connected as shown, with the bottom plate at potential $+V_0$ and the top plate at potential $-V_0$, and an ammeter is attached as shown:



Inside the cylinder are a large number of small, light spherical balls, initially at rest on the bottom plate. The surfaces of the balls are **conducting**, and as a result, the balls will get charged, become equipotential with the bottom plate and be repelled by it. Eventually the balls will collide with the top plate.

(Assume the electric field inside the cylinder can be modelled as that of a parallel-plate capacitor, and that the balls do not collide with each other during their motion. Neglect gravity)

a. What happens next?

O The balls will stick to the top plate and remain there.

O The balls will bounce back to the bottom plate, carrying the same charge (both magnitude and sign) as they went up with.

O The balls will bounce back to the bottom plate, carrying the opposite charge (same magnitude, opposite sign) as they went up with.

O The balls will execute simple harmonic motion between the two plates.

b. The average current registered by the ammeter as $t \to \infty$ is

O zero

O proportional to $\sqrt{V_0}$

O proportional to V_0

O proportional to V_0^2

[IIT JEE Advanced]

32. A long section of a straight horizontal train track is shrouded in a thick fog at night. A railway signal, which emits a light of intensity I_0, is located beside the track. The attenuation of the light due to the fog follows an exponential decay.

The train driver of an oncoming train at constant speed notices the railway signal at a distance d_{fog} when in the fog. Another night, under the same conditions, except that now the fog has cleared, the driver sees the signal at a distance d_{clear}.

Which of these is a reasonable claim to make when evaluating this situation?

(Neglect the reaction time of the driver to observe the signal.)

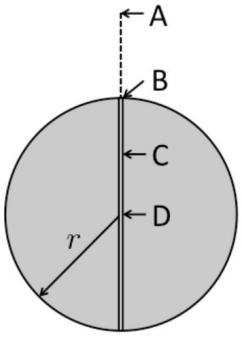
O The attenuation coefficient of the light is higher at night than in daylight.

O The intensity of the light follows an inverse square law with distance.

O The intensity of the light decays exponentially.

O The ratio of $\frac{d_{fog}}{d_{clear}}$ decreases with an increase in the density of the fog.

33. A particular planet does not rotate. There is a linear tunnel through the centre of the planet as shown in the figure. Consider a small object travelling from *A* to *D*.

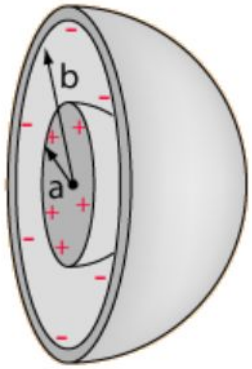


At which point will the magnitude of the gravitational pull by the planet on the object be greatest? (Assume the spherical planet's density is uniform.)

O at *A*, somewhere above the planet
O at *B*, the surface of the planet
O at *C*, the midpoint of *BD*
O at *D*, the centre of the planet [Cambridge ENGAA]

34. A spherical shell capacitor is made by applying a potential difference across two surfaces: a smaller sphere of radius a and a larger hollow sphere of radius b, with each sphere sharing a common centre.

When equilibrium is reached, a charge Q is stored on the spheres' surfaces.



What is the capacitance, C, of this capacitor?

(The region between the sphere and the shell is evacuated.)

O $C = 4\pi\varepsilon_0(a+b)$

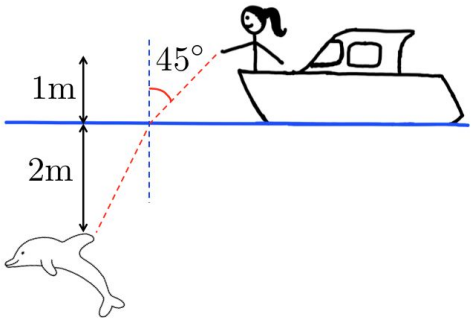
O $C = 4\pi\varepsilon_0(b-a)$

O $C = 4\pi\varepsilon_0\left[\frac{1}{a} - \frac{1}{b}\right]$

O $C = \frac{4\pi\varepsilon_0}{\left[\frac{1}{a} - \frac{1}{b}\right]}$

36. A scientist investigating the movements of dolphins in the Mediterranean uses a dart gun to shoot small, harmless tracking devices onto the fins of dolphins. When standing on deck, her hand is 1 m above the water, and looking along the dart gun she is holding at an angle of 45°, she sees a dolphin.

Using sonar she has found that the dolphin is swimming at a depth of 2 m. The refractive index of water is 1.33.



What angle from the horizontal should she point the dart gun to hit the dolphin?

O 32°
O 45°
O 53°
O 60°

[Cambridge ENGAA]

37. During an experiment to determine the Young modulus of a wire, a micrometer screw-gauge is used to measure the length of the wire. In its unloaded state, the zero of the Vernier scale lies between 3.20×10^{-2} m and 3.25×10^{-2} m of the main scale. The 20th division of the Vernier scale exactly coincides with one of the main scale divisions.

When a load is applied to the wire, the zero of the Vernier scale still lies between 3.20×10^{-2} m and 3.25×10^{-2} m of the main scale but now the 45th division of Vernier scale coincides with one of the main scale divisions.

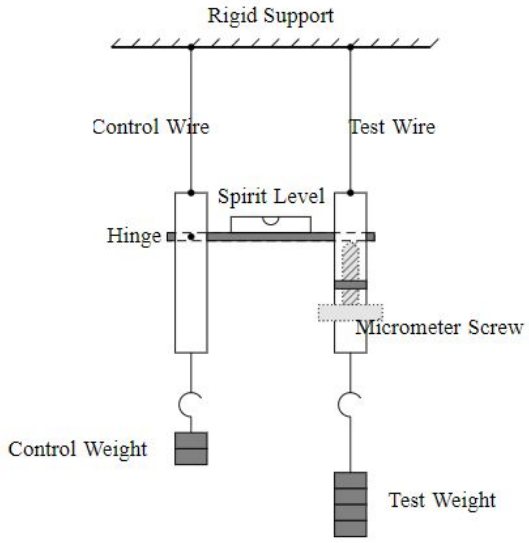
(Given: resolution (least count) of Vernier scale is 10 μm.)

What is the maximum percentage error in the extension of this wire?

O 0.5 %
O 2 %
O 4 %
O 8 %

[IIT JEE Advanced]

38. Searle's apparatus is an alternative high-precision method to measure the Young modulus of a material. In this setup, two long thin wires of identical dimensions (but possibly different material) are suspended from a rigid horizontal beam support, and hinged at the other end to a single platform with a spirit level:



The test wire is made of the material for which the Young modulus is to be obtained. Masses are attached to both wires, with the test wire increasing in load and taking measurements from the micrometer screw-gauge's Vernier scale.

Which of these gives a valid comment on the apparatus used in this setup?

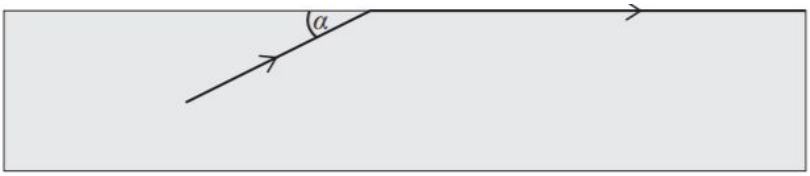
O If the wires are made of different materials, then the different thermal expansions of the wires due to ambient temperature variation during the experiment will introduce an error.

O The percentage error in the Young modulus result would be smaller if the wires were both shorter.

O After adding or removing a load, the measurement should be taken as soon as possible to ensure the material obeys Hooke's law.

O The purpose of the test (control) weight is to ensure that the test wire is just exactly taut i.e. has no tension.

39. Light travelling in a transparent liquid strikes the surface from below. The angle between the surface of the liquid and the direction of travel of the light is α. The light then travels along the surface between the liquid and the air as shown.



Now, light travelling in air strikes the surface from above so that the angle between the surface and the direction of travel of this light is also α. After the light strikes the surface from above, the angle between the surface and the direction of travel of the refracted light is β.

Which expression gives β?

O $\beta = \alpha$

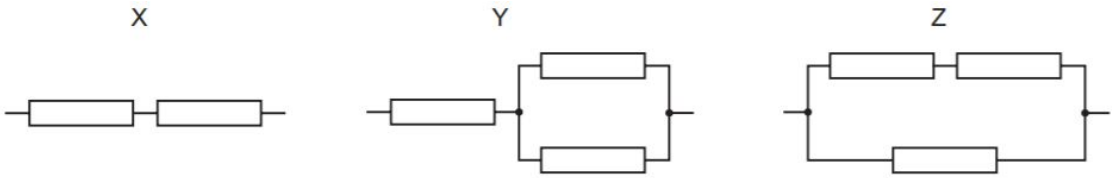
O $\sin\beta = \sin^2\alpha$

O $\cos\beta = \cos^2\alpha$

O $\tan\beta = \cos\alpha \cdot \sin^{-1}\left(\frac{1}{\alpha}\right)$

[Cambridge ENGAA]

40. Identical resistors are used to produce three different arrangements X, Y and Z:



Each arrangement is connected, separately, across identical and ideal batteries, and then the resistive sections submerged in equal volumes of water in identical insulated beakers.

The temperature rise of the water in each beaker after five minutes for arrangements *X*, *Y* and *Z* are denoted ΔT_X, ΔT_Y and ΔT_Z respectively.

What is the correct ordering of ΔT_X, ΔT_Y and ΔT_Z?
(Neglect the conductivity of the water. The water is mixed throughout.)

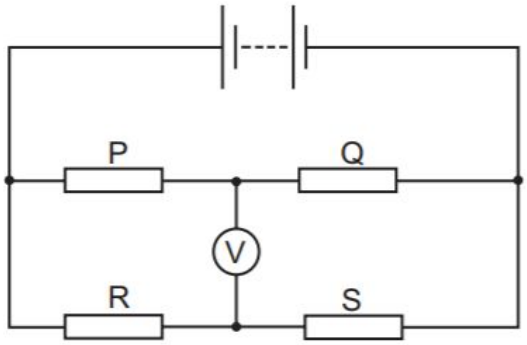
O $\Delta T_X < \Delta T_Y < \Delta T_Z$
O $\Delta T_X < \Delta T_Z < \Delta T_Y$
O $\Delta T_Z < \Delta T_Y < \Delta T_X$
O $\Delta T_Z < \Delta T_X < \Delta T_Y$ [Cambridge ENGAA]

41. A light spring has unstretched length 0.40 m and spring constant 50 Nm^{-1} . The spring is stretched by a varying tension force that starts at a value of zero and increases at a constant rate of 0.20 Ns^{-1} up to a maximum value.

When the force reaches its maximum value, the strain energy of the spring is 0.25 J. What is the average power used to stretch the spring?

O 0.01 W
O 0.02 W
O 1.0 W
O 2.0 W [Cambridge ENGAA]

42. Four resistors, P, Q, R and S, are connected to a battery with negligible internal resistance, as shown in the diagram. P and S each have resistance *x*. Q and R each has resistance 2*x*.

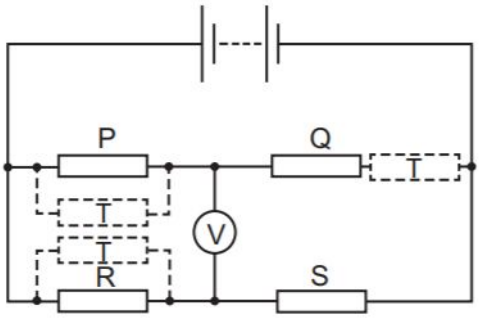


A fifth resistor, T, which has resistance *x*, is to be added to the circuit in **one** of the following listed positions, as shown in the diagram:

1 in parallel with P

2 in series with Q

3 in parallel with R

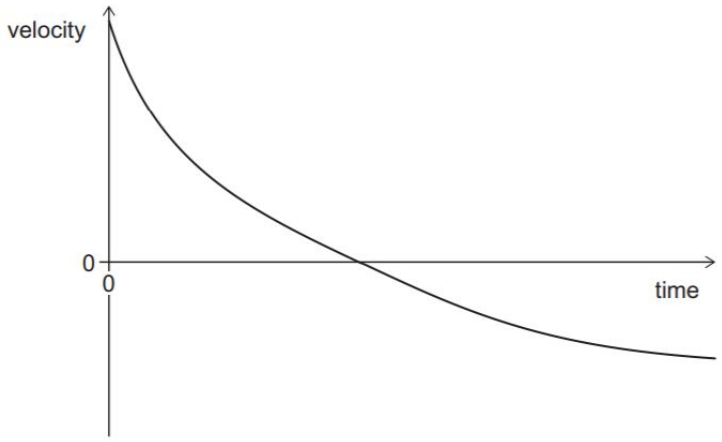


Which of the positions for resistor T causes an increase in the magnitude of the voltmeter reading?

O **1** and **2** only
O **2** and **3** only
O **1** and **3** only
O All of them

[Cambridge ENGAA]

43. A ball is thrown vertically upwards in air. The ball travels upwards to reach its highest point and then falls back down to its initial starting position. The velocity–time graph for the ball is shown.



Which statements are correct? (Assume a uniform gravitational field.)

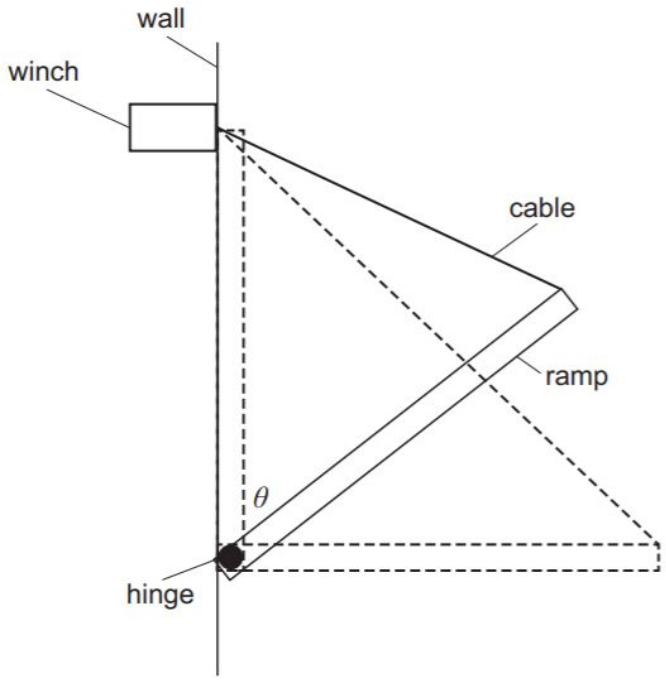
1 The magnitude of the acceleration of the ball is only equal to the magnitude of the acceleration of free fall when it is at its highest point.

2 The time taken for the upward journey of the ball is equal to the time taken for the journey back down to its starting position.

3 The maximum increase in the gravitational potential energy of the ball is less than its initial kinetic energy and greater than its kinetic energy when it returns to its starting position.

O **1** and **2** only
O **2** and **3** only
O **1** and **3** only
O All of them [Cambridge ENGAA]

44. A drawbridge system consists of a uniform ramp, of weight 10 tonnes, that is smoothly hinged at its lower end. The upper end is connected by an inextensible cable to a winch that is fixed to the wall in the position shown in the diagram.



The ramp is lowered slowly, at constant speed, from its closed (vertical; θ = 0°) position to its open (horizontal; θ = 90°) position.

What is the **maximum** tension in the cable during this process?

You are given the following useful formula:

$$\sin 2x = 2 \sin x \cos x \qquad \text{for any } x.$$

(1 tonne = 1000 kg; take g = 10 N kg^{-1}; mass of cable is negligible compared to mass of ramp. Round your answer to nearest 10 kN).

O 50 kN
O 60 kN
O 70 kN
O 90 kN

[Cambridge ENGAA]

45. The critical angle for light incident on a boundary from medium X to air is 45°. The critical angle for light of the same frequency incident on a boundary from medium Y to air is 60°.

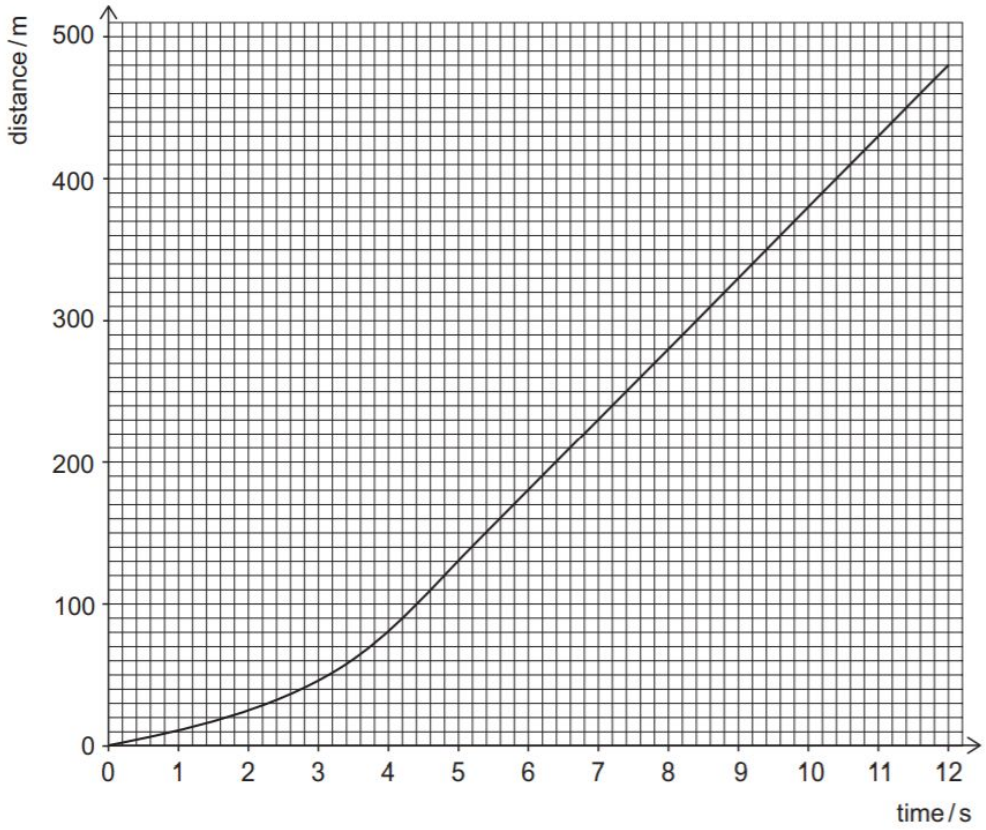
There is a boundary between medium X and medium Y. Light of the same frequency travelling in one of these mediums is incident on this boundary.

In which direction of incidence is there a critical angle at this boundary, and within what range is this critical angle?

	direction of incidence	*critical angle*
O	X to Y	less than 45°
O	X to Y	between 45° and 60°
O	Y to X	between 45° and 60°
O	Y to X	more than 60°

[Cambridge ENGAA]

46. A skydiver of weight 100 kg falls vertically. The distance–time graph for the skydiver is shown below.



The air resistance F (in N) acting on the skydiver travelling at velocity v (in ms^{-1}) is given by the equation $F = kv^2$, where k is a constant.

What is the numerical value of k for the skydiver, and what are its units?

(Take g = 10 N kg^{-1}). [Cambridge NSAA]

	value of *k*	units of *k*
O	0.40	N m^{-2} s^2
O	0.40	N m^2 s^{-2}
O	20	N m^{-2} s^{-2}
O	20	N m^2 s^{-2}

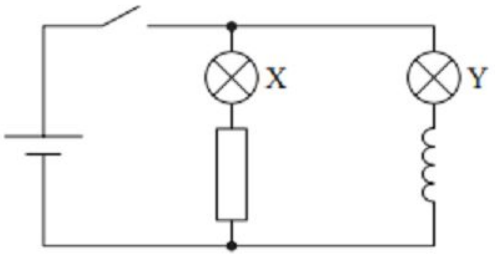
47. The radioactive isotope carbon-14 is found in living material in small quantities. There are approximately 1000 carbon-14 atoms for every 10^{15} carbon-12 atoms. Whilst the material is still living this ratio remains constant, because even though the carbon-14 is decaying, it is being constantly replenished. When the material dies the carbon-14 decays and is not replaced. The half-life of carbon-14 is about 6000 years.

In a bone the ratio of carbon-14 to carbon-12 atoms is found to be 1 : 10^{13} .

Which of the following is the closest estimate of the age of the bone?

O 600 years
O 2000 years
O 20 000 years
O 60 000 years [Cambridge NSAA]

48. A circuit is set up as shown in the diagram. Lamps X and Y are identical, with X in series with a fixed resistor of resistance R and with Y in series with a solenoid whose resistance is also R. The coil in the solenoid has a soft iron core.



The switch is closed and lamp X lights instantly. Which of these best describes the behaviour of lamp Y?

O Lights after a delay with a final brightness less than X
O Lights after a delay with a final brightness the same as X
O Lights instantly with less brightness than X
O Lights instantly with the same brightness as X

[Edexcel A-level physics]

49. Which of the options below about combining springs, resistors and capacitors in different arrangements is true?

O Two springs in series combine their force constants in the same way two capacitors in parallel combine their capacitances.

O Two springs in parallel combine their force constants in the same way two resistors in series combine their resistances.

O Two capacitors in series combine their capacitances in the same way two resistors in series combine their resistances.

O Two capacitors in parallel combine their capacitances in the same way two springs in series combine their force constants.

50. A spring has a length of 1.20 cm when lying on a horizontal table in its unstretched state. When one end of the same spring is attached to a clamp and allowed to hang vertically under its own weight, the spring extends by 0.7 mm.

When the spring is hung vertically, which of these is true?

(Assume the spring has a uniform coil density.)

1 The strain energy in the spring in its vertical state is equal to the magnitude of the gravitational potential energy lost by the spring

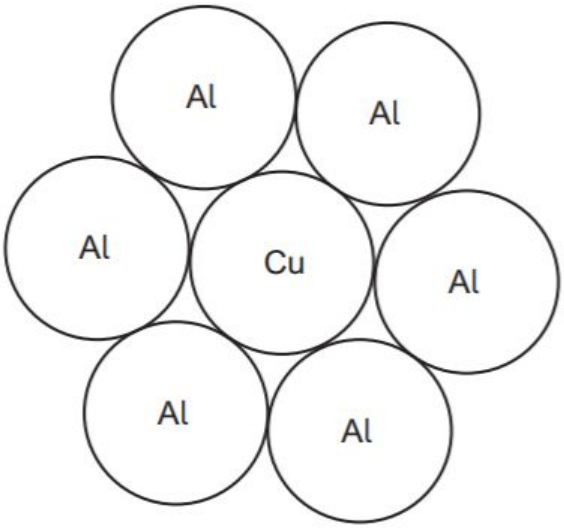
2 When a mass is attached to the other end of the vertically-hung spring, the equilibrium position for simple harmonic motion is at a length of 1.27 cm

3 The ratio of the force constant (in N m^{-1}) to the mass (in kg) of the spring is about 14 000 s^{-2}

O **1** and **2** only
O **2** and **3** only
O **1** and **3** only
O **1**, **2** and **3**

Section C: Challenging. Aim to answer 1 question per 4 minutes in this section.

1. A power cable consists of a cylindrical copper (Cu) wire surrounded by six cylindrical aluminium (Al) wires. All the wires are of the same cross-sectional area as shown:



The table gives the densities and resistivities of aluminium and copper.

material	*density*	*resistivity*
aluminium	d	3ρ
copper	$3d$	2ρ

The cable has mass *M* and length *L*.

The resistance *R* between the two ends of the cable is

O $\dfrac{18\rho dL^2}{5M}$

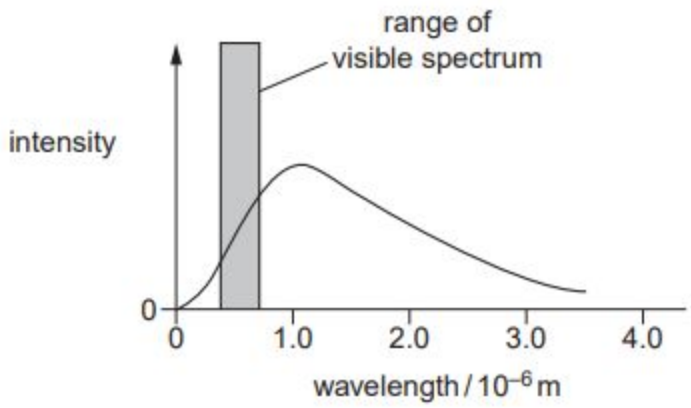
O $\dfrac{21\rho dL^2}{M}$

O $\dfrac{180\rho dL^2}{7M}$

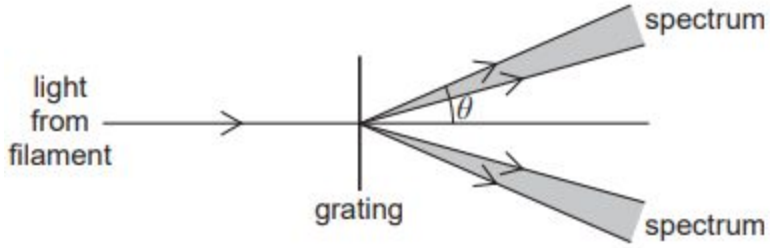
O $\dfrac{28\rho dL^2}{3M}$

[Cambridge ENGAA]

2. The tungsten filament of a 12 V / 24 W lamp glows white hot emitting photons across a continuous spectrum of energies. The intensity variation with the wavelength of the electromagnetic radiation from the filament is shown below.



When the light from the filament is focussed through a diffraction grating having 300 lines per millimetre, the continuous first order visible spectrum is seen on a hemispherical screen normal to the light at angles of θ = 7° and 12°.



At angles of θ = 7° and 12°, the colours and relative intensities seen on the screen are, respectively,

O 7°: red (brightest), 12°: violet (dimmest)
O 7°: red (dimmest), 12°: violet (brightest)
O 7°: violet (brightest), 12°: red (dimmest)
O 7°: violet (dimmest), 12°: red (brightest) [OCR A-level physics]

3. A spring with force constant k is oscillating on a frictionless horizontal surface with a mass m attached to its end. At any time t, the displacement of the mass from the equilibrium position is x. The amplitude of the oscillations is A.

When $x = \pm pA$, the kinetic energy of the mass is equal to the elastic potential energy stored in the spring. The value of p is exactly

O $\frac{1}{2}$

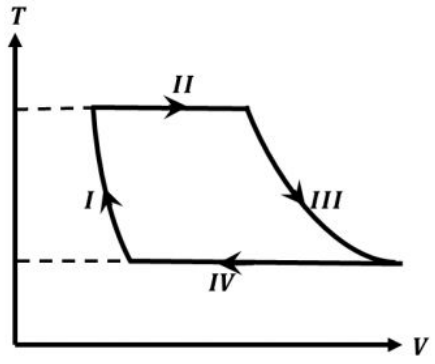
O $\frac{2}{3}$

O $\frac{\sqrt{2}}{2}$

O $\frac{\sqrt{3}}{2}$ [IIT JEE Advanced]

4. One mole of a monatomic ideal gas undergoes a cyclic sequence of thermodynamic processes as shown in the diagram (where *V* is the volume occupied by the gas and *T* is its absolute temperature).

The processes are labelled **I**, **II**, **III** and **IV** below.



Which of these statements are true?

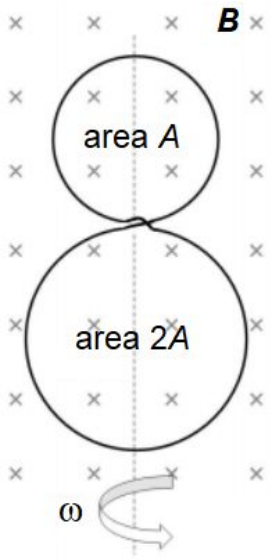
1 Processes **I** and **III** occur at constant (but different) pressures

2 In Process **II**, the gas absorbs heat energy

3 In Process **IV**, the work done on the gas by the surroundings equals the heat energy released by the gas

O **1** and **2** only
O **1** and **3** only
O **2** and **3** only
O **1**, **2** and **3** [IIT JEE Advanced]

5. A circular insulated copper wire loop is twisted to form two loops of area A and $2A$ in a single turn as shown in the figure. The entire loop lies in the same plane.



A uniform magnetic field $\boldsymbol{B}$ points into the plane of the paper. At time $t = 0$, the loop starts rotating about the common diameter with a constant angular velocity ω in the magnetic field.

Assuming that at the point of crossing the wires remain electrically insulated from each other, which one of the following is true?

O The e.m.f. induced in the loop is proportional to the sum of the areas of the two loops viewed from the plane of the magnetic field.

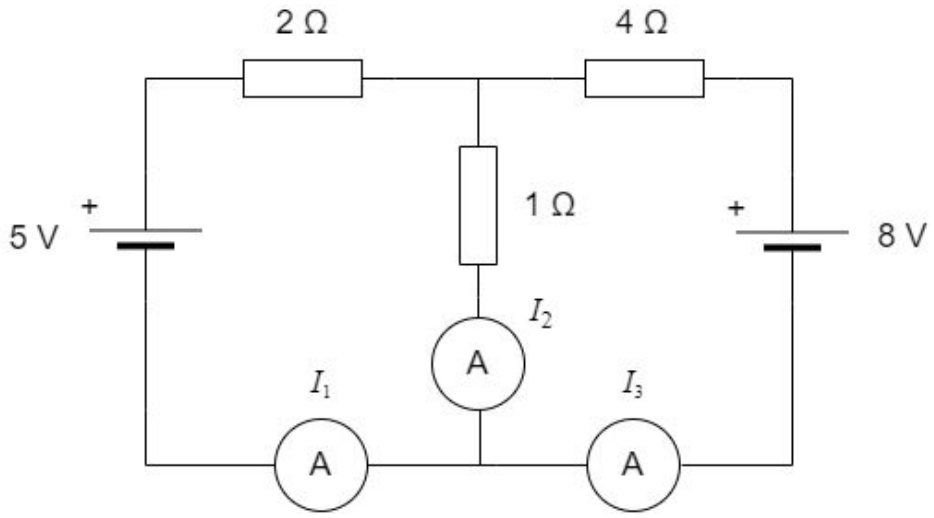
O The rate of change of the flux is zero when the plane of the loops is perpendicular to the plane of the paper.

O At any time t, the net e.m.f. induced due to both the loops is proportional to cos ωt.

O The amplitude of the maximum net e.m.f. induced due to both the loops is equal to the amplitude of maximum e.m.f. induced in the smaller loop alone.

[IIT JEE Advanced]

6. An electrical circuit with two sources of e.m.f. is set up as shown below.



The ammeters measure currents of I_1, I_2 and I_3 in amps respectively.

Which of these equations may **not** be obtained by applying Kirchhoff's second law to this circuit?

(Assume that all readings from the ammeters are positive and neglect the internal resistances of the cells.)

O $2I_1 + I_2 = 5$
O $2I_1 + 4I_3 = 13$
O $I_2 + 4I_3 = 8$
O $4I_3 - 2I_1 = 3$

7. A person twirls a circular ring (of mass *M* and radius *R*) near the tip of their finger as shown in Figure 1. In the process the finger never loses contact with the inner rim of the ring. The finger traces out the surface of a cone, shown by the dotted line. The radius of the path traced out by the point where the ring and the finger is in contact is *r*. The finger rotates with an angular velocity ω_0.

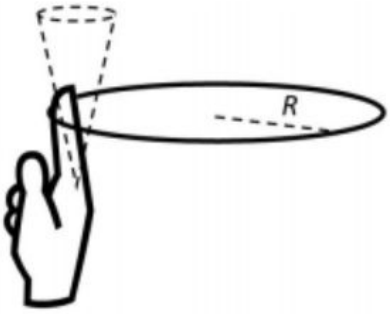


Figure 1

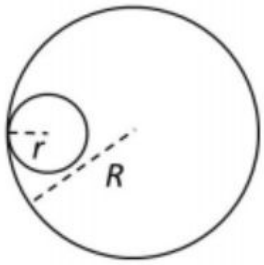


Figure 2

The rotating ring rolls without slipping on the outside of a smaller circle described by the point where the ring and the finger is in contact (Figure 2).

The kinetic energy of the ring is

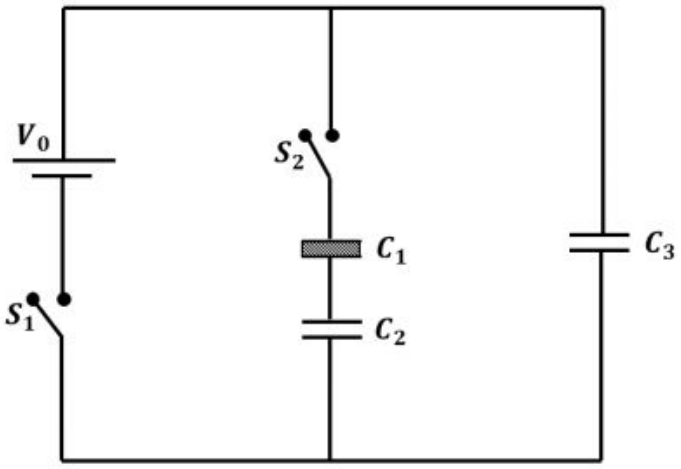
O $\frac{1}{2}M\omega_0{}^2R^2$

O $\frac{1}{2}M\omega_0{}^2r^2$

O $\frac{1}{2}M\omega_0{}^2(R^2-r^2)$

O $\frac{1}{2}M\omega_0{}^2(R-r)^2$ [IIT JEE Advanced]

8. Three identical capacitors C_1 , C_2 and C_3 have a capacitance of 1.00 μF each and are initially uncharged. They are connected in a circuit as shown in the figure and C_1 is then filled completely with a dielectric material of relative permittivity ε_r while C_2 and C_3 remain evacuated.



The cell e.m.f. V_0 = 8.00 V. First the switch S_1 is closed while the switch S_2 is kept open. When the capacitor C_3 is fully charged, S_1 is opened and S_2 is closed simultaneously. When all the capacitors reach equilibrium, the charge on C_3 is found to be 5.00 μC.

The relative permittivity ε_r of the dielectric material in capacitor C_1 is

O 1.33
O 1.50
O 1.60
O 1.67 [IIT JEE Advanced]

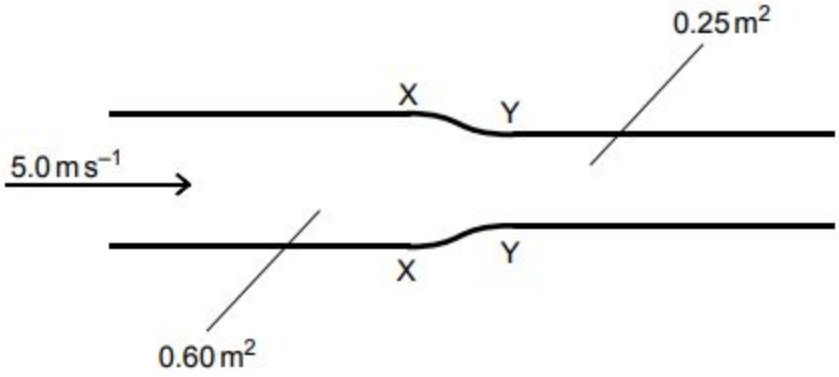
9. ^{131}I is an isotope of iodine that β-decays to a stable isotope of xenon with a half-life of 8 days. A small amount of a serum labelled with ^{131}I is injected into the blood of a person. The activity of the amount of ^{131}I injected was 2.4×10^5 Bq. It is known that the injected serum will get distributed uniformly in the bloodstream in less than half an hour.

After 11.5 hours, 2.5 ml of blood is drawn from the person's body, and gives an activity of 115 Bq.

The total volume of blood in the person's body is

O 1.0 litres
O 1.4 litres
O 3.9 litres
O 5.0 litres [IIT JEE Advanced]

10. Oil of density 800 kg m^{-3} is being pumped through a pipe of cross-sectional area 0.60 m^2 at a speed of 5 ms^{-1}. Between points *X* and *Y*, the oil passes through a contraction to a new cross-sectional area of 0.25 m^2 .



Assuming the oil is incompressible and the pipe is flowing at maximum capacity, the resultant force exerted on the oil as it passes from *X* to *Y* is

O 7000 N to the right
O 17000 N to the right
O 7000 N to the left
O 17000 N to the left [Cambridge ENGAA]

11. In electromagnetic theory, the electric and magnetic phenomena are related to each other. The *permittivity* of free space, ε_0, and the *permeability* of free space, μ_0, are physical constants quantifying how easily electric and magnetic fields propagate through a vacuum.

Through a more advanced derivation, it can be shown that these quantities satisfy the relationship

$$c^2 = \frac{1}{\varepsilon_0 \mu_0}$$

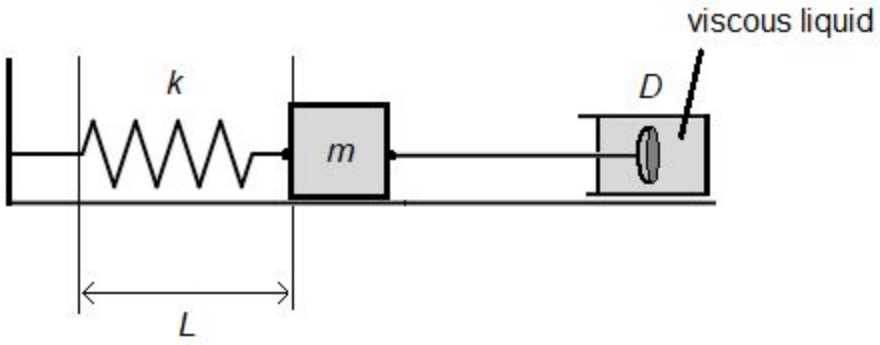
where *c* is the speed of light in a vacuum.

Based on this equation, which of these is/are possible set(s) of units for μ_0?

1 N A^{-2}
2 Wb A^{-1} m^{-1}
3 kg m s^{-1} A^{-1}

O **3** only
O **1** and **2** only
O **2** and **3** only
O **1** and **3** only [IIT JEE Advanced]

12. Consider the mechanical system shown below.



The spring has force constant k and natural (unstretched) length 0.1 m. The box has mass m kg and is in contact with the smooth table. The mass is also attached by an inextensible rod of negligible mass to a plunger D which moves in a fixed volume of a viscous liquid. The liquid exerts a resistive force on the plunger of magnitude $4V$ N, where V is the speed of the plunger in the liquid.

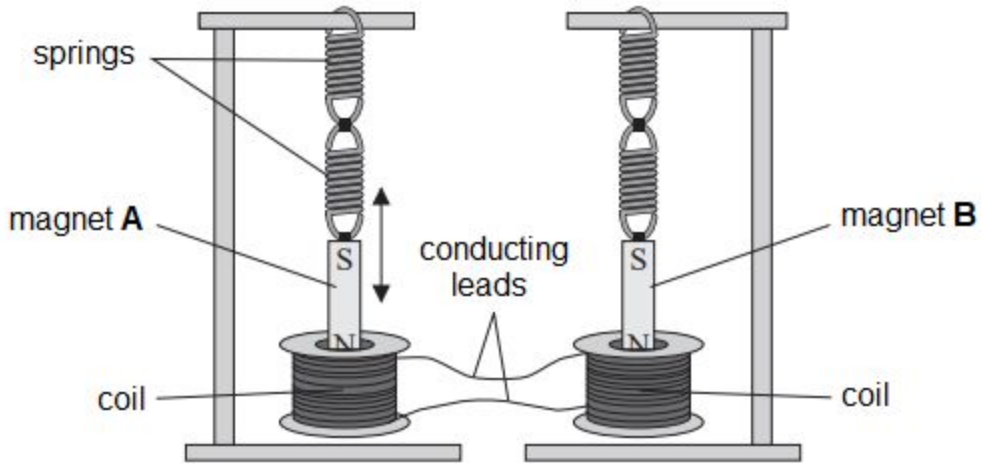
At time $t = 0$, the system is released from rest with the spring at a length of 0.4 m. The system remains horizontal throughout the motion. At any time t s, the length of the spring, **velocity** of the mass and acceleration of the mass are L, v and a respectively, where positive values are directed to the right.

Which of the following is the correct and complete application of Newton's Second Law to this system?

(Neglect air resistance. Assume the spring obeys Hooke's law at all times.)

O $ma + 4v + kL = 0$
O $ma - 4v - kL = 0$
O $ma + 4v + k(L - 0.1) = 0$
O $ma - 4v - k(L - 0.1) = 0$

13. Identical bar magnets are suspended from identical springs, with the North pole of each magnet inside a coil of wire as shown. The two coils have the same number of turns and are connected together with conducting leads of negligible resistance.



Magnet **A** is displaced so that it oscillates vertically. The North pole of magnet **A** moves into and out of the coil of wire with simple harmonic motion. As this motion continues, magnet **B** starts to oscillate.

Assuming negligible damping effects from external sources, which of these correctly describes the nature of the oscillations of magnets **A** and **B**?

1 The amplitude of the oscillation of magnet **B** increases from zero to a value less than the initial amplitude of magnet **A**.

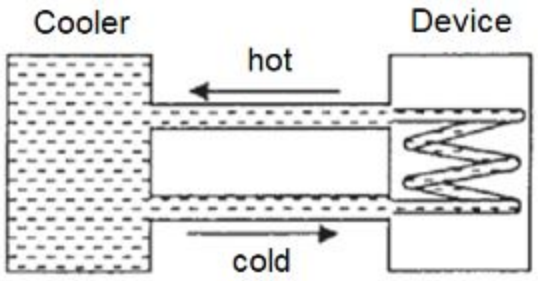
2 The net e.m.f. induced in the conducting leads oscillates with decreasing amplitude, falling to zero after oscillations continue for a long time.

3 The oscillations of magnets **A** and **B** maintain a constant phase difference of 180^{o} for the duration of the motion.

O **1** and **2** only
O **2** and **3** only
O **1** and **3** only
O **1**, **2** and **3**

[Edexcel A-level physics]

14. A water cooler of storage capacity 120 litres can cool water at a constant rate of *P* kilowatts. In a closed circulation system (as shown in the figure), the water from the cooler is used to cool an external device that generates constantly 3 kW of thermal power.



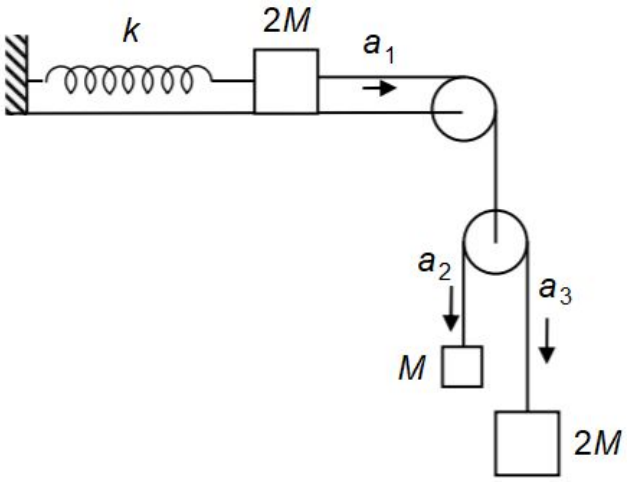
The temperature of water fed into the device cannot exceed 30 ^{o}C and the entire stored 120 litres of water is initially cooled to 10 ^{o}C. The entire system is thermally insulated.

Specific heat capacity of water = 4.2 kJ kg K^{-1}; density of water = 1000 kg m^{-3}.

The minimum rate at which the cooler can work, *P*, for which the device can be operated for 3 hours, is

O 1.6 kW
O 2.1 kW
O 2.5 kW
O 3.9 kW [IIT JEE Advanced]

15. A block of mass 2*M* is attached to a massless spring with spring constant *k*. This block is connected to two other blocks of masses *M* and 2*M* using two massless pulleys and strings as shown below.



The accelerations of the three blocks are a_1, a_2 and a_3, with positive values directed as shown in the figure. The system is released from rest with the spring in its unstretched state. The maximum extension of the spring in the subsequent motion is x_0.

Which of the following is true?

O $a_2 - a_1 = a_1 - a_3$

O When the spring is extended by $\frac{x_0}{4}$, the magnitude of the acceleration of the block directly connected to the spring is $\frac{3g}{10}$.

O $x_0 = \frac{4Mg}{k}$

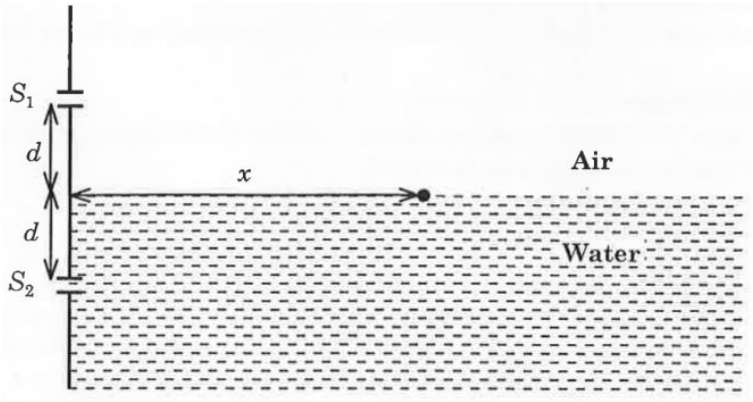
O When the spring is extended by $\frac{x_0}{2}$ for the first time, the speed of the block directly connected to the spring is $3g\sqrt{\frac{M}{5k}}$.

[IIT JEE Advanced]

16. An arrangement of the Young's double slit experiment is shown below.

Slits S_1 and S_2 lie in along a vertical line with a slit separation of 2*d*. One slit is submerged in **water** such that each slit is a distance *d* from the water level.

Monochromatic laser light of wavelength λ (measured in air) is then incident on the two slits, and the maxima are seen on the surface of the water at a distance *x* from the slits.



(Take the refractive index of water as exactly $\frac{4}{3}$. Assume *x* >> *d* >> λ).

The positions of the maxima are given by $x^2 = p^2 m^2 \lambda^2 - d^2,$ where *m* takes integer values and the value of *p* is

O $\frac{2}{3}$

O $\frac{4}{3}$

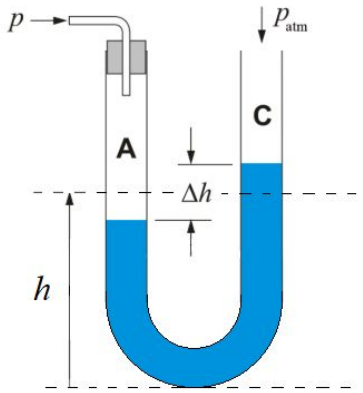
O 3

O $\frac{8}{3}$

[IIT JEE Advanced]

17. A U-shaped glass tube of uniform cross sectional area *A* is filled with a volume *V* of a liquid of density *ρ* and the liquid comes to rest with the level at a height *h* above the bottom of the tube.

One end of the tube is now bunged and a tube inserted, which passes gas at pressure *p* into section **A** (see figure), while section **C** remains exposed to the atmosphere. As a result of this pressure, the liquid becomes displaced on both sides from its equilibrium position by a **total** distance Δh.



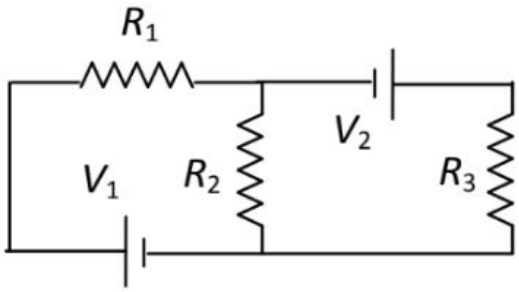
The bung and gas supply is then instantly removed at time *t* = 0 and the liquid level oscillates, executing lightly damped simple harmonic motion.

Which row in the table describes the cause and nature of the oscillations?

(You may assume that Δh << *h* and that $\frac{V}{A} \approx 2h$.)

	Δh *(in terms of* p*)*	***square** of period of the oscillations,* T^2	*main cause of damping*
O	$\Delta h = \frac{p}{\rho g}$	$T^2 = \frac{4\pi^2 h}{g}$	friction with the sides of the tube
O	$\Delta h = \frac{p}{\rho g}$	$T^2 = \frac{8\pi^2 h\rho}{g}$	friction with the sides of the tube
O	$\Delta h = \frac{p - p_{atm}}{\rho g}$	$T^2 = \frac{4\pi^2 h}{g}$	internal viscous drag
O	$\Delta h = \frac{p - p_{atm}}{\rho g}$	$T^2 = \frac{8\pi^2 h\rho}{g}$	internal viscous drag

18. Two ideal batteries of e.m.f. V_1 and V_2 and three resistances R_1, R_2 and R_3 are connected as shown.



A non-zero current would flow in resistance R_2 if

O $V_1 = V_2$ and $R_1 = R_2 = R_3$

O $V_1 = V_2$ and $R_1 = 2R_2 = R_3$

O $V_1 = 2V_2$ and $2R_1 = 2R_2 = R_3$

O $2V_1 = V_2$ and $2R_1 = R_2 = R_3$

[IIT JEE Advanced]

19. A spherical bubble of gas forms at the bottom of a glass containing a fizzy drink. The radius of the bubble at the point of formation, at the bottom of the drink, is R. The depth of the liquid in the glass is h, and the density of the liquid of the drink is ρ. Atmospheric pressure is P.

As the bubble rises, its radius changes. Which expression gives the radius of the bubble when it is at a depth x below the surface of the drink?

(gravitational field strength = g; the mass of the gas in the bubble is constant and the process is isothermal throughout.)

O $R\left(\dfrac{h\rho g - P}{x\rho g - P}\right)^{\frac{1}{3}}$

O $R\left(\dfrac{h}{x}\right)^{\frac{1}{3}}$

O $R\left(\dfrac{h\rho g + P}{x\rho g + P}\right)^{\frac{1}{3}}$

O $R\left(\dfrac{x\rho g - P}{h\rho g - P}\right)^{\frac{1}{3}}$

[Cambridge ENGAA]