Physics
Higher level
Paper 1

Thursday 3 November 2022 (afternoon)

1 hour

Instructions to candidates

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

8822 – 6501

1. What is the definition of the SI unit for a force?

A. The force required to accelerate, in the direction of the force, a mass of 1 kg at 1 $m\,s^{-2}$

B. The force required to accelerate, in the direction of the force, a mass at 1 $m\,s^{-2}$

C. The weight of a mass of 0.1 kg

D. The change in momentum per second

2. A rectangular sheet of paper has dimensions of (30.0 ± 0.5) cm and (20.0 ± 0.5) cm.

What is the percentage uncertainty of the perimeter of the paper?

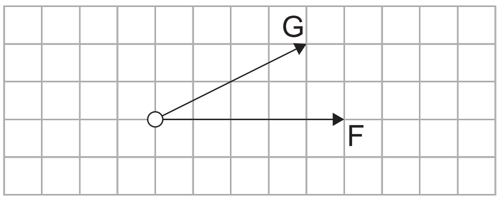
A. 1 %

B. 2 %

C. 2.5 %

D. 4 %

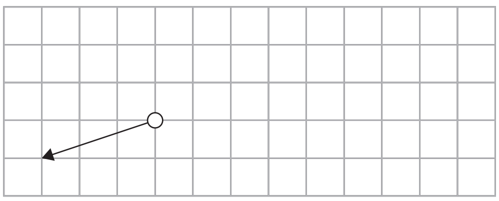
3. Two forces, F and G, act on a system.



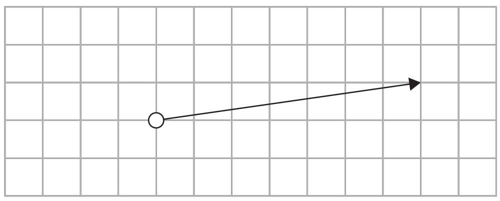
F is reversed in direction and G is halved.

Which vector correctly represents the new resultant force?

A.

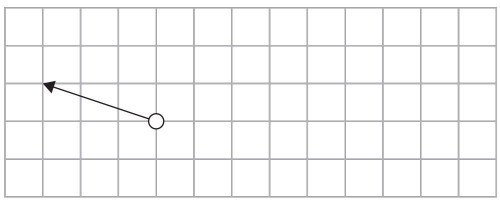


B.

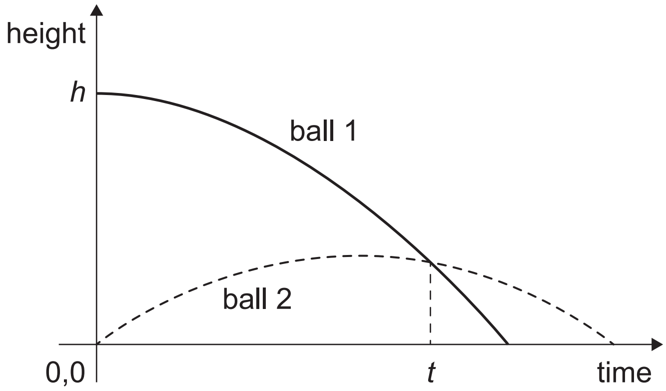


C.

D.



4. Ball 1 is dropped from rest from an initial height h. At the same instant, ball 2 is launched vertically upwards at an initial velocity u.



At what time are both balls at the same distance above the ground?

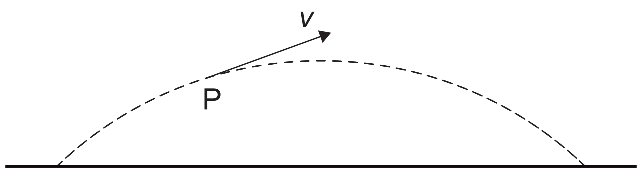
A. $\frac{h}{4u}$

B. $\frac{h}{2u}$

C. $\frac{h}{u}$

D. $\frac{2h}{u}$

5. The diagram shows the trajectory of a projectile and the velocity v of the projectile at point P in its trajectory. P is located before the projectile reaches the peak altitude. Air resistance acts on the projectile. The acceleration of the projectile at P is a.

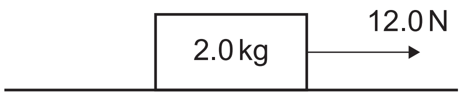


What are the magnitudes of the horizontal component and the vertical component of the acceleration of the projectile at P?

	Horizontal component of *a*	**Vertical component of *a***
A.	zero	greater than $9.8\,m\,s^{-2}$
B.	non-zero	greater than $9.8\,m\,s^{-2}$
C.	zero	$9.8\,m\,s^{-2}$
D.	non-zero	$9.8\,m\,s^{-2}$

6. An object of mass 2.0 kg is on a horizontal surface. The object is pulled by a force of 12.0 N and accelerates at 2.0 m s^{-2}.

What is the coefficient of dynamic friction between the object and the surface?



A. 0.3

B. 0.4

C. 0.6

D. 0.8

7. A person lifts a total mass of 20 kg through a vertical distance of 0.60 m. The person repeats the lift *n* times to transfer a total energy of 6.0×10^4 J.

What is *n*?

A. 5

B. 50

C. 500

D. 5000

8. An engine is exerting a horizontal force *F* on an object that is moving along a horizontal surface at a constant velocity *v*. The mass of the object is *m* and the coefficient of dynamic friction between the object and the surface is μ.

What is the power of the engine?

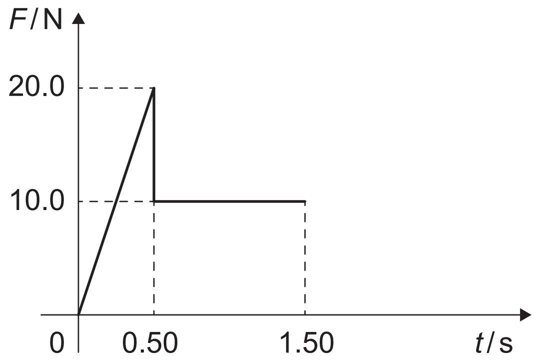
A. $\frac{Fv}{\mu}$

B. μFv

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

D. μmgv

9. A model rocket is launched from rest. The graph shows the variation with time t of the net force F applied on the rocket. The average mass of the rocket is 0.20 kg.



What is the maximum velocity reached by the rocket?

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

B. $25\,\text{m s}^{-1}$

C. $75\,\text{m s}^{-1}$

D. $150\,\text{m s}^{-1}$

10. Three samples of the same liquid are mixed in an insulated container. The masses and initial temperatures of the samples are:

	Mass	**Initial temperature/°C**
Sample 1	$2M$	60
Sample 2	$2M$	30
Sample 3	M	0

What is the equilibrium temperature of the mixture?

A. 45 °C

B. 36 °C

C. 30 °C

D. 24 °C

11. Gases in the atmosphere are compounds of ${}^{12}_{6}C$, ${}^{1}_{1}H$, ${}^{16}_{8}O$ and ${}^{14}_{7}N$.

Four of these gases are CO_2, N_2O, CH_4 and H_2O. A pure sample of each gas is produced. Each sample has the same mass.

Which sample contains the greatest number of molecules?

A. N_2O

B. H_2O

C. CO_2

D. CH_4

12. Three statements about Boltzmann's constant k_B are:

I. k_B has a unit of $J\,K^{-1}$

II. $k_B = \dfrac{\text{gas constant}}{\text{Avogadro's constant}}$

III. $k_B = \dfrac{\text{the average kinetic energy of particles}}{\text{temperature of the gas}}$

Which statements are correct?

A. I and II only

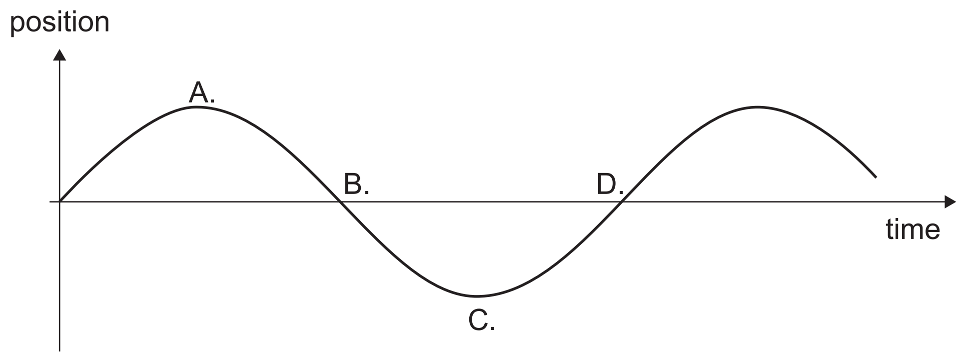
B. I and III only

C. II and III only

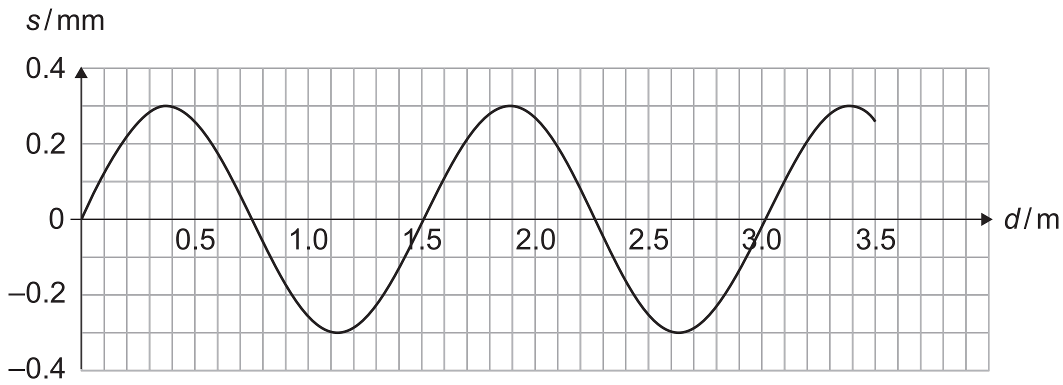
D. I, II and III

13. An object oscillates at the free end of a vertical spring. The graph shows the variation of the object's position with time.

At which position does the object have zero velocity and a negative acceleration?



14. A sound wave travels through a gas at a speed of 270 m s^{-1}. The graph shows the variation of the displacement *s* of the gas particles with distance *d* from the source.



What is the frequency of the wave?

A. 180 Hz

B. 360 Hz

C. 450 Hz

D. 900 Hz

15. A point source emits a sound wave of amplitude *Z*. A person stands a distance *L* from the source. The amplitude is changed to 2*Z*.

What distance must the person move through in order to hear the original intensity again?

A. *L*

B. 2*L*

C. 3*L*

D. 7*L*

16. Two copper wires of equal lengths but different diameters are used to connect a cell to a load. Wire 1 has a diameter *M*, wire 2 has a diameter 2*M*. The electron drift velocities in wires 1 and 2 are v_1 and v_2.

What is $\frac{v_2}{v_1}$?

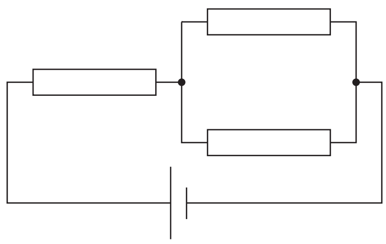
A. 4

B. 2

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

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

17. A cell of negligible internal resistance is connected to three identical resistors. The current in the cell is 3.0A.



The resistors are now arranged in series.

What is the new current in the cell?

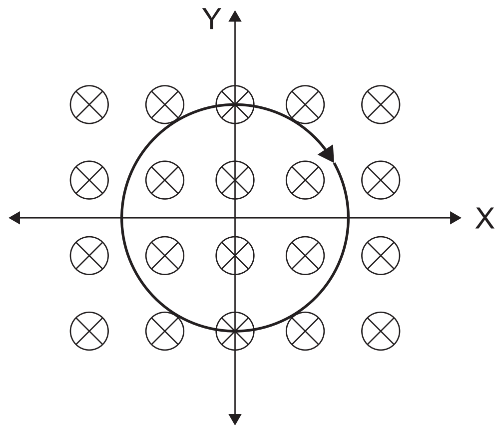
A. 1.0A

B. 1.5A

C. 3.0A

D. 9.0A

18. A loop of wire lies in a magnetic field directed into the plane of the page. The loop carries a current in a clockwise direction.



The magnetic force acting on the wire tends to

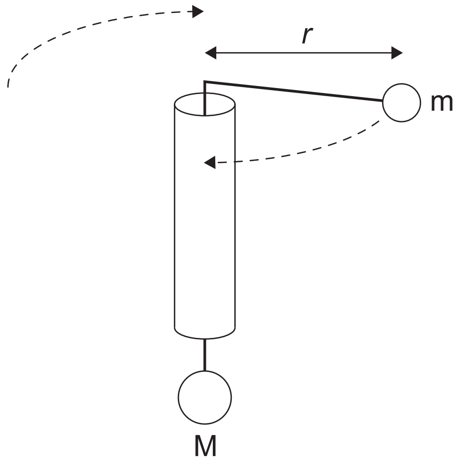
A. rotate the loop about the X axis.

B. rotate the loop about the Y axis.

C. reduce the radius of the loop.

D. increase the radius of the loop.

19. Two masses M and m are connected by a string that runs without friction through a stationary tube. Mass m rotates at constant speed in a horizontal circle of radius 0.25 m. The weight of M provides the centripetal force for the motion of m. The time period for the rotation of m is 0.50 s.



What is $\dfrac{\text{mass of M}}{\text{mass of m}}$?

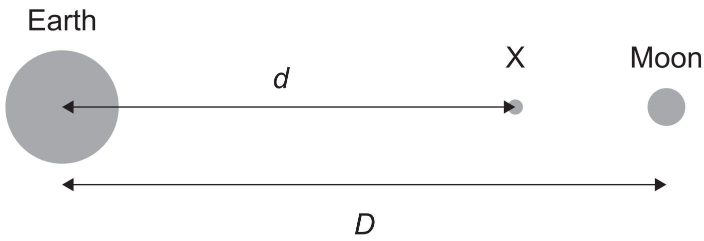
A. 1

B. 2

C. 4

D. 8

20. The centre of the Earth and the Moon are a distance D apart. There is a point X between them where their gravitational fields cancel out. The distance from the centre of the Earth to X is d. The mass of the Earth is M_E and the mass of the Moon is M_M.



What is correct at X?

A. $\frac{M_E}{d} = \frac{M_M}{D-d}$

B. $\frac{M_E}{D-d} = \frac{M_M}{d}$

C. $\frac{M_E}{d^2} = \frac{M_M}{(D-d)^2}$

D. $\frac{M_E}{d^2} = \frac{M_M}{D^2-d^2}$

21. The unified atomic mass unit, u, is a non-SI unit usually used by scientists to state atomic masses.

What is u?

A. It is the mean of the masses of a proton and a neutron.

B. It is the mean of the masses of protons and neutrons in all chemical elements.

C. It is $\frac{1}{16}$ the mass of an ${}^{16}_{8}\mathrm{O}$ atom.

D. It is $\frac{1}{12}$ the mass of a ${}^{12}_{6}\mathrm{C}$ atom.

22. The nuclide uranium-237 follows a sequence of three decays to produce the nuclide uranium-233.

What is a possible sequence for these decays?

A. Beta plus, alpha, beta plus

B. Beta minus, alpha, beta minus

C. Alpha, beta plus, beta minus

D. Alpha, beta minus, beta plus

23. Which development in physics constituted a paradigm shift?

A. The classification of variables into scalars and vectors

B. The determination of the velocity of light in different media

C. The equivalence of $F = ma$ to $F = \frac{\Delta p}{\Delta t}$ when the mass of the system is constant

D. The equivalence of mass and energy

24. A fusion reaction of one nucleus of hydrogen-2 and one nucleus of hydrogen-3 converts 0.019 u to energy. A fission reaction of one nucleus of uranium-235 converts a mass of 0.190 u to energy.

What is the ratio $\frac{\text{specific energy of this fusion of hydrogen}}{\text{specific energy of this fission of uranium}}$?

A. 0.1

B. 0.2

C. 5

D. 10

25. Water is to be pumped through a vertical height difference of 12.5 m. The pump is driven by a wind turbine that has an efficiency of 50 % and an area swept by the blades of 100 m^2. The average wind speed is 5.0 $m\,s^{-1}$ and the air density is 1.2 $kg\,m^{-3}$.

What is the maximum mass of water that can be pumped every second?

A. 3 kg

B. 30 kg

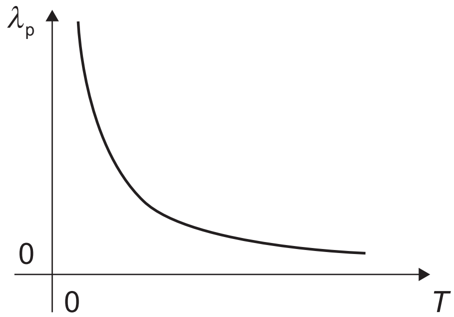
C. 60 kg

D. 120 kg

26. The electromagnetic spectrum radiated by a black body at temperature T shows a peak at wavelength λ_p.

What is the variation of λ_p with T?

A.



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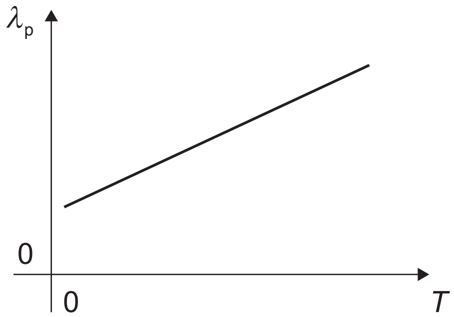
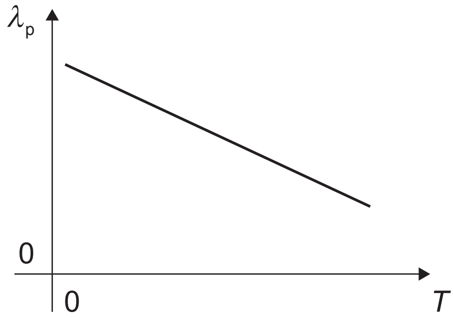
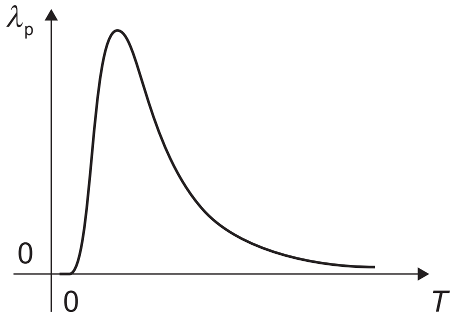


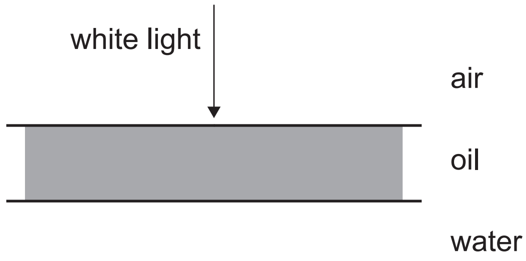
C.



D.



27. A ray of white light is normally incident on a thin layer of oil on water. The refractive index of oil is $\frac{3}{2}$ and the refractive index of water is $\frac{4}{3}$.



The wavelength of violet light in air is λ_v.

What is the minimum thickness of the thin layer of oil so that the colour of the reflected light is violet?

A. $\frac{\lambda_v}{6}$

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

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

D. $\frac{\lambda_v}{3}$

28. A telescope can just resolve images that are separated by an angle of 2×10^{-7} rad. Two stars are a distance of 4×10^{16} m from each other.

What is the maximum distance between the stars and the telescope for their images to be resolved by the telescope?

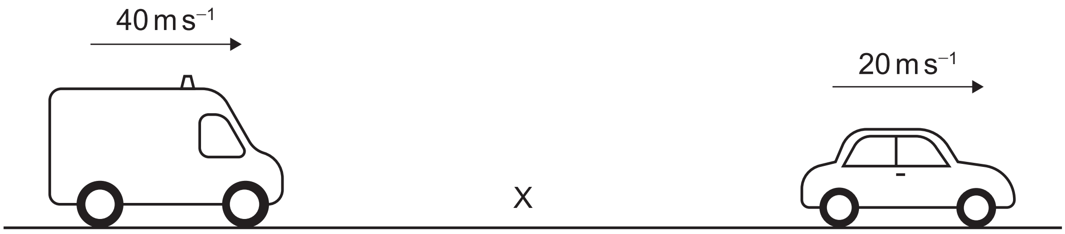
A. 2×10^{9} m

B. 2×10^{11} m

C. 2×10^{23} m

D. 4×10^{23} m

29. An ambulance emitting a sound of frequency f is moving towards a point X at a velocity of $+40\,\mathrm{m\,s^{-1}}$. A car is moving away from X at a velocity of $+20\,\mathrm{m\,s^{-1}}$.



The speed of sound is v.

What is the frequency detected in the car?

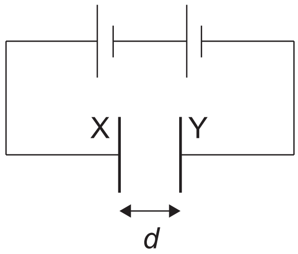
A. $f\dfrac{(v-20)}{(v-40)}$

B. $f\dfrac{v}{(v-20)}$

C. $f\dfrac{(v+20)}{(v+40)}$

D. $f\dfrac{(v+20)}{(v-40)}$

30. A parallel-plate capacitor is fully charged using a battery.



The capacitor has a capacitance C and a charge Q. The plates X and Y of the capacitor are a distance d apart. Edge effects are negligible.

Three statements about the fully charged capacitor are:

I. The electric field strength between the plates is $\frac{Q}{Cd}$.

II. The electric field lines are at right angles to the plates.

III. The equipotential surfaces are parallel to the plates.

Which statements are correct?

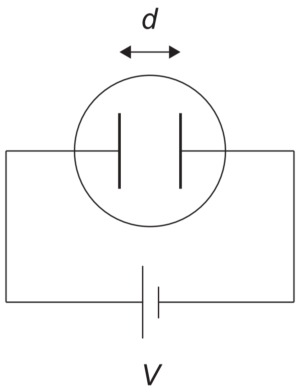
A. I and II only

B. I and III only

C. II and III only

D. I, II and III

31. An electric field is established between two electrodes separated by distance d, held at a potential difference of V. A charged particle in this field experiences a force F.



What is the charge on the particle?

A. $\dfrac{d}{FV}$

B. $\dfrac{FV}{d}$

C. $\dfrac{V}{Fd}$

D. $\dfrac{Fd}{V}$

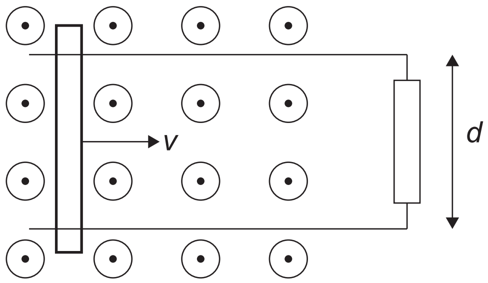
32. Two satellites are in circular orbits around the Earth. Both satellites have the same mass and satellite X is closer to Earth than satellite Y.

What is correct for the orbital periods of X and Y and the total energies of X and Y?

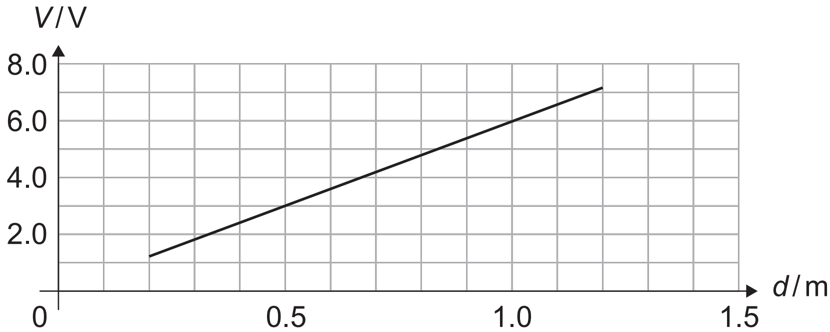
	Orbital periods	**Total energies**
A.	X greater than Y	X greater than Y
B.	X greater than Y	Y greater than X
C.	Y greater than X	X greater than Y
D.	Y greater than X	Y greater than X

33. A resistor connects two parallel conducting rails a distance *d* apart. A conducting bar rolls along the rails at a constant velocity *v* through a uniform magnetic field of 2.0 T perpendicular to the rails as shown.

The voltage *V* across the resistor is measured.



The graph shows the variation of *V* with *d*.



What is *v*?

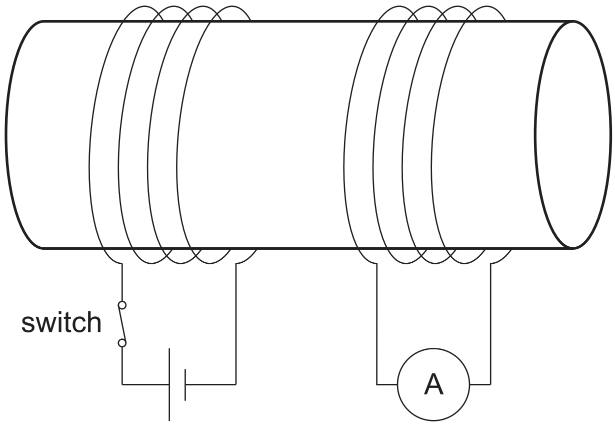
A. $0.33\,\text{m s}^{-1}$

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

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

D. $12.0\,\text{m s}^{-1}$

34. Two coils of wire are wound around an iron cylinder. One coil is connected in a circuit with a cell and a switch that is initially closed. The other coil is connected to an ammeter. The switch is opened at time t_0.



What is the ammeter reading before t_0 and what is the ammeter reading after t_0?

	Ammeter reading before t_0	Ammeter reading after t_0
A.	zero	a peak of current falling to zero
B.	zero	zero
C.	non–zero	a peak of current falling to zero
D.	non–zero	zero

35. What is the purpose of using a step-up transformer at a power station?

A. To step up the current to decrease the energy losses

B. To step up the current to decrease the power transmitted

C. To step up the voltage to decrease the energy losses

D. To step up the voltage to decrease the power transmitted

36. A student states three facts about the time constant of a resistor-capacitor series circuit.

I. It is the time required for the capacitor to be charged through the resistor to a voltage of $0.632\,V$ from an initial value of zero, where V is the voltage of the source.

II. It is the time required for the capacitor to be discharged through the resistor to a voltage of $0.632\,V$, where V is the initial voltage of the capacitor.

III. It is the product of the resistance of the resistor and the capacitance of the capacitor.

Which statements are correct?

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

37. Monochromatic electromagnetic radiation ejects photoelectrons from a metal surface. The minimum frequency for which this is possible is f.

When radiation of frequency $2f$ is incident on the surface, the kinetic energy of the photoelectrons is K.

What is the kinetic energy of the photoelectrons when the frequency of the radiation is $4f$?

A. K

B. $2K$

C. $3K$

D. $4K$

38. A student quotes three equations related to atomic and nuclear physics:

I. $E = \frac{-13.6}{n^2}$ eV

II. $N = N_0 e^{-\lambda t}$

III. $mvr = \frac{nh}{2\pi}$

Which equations refer to the Bohr model for hydrogen?

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

39. Which emission shows a continuous energy spectrum?

A. Photons during energy transitions between atomic energy states

B. Gamma photons from the nuclei of radioactive isotopes

C. Beta particles from the nuclei of radioactive isotopes

D. Alpha particles from the nuclei of radioactive isotopes

40. The nucleus of the isotope hydrogen-2 has a radius R and a density ρ.

What are the approximate radius and density of a nucleus of oxygen-16?

	Oxygen-16 radius	**Oxygen-16 density**
A.	$2R$	ρ
B.	$2R$	2ρ
C.	$8R$	ρ
D.	$8R$	2ρ

References: