Diploma Programme
Programme du diplôme
Programa del Diploma

Physics
Higher level
Paper 1

Monday 15 May 2017 (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]**.

2217 – 6513

21 pages

1. A stone falls from rest to the bottom of a water well of depth *d*. The time *t* taken to fall is 2.0 ± 0.2 s. The depth of the well is calculated to be 20 m using $d = \frac{1}{2}at^2$. The uncertainty in *a* is negligible.

What is the absolute uncertainty in *d*?

A. ± 0.2 m

B. ± 1 m

C. ± 2 m

D. ± 4 m

2. A projectile is fired horizontally from the top of a cliff. The projectile hits the ground 4 s later at a distance of 2 km from the base of the cliff. What is the height of the cliff?

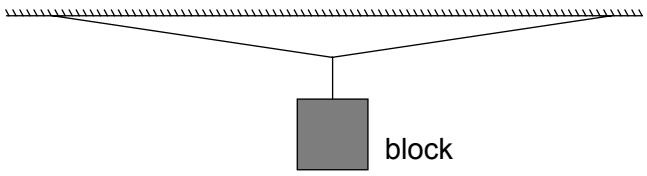
A. 40 m

B. 80 m

C. 120 m

D. 160 m

3. A block of weight *W* is suspended by two strings of equal length. The strings are almost horizontal.



What is correct about the tension *T* in one string?

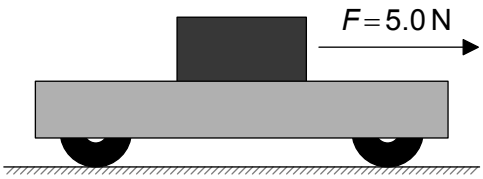
A. $T < \frac{W}{2}$

B. $T = \frac{W}{2}$

C. $\frac{W}{2} < T \leq W$

D. $T > W$

4. A block of mass 1.0 kg rests on a trolley of mass 4.0 kg. The coefficient of dynamic friction between the block and the trolley is 0.30.



A horizontal force $F = 5.0\,\text{N}$ acts on the block. The block slides over the trolley. What is the acceleration of the trolley?

A. $5.0\,\text{m s}^{-2}$

B. $1.0\,\text{m s}^{-2}$

C. $0.75\,\text{m s}^{-2}$

D. $0.60\,\text{m s}^{-2}$

5. A tennis ball is released from rest at a height h above the ground. At each bounce 50 % of its kinetic energy is lost to its surroundings. What is the height reached by the ball after its second bounce?

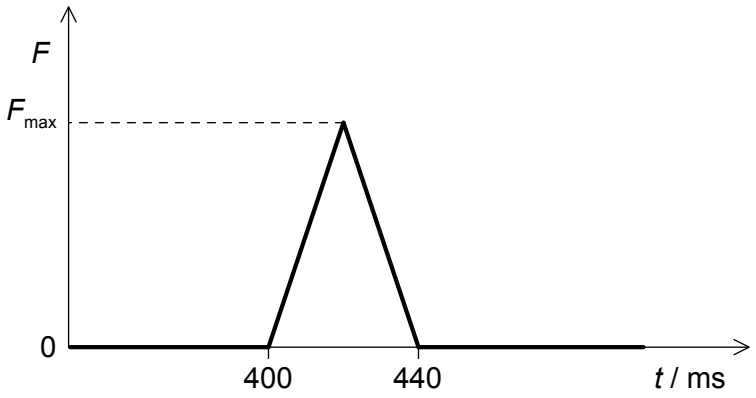
A. $\frac{h}{8}$

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

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

D. zero

6. A ball of mass 0.2 kg strikes a force sensor and sticks to it. Just before impact the ball is travelling horizontally at a speed of 4.0 m s^{-1}. The graph shows the variation with time t of the force F recorded by the sensor.



What is F_{max}?

A. 2 N

B. 4 N

C. 20 N

D. 40 N

7. A stationary nucleus of polonium-210 undergoes alpha decay to form lead-206. The initial speed of the alpha particle is v. What is the speed of the lead-206 nucleus?

A. $\frac{206}{4}v$

B. v

C. $\frac{206}{210}v$

D. $\frac{4}{206}v$

8. A mass m of ice at a temperature of –5 °C is changed into water at a temperature of 50 °C.

Specific heat capacity of ice $= c_i$
Specific heat capacity of water $= c_w$
Specific latent heat of fusion of ice $= L$

Which expression gives the energy needed for this change to occur?

A. $55\,m\,c_w + m\,L$

B. $55\,m\,c_i + 5\,m\,L$

C. $5\,m\,c_i + 50\,m\,c_w + m\,L$

D. $5\,m\,c_i + 50\,m\,c_w + 5\,m\,L$

9. A sealed container contains a mixture of oxygen and nitrogen gas.

The ratio $\frac{\text{mass of an oxygen molecule}}{\text{mass of a nitrogen molecule}}$ is $\frac{8}{7}$.

The ratio $\frac{\text{average kinetic energy of oxygen molecules}}{\text{average kinetic energy of nitrogen molecules}}$ is

A. 1.

B. $\frac{7}{8}$.

C. $\frac{8}{7}$.

D. dependent on the concentration of each gas.

10. An ideal gas has a volume of 15 ml, a temperature of 20 °C and a pressure of 100 kPa. The volume of the gas is reduced to 5 ml and the temperature is raised to 40 °C. What is the new pressure of the gas?

A. 600 kPa

B. 320 kPa

C. 200 kPa

D. 35 kPa

11. In simple harmonic oscillations which two quantities always have opposite directions?

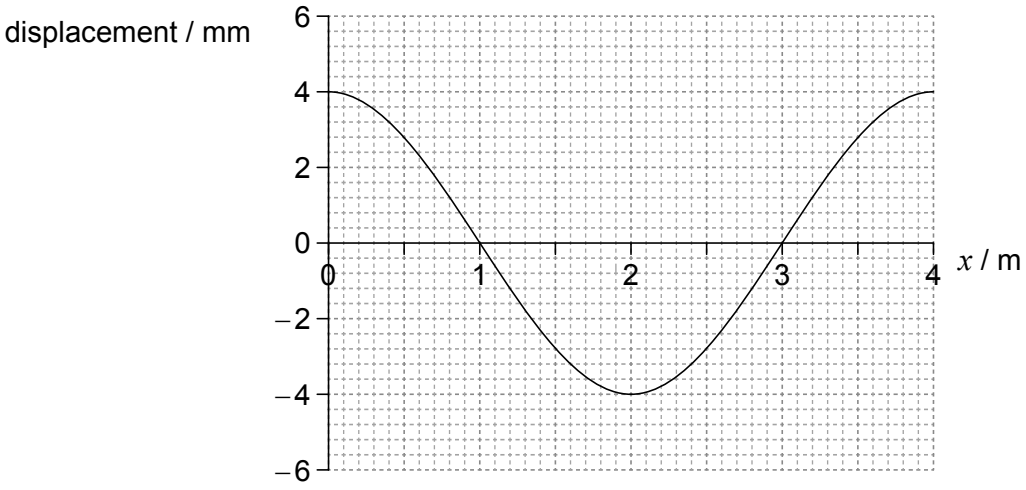
A. Kinetic energy and potential energy

B. Velocity and acceleration

C. Velocity and displacement

D. Acceleration and displacement

12. The graph shows the variation with distance x of the displacement of the particles of a medium in which a longitudinal wave is travelling from left to right. Displacements to the right of equilibrium positions are positive.



Which point is at the centre of a compression?

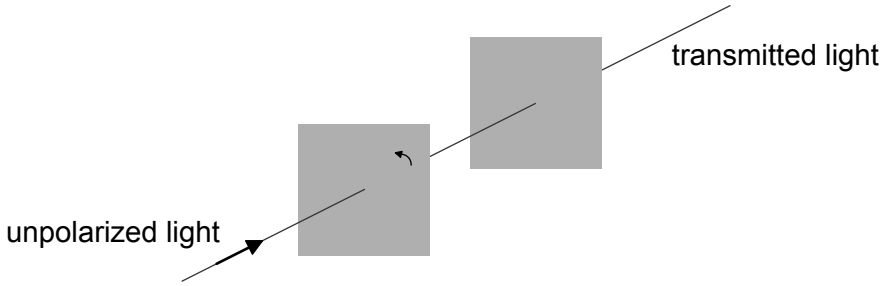
A. $x = 0$

B. $x = 1\,\text{m}$

C. $x = 2\,\text{m}$

D. $x = 3\,\text{m}$

13. A beam of unpolarized light is incident on the first of two parallel polarizers. The transmission axes of the two polarizers are initially parallel.



The first polarizer is now rotated about the direction of the incident beam by an angle smaller than 90°. Which gives the changes, if any, in the intensity and polarization of the transmitted light?

	Intensity	Polarization
A.	different	same
B.	different	different
C.	same	same
D.	same	different

14. The frequency of the first harmonic standing wave in a pipe that is open at both ends is 200 Hz. What is the frequency of the first harmonic in a pipe of the same length that is open at one end and closed at the other?

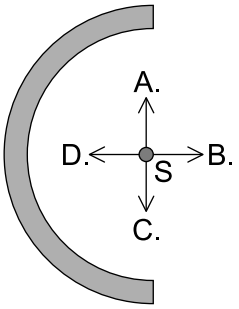
A. 50 Hz

B. 75 Hz

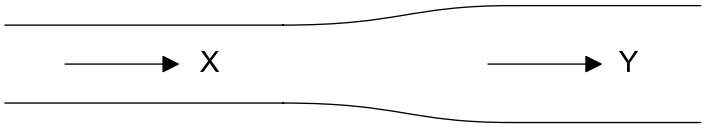
C. 100 Hz

D. 400 Hz

15. Positive charge is uniformly distributed on a semi-circular plastic rod. What is the direction of the electric field strength at point S?



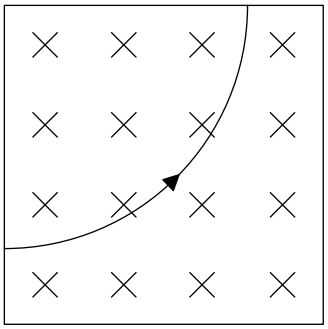
16. A wire has variable cross-sectional area. The cross-sectional area at Y is double that at X.



At X, the current in the wire is I and the electron drift speed is v. What is the current and the electron drift speed at Y?

	Current	Drift speed
A.	I	v
B.	I	$\frac{v}{2}$
C.	$2I$	v
D.	$2I$	$\frac{v}{2}$

17. The diagram shows the path of a particle in a region of uniform magnetic field. The field is directed into the plane of the page.



This particle could be

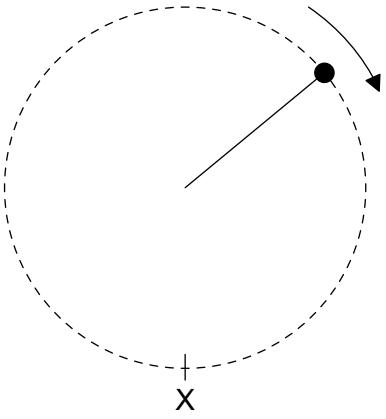
A. an alpha particle.

B. a beta particle.

C. a photon.

D. a neutron.

18. A small ball of weight W is attached to a string and moves in a vertical circle of radius R.



What is the smallest kinetic energy of the ball at position X for the ball to maintain the circular motion with radius R?

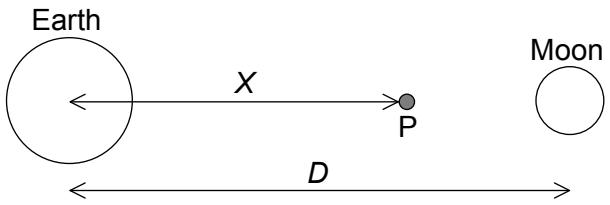
A. $\frac{WR}{2}$

B. WR

C. $2WR$

D. $\frac{5WR}{2}$

19. The centre of the Earth is separated from the centre of the Moon by a distance *D*. Point P lies on a line joining the centre of the Earth and the centre of the Moon, a distance *X* from the centre of the Earth. The gravitational field strength at P is zero.



What is the ratio $\frac{\text{mass of the Moon}}{\text{mass of the Earth}}$?

A. $\frac{(D-X)^2}{X^2}$

B. $\frac{(D-X)}{X}$

C. $\frac{X^2}{(D-X)^2}$

D. $\frac{X}{D-X}$

20. The binding energy per nucleon of $^{11}_{4}\text{Be}$ is 6 MeV. What is the energy required to separate the nucleons of this nucleus?

A. 24 MeV

B. 42 MeV

C. 66 MeV

D. 90 MeV

21. In the nuclear reaction $X + Y \rightarrow Z + W$, involving nuclides X, Y, Z and W, energy is released. Which is correct about the masses (M) and the binding energies (BE) of the nuclides?

	Masses	Binding energies
A.	$M_X + M_Y < M_Z + M_W$	$BE_X + BE_Y < BE_Z + BE_W$
B.	$M_X + M_Y < M_Z + M_W$	$BE_X + BE_Y > BE_Z + BE_W$
C.	$M_X + M_Y > M_Z + M_W$	$BE_X + BE_Y < BE_Z + BE_W$
D.	$M_X + M_Y > M_Z + M_W$	$BE_X + BE_Y > BE_Z + BE_W$

22. The reaction $p^+ + n^0 \rightarrow p^+ + \pi^0$ does **not** occur because it violates the conservation law of

A. electric charge.

B. baryon number.

C. lepton number.

D. strangeness.

23. The main role of a moderator in a nuclear fission reactor is to

A. slow down neutrons.

B. absorb neutrons.

C. reflect neutrons back to the reactor.

D. accelerate neutrons.

24. A room is at a constant temperature of 300 K. A hotplate in the room is at a temperature of 400 K and loses energy by radiation at a rate of *P*. What is the rate of loss of energy from the hotplate when its temperature is 500 K?

A. $\frac{4^4}{5^4}P$

B. $\frac{5^4+3^4}{4^4+3^4}P$

C. $\frac{5^4}{4^4}P$

D. $\frac{5^4-3^4}{4^4-3^4}P$

25. Which of the following leads to a paradigm shift?

A. Multi-loop circuits

B. Standing waves

C. Total internal reflection

D. Atomic spectra

26. A mass oscillates with simple harmonic motion (SHM) of amplitude x_0. Its total energy is 16 J.

What is the kinetic energy of the mass when its displacement is $\frac{x_0}{2}$?

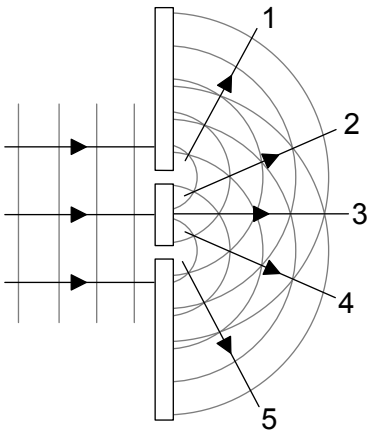
A. 4 J

B. 8 J

C. 12 J

D. 16 J

27. Blue light is incident on two narrow slits. Constructive interference takes place along the lines labelled 1 to 5.



The blue light is now replaced by red light. What additional change is needed so that the lines of constructive interference remain in the same angular positions?

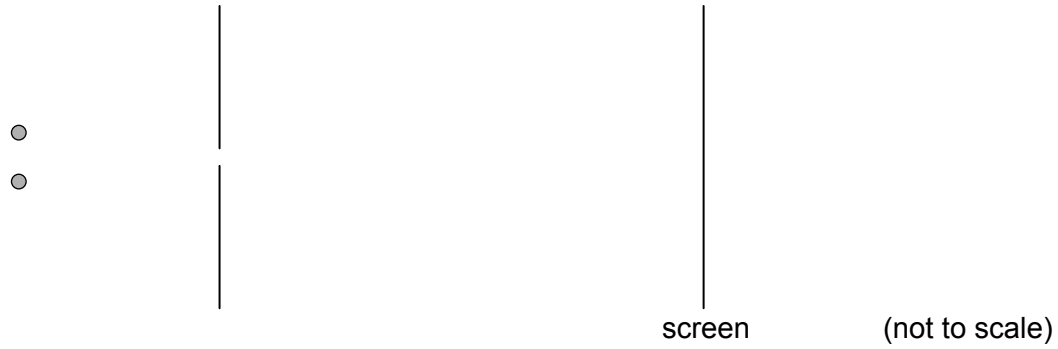
A. Make the slits wider

B. Make the slits narrower

C. Move the slits closer together

D. Move the slits further apart

28. Two points illuminated by monochromatic light are separated by a small distance. The light from the two sources passes through a small circular aperture and is detected on a screen far away.



The images of the two light sources are just resolved. What changes to the wavelength and the size of the aperture will definitely allow the two images to be well-resolved?

	Wavelength	Size of aperture
A.	increase	increase
B.	increase	decrease
C.	decrease	increase
D.	decrease	decrease

29. A train travelling in a straight line emits a sound of constant frequency f. An observer at rest very close to the path of the train detects a sound of continuously decreasing frequency. The train is

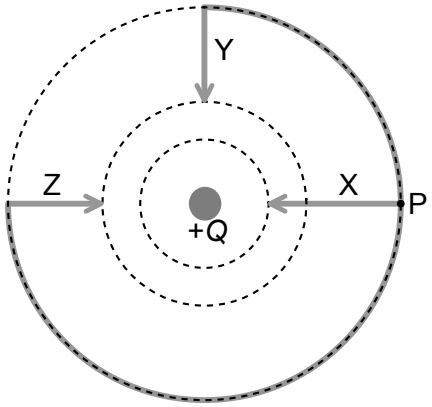
A. approaching the observer at constant speed.

B. approaching the observer at increasing speed.

C. moving away from the observer at constant speed.

D. moving away from the observer at increasing speed.

30. A positive charge *Q* is deposited on the surface of a small sphere. The dotted lines represent equipotentials.



A small positive point charge is moved from point P closer to the sphere along three different paths X, Y and Z. The work done along each path is W_X, W_Y and W_Z. What is a correct comparison of W_X, W_Y and W_Z?

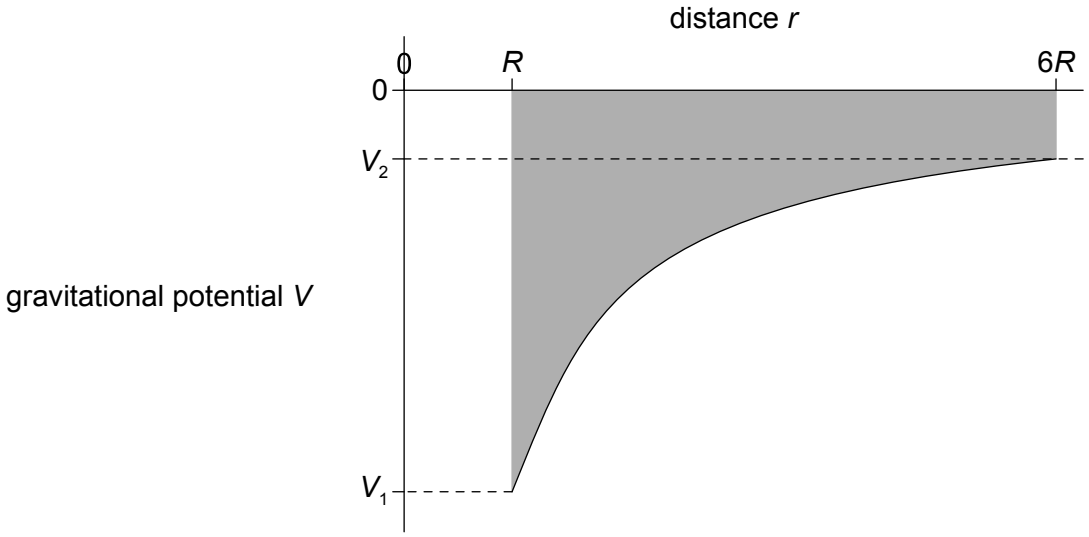
A. $W_Z > W_Y > W_X$

B. $W_X > W_Y = W_Z$

C. $W_X = W_Y = W_Z$

D. $W_Z = W_Y > W_X$

31. The graph shows the variation of the gravitational potential V with distance r from the centre of a uniform spherical planet. The radius of the planet is R. The shaded area is S.



What is the work done by the gravitational force as a point mass m is moved from the surface of the planet to a distance $6R$ from the centre?

A. $m(V_2 - V_1)$

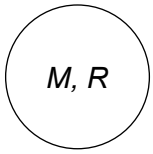
B. $m(V_1 - V_2)$

C. mS

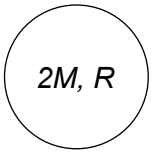
D. S

32. Four uniform planets have masses and radii as shown. Which planet has the smallest escape speed?

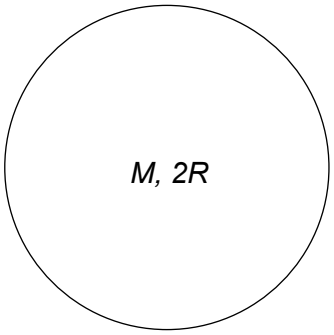
A.



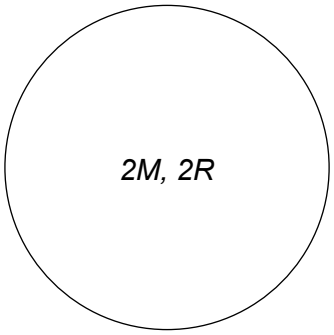
B.



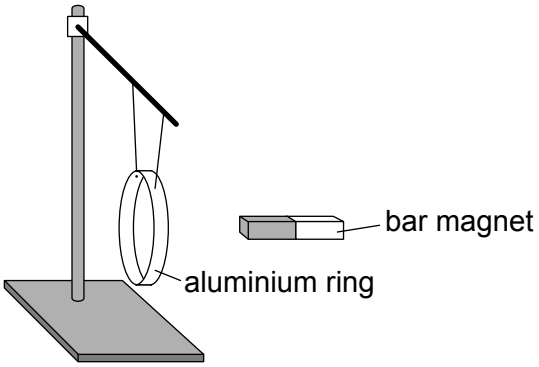
C.



D.



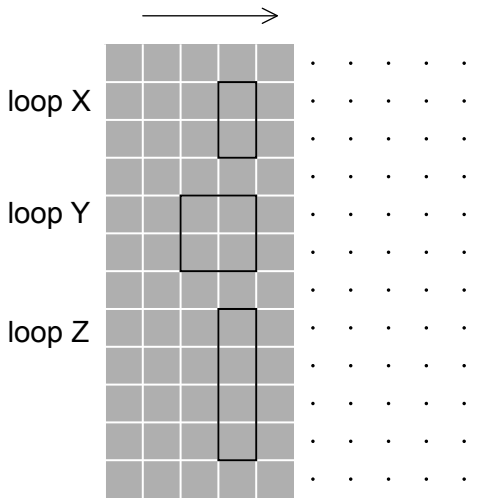
33. The diagram shows a bar magnet near an aluminium ring.



The ring is supported so that it is free to move. The ring is initially at rest. In experiment 1 the magnet is moved towards the ring. In experiment 2 the magnet is moved away from the ring. For each experiment what is the initial direction of motion of the ring?

	Experiment 1	Experiment 2
A.	to the left	to the left
B.	to the left	to the right
C.	to the right	to the left
D.	to the right	to the right

34. Three conducting loops, X, Y and Z, are moving with the same speed from a region of zero magnetic field to a region of uniform non-zero magnetic field.



Which loop(s) has/have the largest induced electromotive force (emf) at the instant when the loops enter the magnetic field?

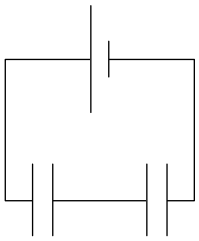
A. Z only

B. Y only

C. Y and Z only

D. X and Y only

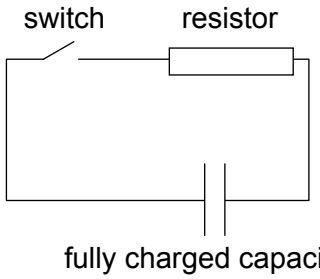
35. Two capacitors of different capacitance are connected in series to a source of emf of negligible internal resistance.



What is correct about the potential difference across each capacitor and the charge on each capacitor?

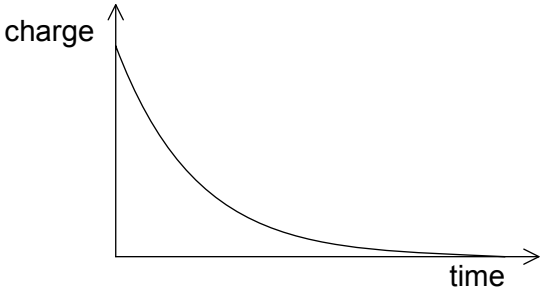
	Potential difference	Charge
A.	same	same
B.	same	different
C.	different	same
D.	different	different

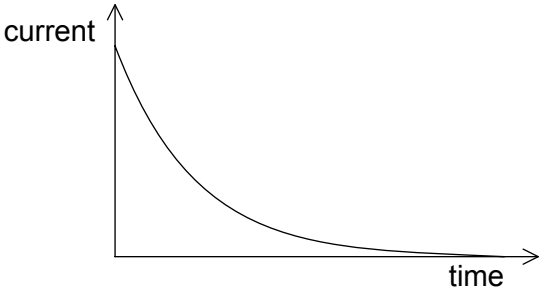
36. A fully charged capacitor is connected to a resistor. When the switch is closed the capacitor will discharge through the resistor.



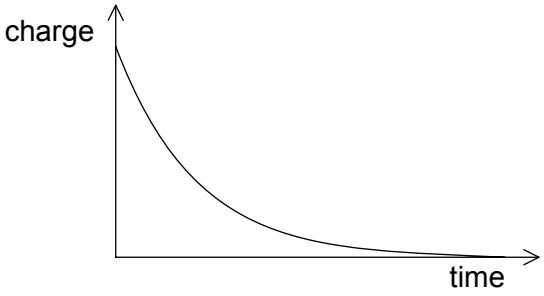
Which graphs correctly show how the charge on the capacitor and the current in the circuit vary with time during the discharging of the capacitor?

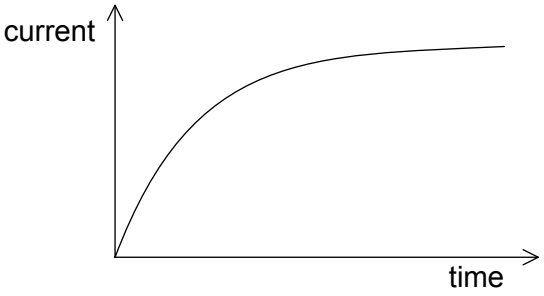
A.



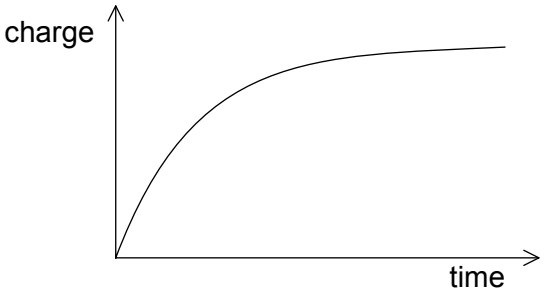


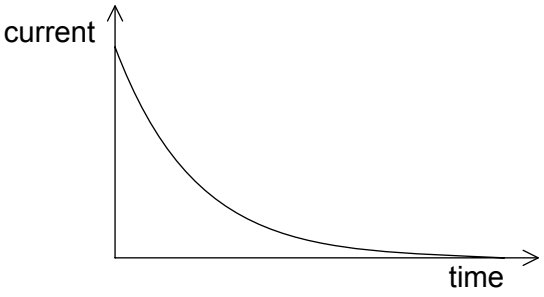
B.



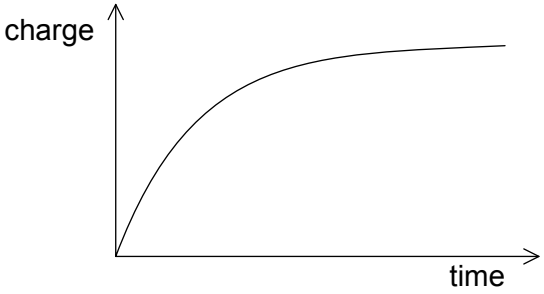


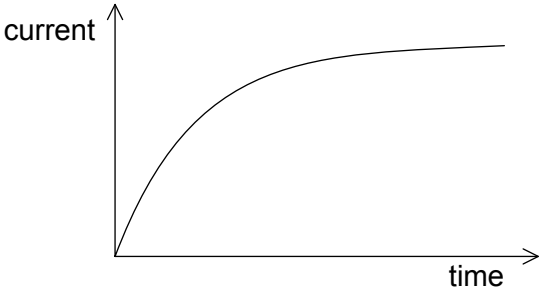
C.





D.





37. When monochromatic light is incident on a metallic surface, electrons are emitted from the surface. The following changes are considered.

I. Increase the intensity of the incident light
II. Increase the frequency of light
III. Decrease the work function of the surface

Which changes will result in electrons of greater energy being emitted from the surface?

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

38. In the Bohr model for hydrogen an electron in the ground state has orbit radius r and speed v. In the first excited state the electron has orbit radius $4r$. What is the speed of the electron in the first excited state?

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

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

C. $\frac{v}{8}$

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

39. A neutron of mass m is confined within a nucleus of diameter d. Ignoring numerical constants, what is an approximate expression for the kinetic energy of the neutron?

A. $\frac{h^2}{md^2}$

B. $\frac{h}{md}$

C. $\frac{mh^2}{d^2}$

D. $\frac{h}{m^2d}$

40. A radioactive element has decay constant λ (expressed in s^{-1}). The number of nuclei of this element at $t = 0$ is N. What is the expected number of nuclei that will have decayed after 1 s?

A. $N(1 - e^{-\lambda})$

B. $\frac{N}{\lambda}$

C. $Ne^{-\lambda}$

D. λN