



**PHYSICS (PRINCIPAL)**

Paper 1 Multiple Choice

**9792/01**

**May/June 2016**

**1 hour 30 minutes**

Additional Materials: Multiple Choice Answer Sheet  
Soft clean eraser  
Soft pencil (type B or HB is recommended)



**READ THESE INSTRUCTIONS FIRST**

Write in soft pencil.

Do not use staples, paper clips, glue or correction fluid.

Write your name, Centre number and candidate number on the Answer Sheet in the spaces provided unless this has been done for you.

**DO NOT WRITE IN ANY BARCODES.**

There are **forty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A, B, C** and **D**.

Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

**Read the instructions on the Answer Sheet very carefully.**

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.

Any working should be done in this booklet.

Electronic calculators may be used.

The syllabus is approved for use in England, Wales and Northern Ireland as a Cambridge International Level 3 Pre-U Certificate.

This document consists of **18** printed pages and **2** blank pages.

**Data**

gravitational field strength close to Earth's surface	$g = 9.81 \text{ N kg}^{-1}$
elementary charge	$e = 1.60 \times 10^{-19} \text{ C}$
speed of light in vacuum	$c = 3.00 \times 10^8 \text{ m s}^{-1}$
Planck constant	$h = 6.63 \times 10^{-34} \text{ J s}$
permittivity of free space	$\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$
gravitational constant	$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
electron mass	$m_e = 9.11 \times 10^{-31} \text{ kg}$
proton mass	$m_p = 1.67 \times 10^{-27} \text{ kg}$
unified atomic mass constant	$u = 1.66 \times 10^{-27} \text{ kg}$
molar gas constant	$R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$
Avogadro constant	$N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$
Boltzmann constant	$k = 1.38 \times 10^{-23} \text{ J K}^{-1}$
Stefan-Boltzmann constant	$\sigma = 5.67 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$

**Formulae**

uniformly accelerated motion

$$s = ut + \frac{1}{2}at^2$$

$$v^2 = u^2 + 2as$$

$$s = \left( \frac{u+v}{2} \right) t$$

heating

$$\Delta E = mc\Delta\theta$$

change of state

$$\Delta E = mL$$

refraction

$$n = \frac{\sin\theta_1}{\sin\theta_2}$$

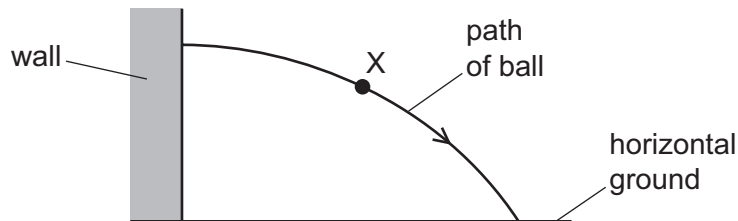
$$n = \frac{v_1}{v_2}$$

diffraction		electromagnetic induction	$E = -\frac{d(N\Phi)}{dt}$
single slit, minima	$n\lambda = b \sin \theta$	Hall effect	$V = Bvd$
grating, maxima	$n\lambda = d \sin \theta$	time dilation	$t' = \frac{t}{\sqrt{1 - \frac{v^2}{c^2}}}$
double slit interference	$\lambda = \frac{ax}{D}$	length contraction	$l' = l\sqrt{1 - \frac{v^2}{c^2}}$
Rayleigh criterion	$\theta \approx \frac{\lambda}{b}$	kinetic theory	$\frac{1}{2}m\langle c^2 \rangle = \frac{3}{2}kT$
photon energy	$E = hf$	work done on/by a gas	$W = p\Delta V$
de Broglie wavelength	$\lambda = \frac{h}{p}$	radioactive decay	$\frac{dN}{dt} = -\lambda N$
simple harmonic motion	$x = A \cos \omega t$		$N = N_0 e^{-\lambda t}$
	$v = -A\omega \sin \omega t$		$t_{\frac{1}{2}} = \frac{\ln 2}{\lambda}$
	$a = -A\omega^2 \cos \omega t$	attenuation losses	$I = I_0 e^{-\mu x}$
	$F = -m\omega^2 x$	mass-energy equivalence	$\Delta E = c^2 \Delta m$
	$E = \frac{1}{2}mA^2\omega^2$	hydrogen energy levels	$E_n = \frac{-13.6 \text{ eV}}{n^2}$
energy stored in a capacitor	$W = \frac{1}{2}QV$	Heisenberg uncertainty principle	$\Delta p \Delta x \geq \frac{h}{2\pi}$
capacitor discharge	$Q = Q_0 e^{-\frac{t}{RC}}$	Wien's displacement law	$\lambda_{\text{max}} \propto \frac{1}{T}$
electric force	$F = \frac{Q_1 Q_2}{4\pi\epsilon_0 r^2}$	Stefan's law	$L = 4\pi\sigma r^2 T^4$
electrostatic potential energy	$W = \frac{Q_1 Q_2}{4\pi\epsilon_0 r}$	electromagnetic radiation from a moving source	$\frac{\Delta\lambda}{\lambda} \approx \frac{\Delta f}{f} \approx \frac{v}{c}$
gravitational force	$F = -\frac{Gm_1 m_2}{r^2}$		
gravitational potential energy	$E = -\frac{Gm_1 m_2}{r}$		
magnetic force	$F = BIl \sin \theta$		
	$F = BQv \sin \theta$		

1 Which statement is **not** in agreement with Newton's laws of motion?

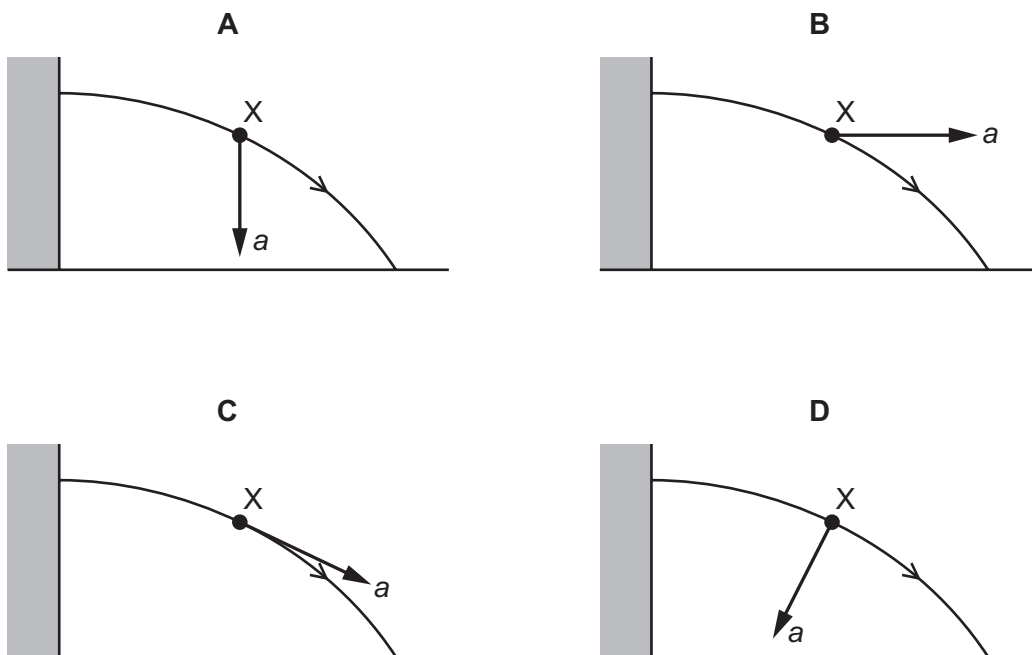
- A If I jump vertically upwards in a train moving at constant velocity, I will land back in my original position in the train.
- B If I hit a ball, the force I exert on the ball is equal in magnitude to the force the ball exerts on me.
- C To maintain constant speed an aircraft's thrust must exceed the total drag acting on the aircraft.
- D The maximum acceleration of a car increases as its fuel tank empties.

2 The diagram shows the path described by a ball after bouncing from a vertical wall.



Air resistance has negligible effect on the motion of the ball.

Which diagram shows the direction of the acceleration  $a$  of the ball when at point X?

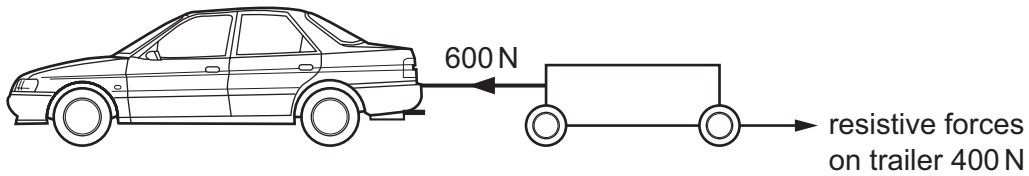


3 On the asteroid Ceres, a stone dropped from rest from a height of 1.0 m would take 2.8 s to reach the surface of the asteroid.

What would be the weight of a 70 kg astronaut on Ceres?

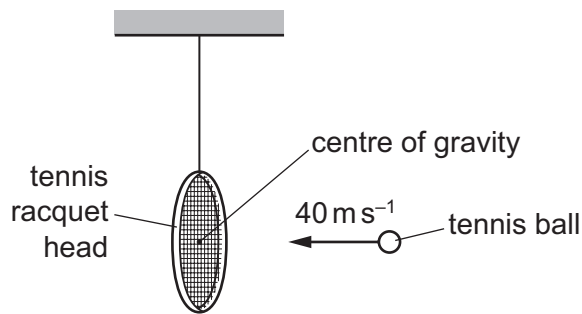
- A 18 N
- B 70 N
- C 250 N
- D 700 N

- 4 A trailer of mass 500 kg is pulled by a car of mass 1000 kg. The diagram shows the horizontal forces acting on the trailer.



What is the driving force provided by the car?

- A 400 N      B 800 N      C 1000 N      D 1200 N
- 5 In a test laboratory, the head of a tennis racquet is suspended on a long string.



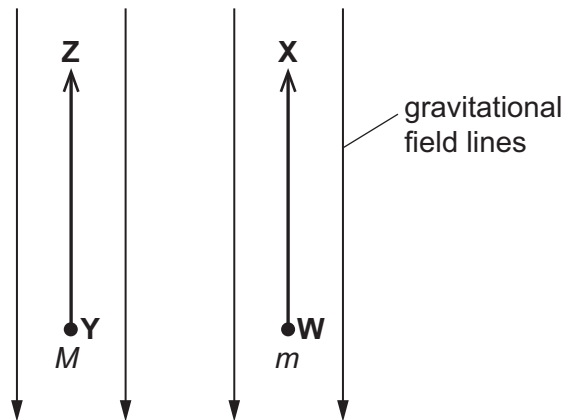
A tennis ball is fired at the centre of gravity of the racquet head at a speed of  $40 \text{ m s}^{-1}$ . The ball bounces from the racquet head in the opposite direction at a speed of  $30 \text{ m s}^{-1}$ .

The mass of the tennis ball is 0.060 kg and the mass of the racquet head is 1.2 kg.

What is the change in speed of the racquet head?

- A  $0.50 \text{ m s}^{-1}$       B  $1.5 \text{ m s}^{-1}$       C  $2.0 \text{ m s}^{-1}$       D  $3.5 \text{ m s}^{-1}$

- 6 Masses  $M$  and  $m$  are placed in a constant gravitational field of strength  $g$ . Mass  $M$  is greater than mass  $m$ .



Mass  $m$  is moved from **W** to **X** through a distance  $d$ .

Mass  $M$  is moved the same distance  $d$  from **Y** to **Z**.

Which statement is correct?

- A**  $m$  and  $M$  experience identical changes of gravitational potential.
- B**  $m$  and  $M$  experience a total change of gravitational potential of  $(m + M)gd$ .
- C**  $M$  experiences a bigger increase in gravitational potential than  $m$ .
- D**  $M$  experiences a bigger decrease in gravitational potential than  $m$ .
- 7 A heavy weight is hung from a steel cable. The cable is then replaced with a steel cable of the same length and half the diameter. The same weight is now hung from the new cable.

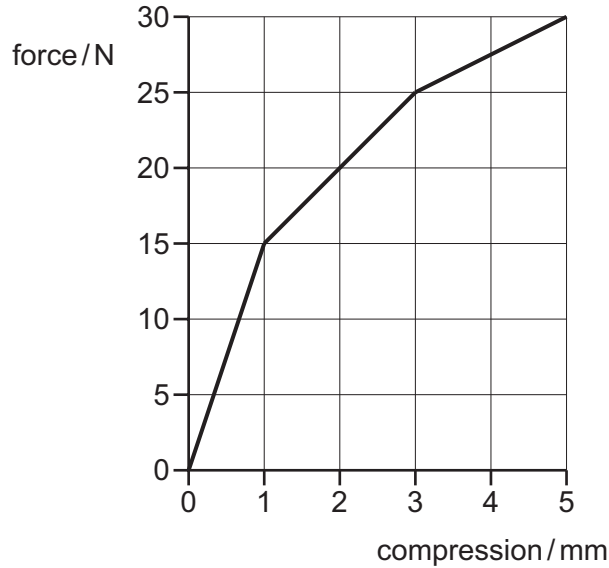
What will be the tensile stress and strain in the new cable compared with the original cable?

	stress	strain
<b>A</b>	$\times 2$	$\times 1$
<b>B</b>	$\times 2$	$\times 2$
<b>C</b>	$\times 4$	$\times 1$
<b>D</b>	$\times 4$	$\times 4$

- 8 A new composite material is manufactured for medical implantation.

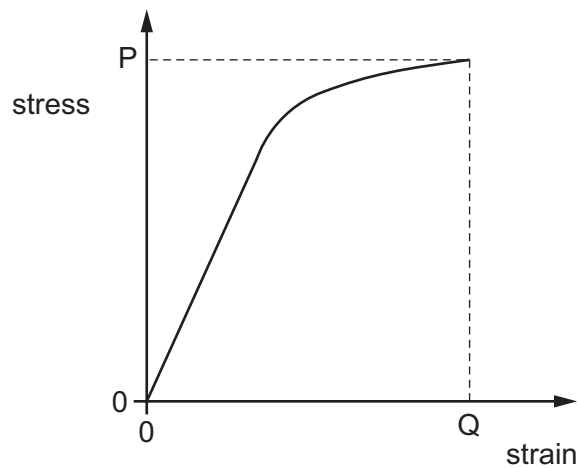
In laboratory tests, a spring-shaped sample is compressed.

A graph of the force applied versus the compression of the spring is shown.



How much energy is stored in the composite spring when the compressive force is 25 N?

- A** 37.5 mJ      **B** 47.5 mJ      **C** 37.5 J      **D** 47.5 J
- 9 The graph shows how the stress and strain of a sample of a material are related.



Which feature of the graph gives an indication of the toughness of the material?

- A** the area under the curve  
**B** the initial gradient  
**C** the value of P  
**D** the value of Q

- 10 A rectangular tank, with vertical sides, contains water to a depth of 30 cm. On a cold day, the water is initially  $0^{\circ}\text{C}$ . The top 3.0 cm of water freezes into ice at  $0^{\circ}\text{C}$ .

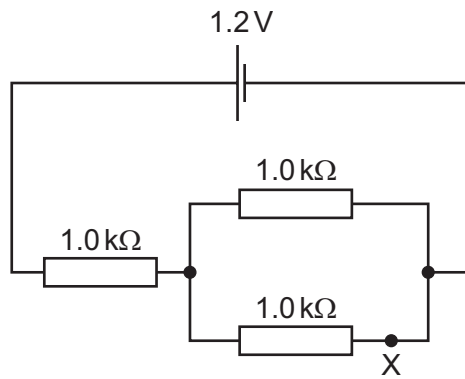
Assume that half of the latent heat given out by the ice goes to heating the remainder of the water.

Specific latent heat of fusion of water =  $330\text{ kJ kg}^{-1}$ .

Specific heat capacity of water =  $4.2\text{ kJ kg}^{-1}\text{ K}^{-1}$ .

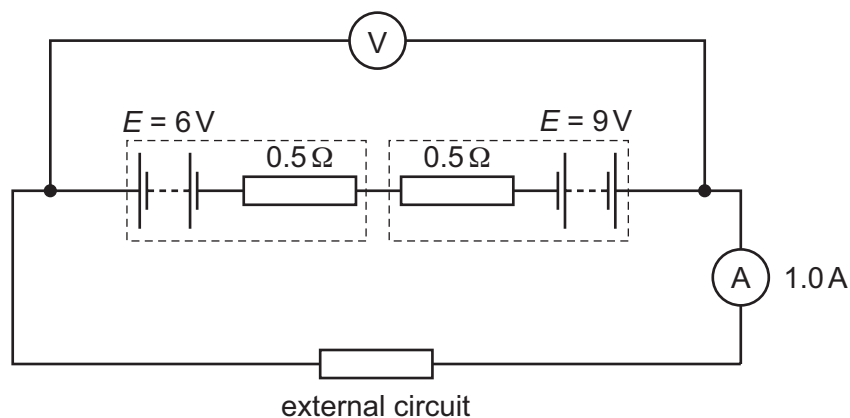
What is now the temperature of the water below the ice?

- A  $3.9^{\circ}\text{C}$       B  $4.4^{\circ}\text{C}$       C  $7.9^{\circ}\text{C}$       D  $8.7^{\circ}\text{C}$
- 11 In the circuit shown, all resistors have resistance  $1.0\text{ k}\Omega$ , and the cell has electromotive force (emf)  $1.2\text{ V}$  and negligible internal resistance.



How many electrons pass point X in one second?

- A  $2.5 \times 10^{15}$       B  $5.0 \times 10^{15}$       C  $2.5 \times 10^{18}$       D  $5.0 \times 10^{18}$
- 12 Two batteries, each of internal resistance  $0.5\Omega$ , are connected to an external circuit. The emf of the batteries is  $6\text{ V}$  and  $9\text{ V}$  respectively. When the external circuit is connected, the ammeter reads  $1.0\text{ A}$ .

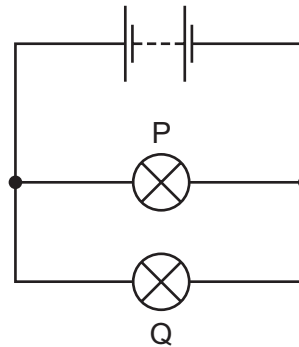
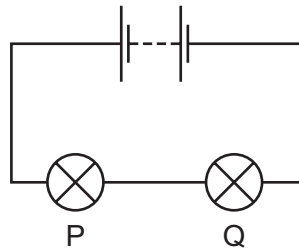


What is the reading on the voltmeter?

- A  $2\text{ V}$       B  $3\text{ V}$       C  $14\text{ V}$       D  $15\text{ V}$



- 13 Two lamps, P and Q, are connected in series and then in parallel to a battery of negligible internal resistance.



The resistance of lamp Q is larger than the resistance of lamp P.

Which row indicates how the brightness of the two lamps compares?

Assume that the resistances of the lamps do not change.

	lamps in series	lamps in parallel
<b>A</b>	P brighter than Q	P brighter than Q
<b>B</b>	P brighter than Q	Q brighter than P
<b>C</b>	Q brighter than P	P brighter than Q
<b>D</b>	Q brighter than P	Q brighter than P

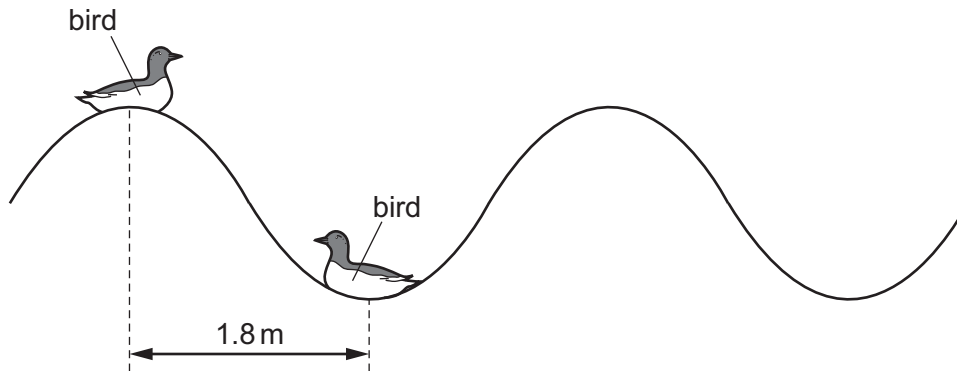
- 14 Diamond has a refractive index of 2.4.

A ray of light of wavelength  $\lambda$  and frequency  $f$  passes from air into diamond. The light has speed  $c$  in air.

Which row gives the wavelength, frequency and speed of the light inside diamond?

	wavelength	frequency	speed
<b>A</b>	$\frac{\lambda}{2.4}$	$f$	$\frac{c}{2.4}$
<b>B</b>	$\frac{\lambda}{2.4}$	$2.4f$	$c$
<b>C</b>	$2.4\lambda$	$\frac{f}{2.4}$	$c$
<b>D</b>	$2.4\lambda$	$f$	$\frac{c}{2.4}$

- 15 Two birds float on the sea as shown. They are separated by a distance of 1.8 m. They bob up and down with a period of 4.0 s.



What is the speed of the waves?

- A  $0.45 \text{ ms}^{-1}$       B  $0.90 \text{ ms}^{-1}$       C  $7.2 \text{ ms}^{-1}$       D  $14 \text{ ms}^{-1}$
- 16 Plane polarised light of amplitude  $A$  is incident on a polarising filter aligned so that no light is transmitted.

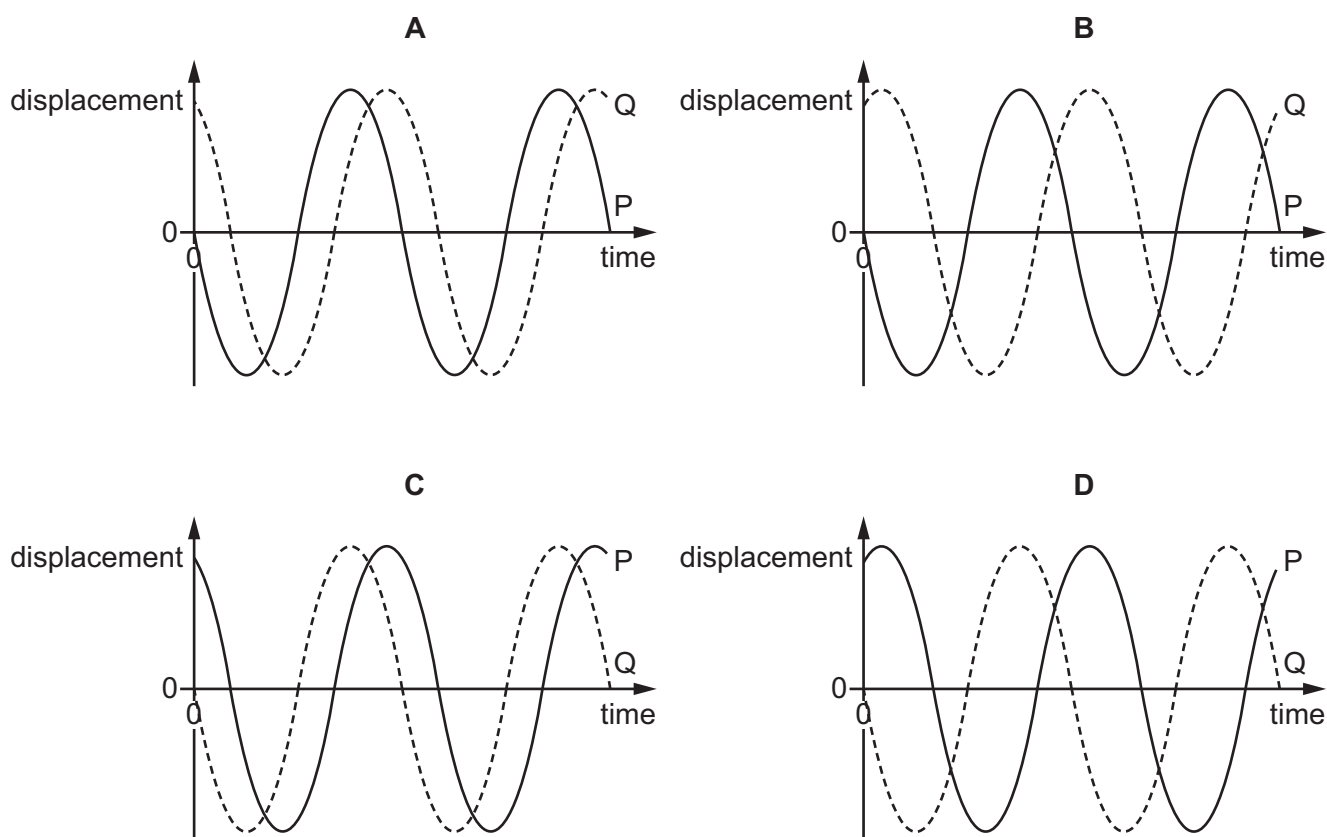
The filter is now rotated through an angle of  $30^\circ$ .

What is the amplitude of the transmitted light?

- A  $0.25A$       B  $0.50A$       C  $0.75A$       D  $0.87A$

17 The diagrams show the variation with time of the displacement of two waves, P and Q.

In which diagram does wave P lead wave Q by  $\frac{\pi}{3}$  rad?



18 In a double-slit interference experiment, the observation screen is placed at a distance of 2.50 m from the double slit.

The slit separation is 0.25 mm and light of wavelength 532 nm is used.

What will the fringe separation be on the observation screen?

- A  $5.32 \times 10^{-6}$  m
- B  $5.32 \times 10^{-3}$  m
- C 0.532 m
- D  $5.32 \times 10^3$  m

- 19 A radioactive source has an activity of 800 kBq. It contains an isotope which has a half-life of 3.0 hours and which decays to form a stable isotope.

Another radioactive source also has an activity of 800 kBq. It contains an isotope with a half-life of 6.0 hours, which also decays to form a stable isotope.

These two sources are mixed together.

What is the activity of the mixture after 12 hours?

- A 50 kBq      B 200 kBq      C 250 kBq      D 600 kBq
- 20 When  $^{14}_6\text{C}$  undergoes  $\beta^-$  decay it becomes an isotope of nitrogen.

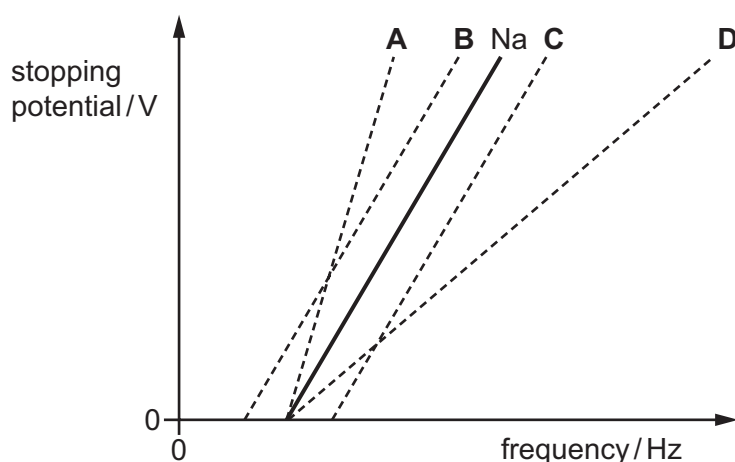
Which row in the table gives the number of neutrons and electrons in a positive ion of nitrogen-14?

	neutrons	electrons
<b>A</b>	7	6
<b>B</b>	7	7
<b>C</b>	8	6
<b>D</b>	8	7

- 21 In a photoelectric cell experiment, sodium metal is exposed to electromagnetic radiation of different frequencies and the potential required to stop the photoelectrons is measured.

The graph uses a solid line, marked Na, to show the results of the photoelectric cell experiment.

Which line represents the results for the photoelectric cell using a metal that has a larger work function than sodium?



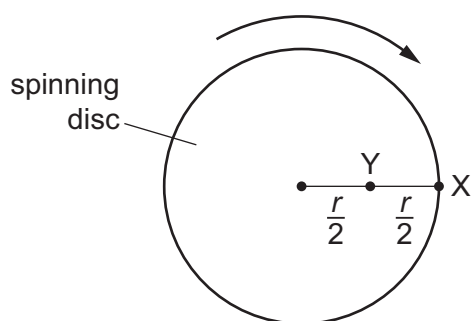
- 22 Monochromatic light is incident on a metal surface and photoelectrons are emitted from the surface.

Monochromatic light of the same intensity, but with a higher frequency, is now used.

Which row describes the changes that will occur to the number of photoelectrons emitted per second and their maximum kinetic energy?

	number of photoelectrons emitted per second	maximum kinetic energy of the photoelectrons that are emitted
<b>A</b>	greater	greater
<b>B</b>	greater	smaller
<b>C</b>	smaller	greater
<b>D</b>	smaller	smaller

- 23 A disc of radius  $r$  undergoes uniform circular motion. The speed of point X is  $v$ , and its period is  $T$ .



Which row shows the correct values of speed and period of point Y, in terms of  $v$  and  $T$ ?

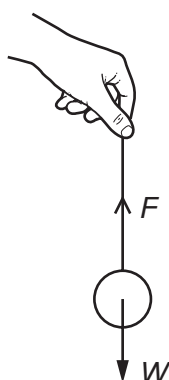
	speed of point Y	period of point Y
<b>A</b>	$\frac{v}{2}$	$T$
<b>B</b>	$\frac{v}{2}$	$2T$
<b>C</b>	$v$	$\frac{T}{2}$
<b>D</b>	$v$	$T$

- 24 A wheel in a piece of machinery has a radius of 6.7 cm. It is rotating at a constant rate of 6000 revolutions per minute.

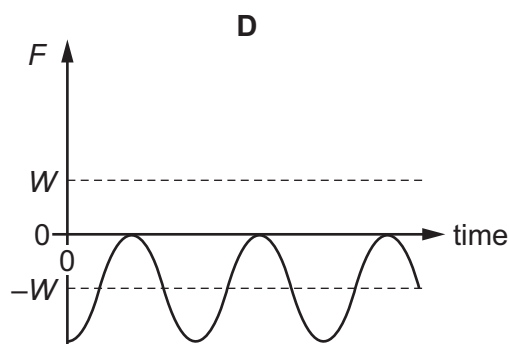
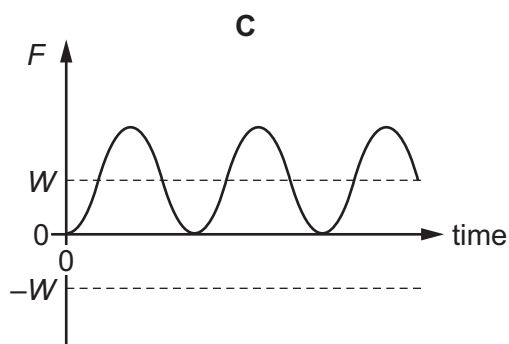
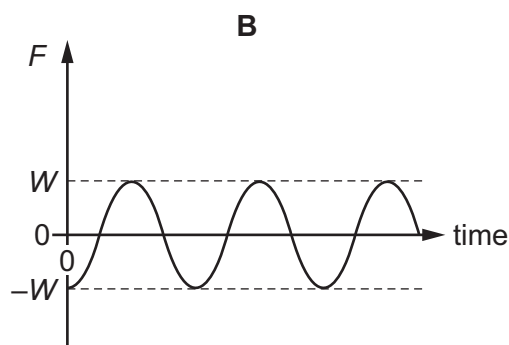
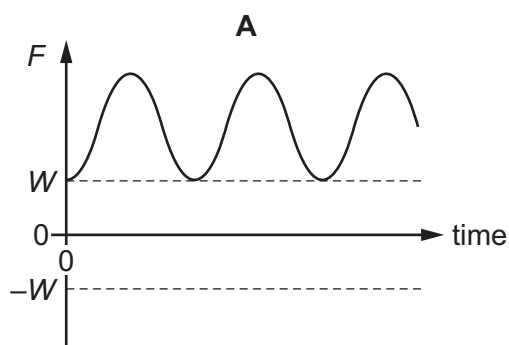
What is the acceleration of a point on the circumference of the wheel?

- A  $4.2 \times 10^3 \text{ ms}^{-2}$   
 B  $2.6 \times 10^4 \text{ ms}^{-2}$   
 C  $1.3 \times 10^6 \text{ ms}^{-2}$   
 D  $9.5 \times 10^7 \text{ ms}^{-2}$

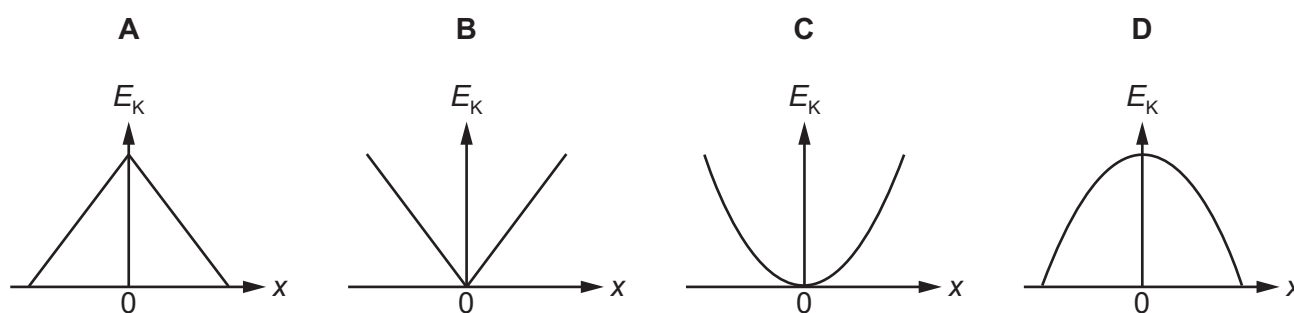
- 25 An object of weight  $W$  is supported by a string. The object can be moved up and down by a person holding the free end of the string, as shown.



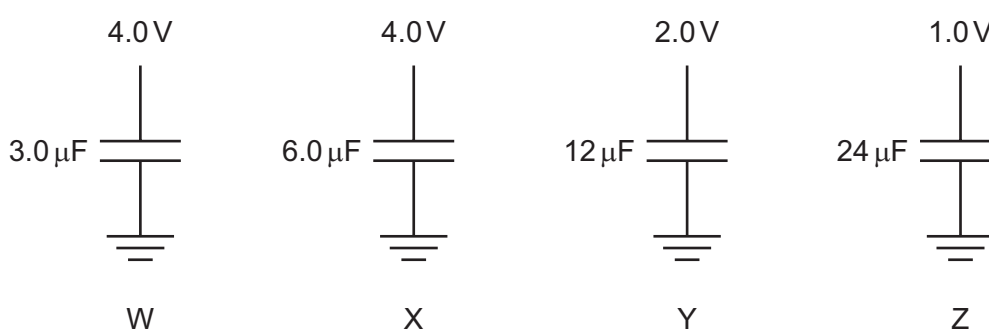
Which graph shows the upward force  $F$  the person needs to apply for the object to move with simple harmonic motion?



- 26 Which graph correctly shows the variation of kinetic energy  $E_K$  with displacement  $x$  for a body undergoing simple harmonic motion?

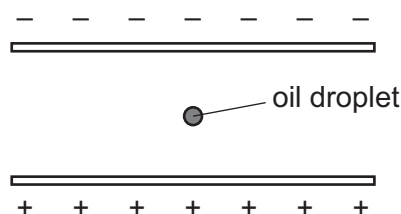


- 27 Which **two** capacitors in the diagram store the same amount of energy?



- A** W and Y      **B** X and Y      **C** X and Z      **D** Y and Z

- 28 A positively charged oil droplet is held stationary in an electric field of strength  $E$ .



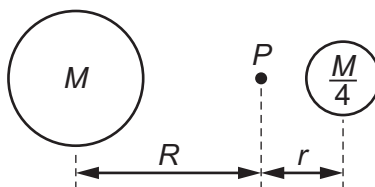
A different droplet of the same oil is held stationary in an electric field of different strength.

The droplet has half the charge and twice the radius of the original droplet.

What is the electric field strength?

- A**  $2E$       **B**  $4E$       **C**  $8E$       **D**  $16E$

- 29 Two large masses, one of mass  $M$ , the other of mass  $\frac{M}{4}$ , are positioned as shown.



A small mass is placed at point  $P$  such that it experiences zero gravitational force from the masses.

What is the ratio  $\frac{R}{r}$ ?

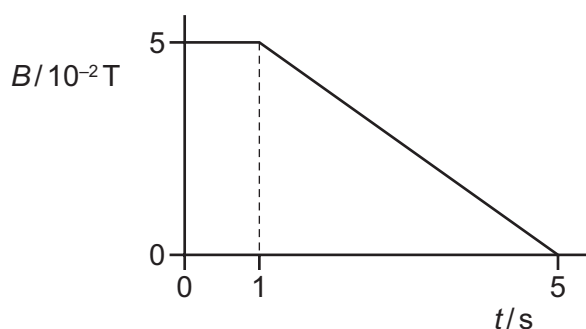
- A  $\frac{1}{4}$       B  $\frac{1}{2}$       C 2      D 4
- 30 Io and Ganymede are moons of Jupiter. The orbital period of Ganymede is four times that of Io. Io's orbital radius is  $4.20 \times 10^8$  m.

What is the orbital radius of Ganymede?

- A  $1.10 \times 10^9$  m    B  $1.68 \times 10^9$  m    C  $3.36 \times 10^9$  m    D  $2.70 \times 10^9$  m
- 31 An electrical current passes through a wire of mass per unit length  $20 \text{ g m}^{-1}$ . It is placed in a magnetic field of strength  $0.50 \text{ T}$ . The current is gradually increased until the wire just levitates.

What is the value of the current when this happens?

- A 0.040 A      B 0.39 A      C 2.6 A      D 390 A
- 32 A 120 turn coil of area  $5.0 \times 10^{-4} \text{ m}^2$  is placed in a magnetic field of strength  $5.0 \times 10^{-2} \text{ T}$ . The magnetic flux density  $B$  is then changed as shown.



What is the induced electromotive force when  $t = 3 \text{ s}$ ?

- A  $6.25 \mu\text{V}$       B  $600 \mu\text{V}$       C  $750 \mu\text{V}$       D  $1250 \mu\text{V}$



- 33 Which statement about gases is **not** correct?
- A Brownian motion is caused by imbalances in molecular bombardment.
  - B In theory, an ideal gas would exert zero pressure at absolute zero.
  - C Molecules of different gases have the same root mean square speed (r.m.s.) at the same pressure.
  - D Work must be done to compress a gas at constant temperature.

- 34 Atoms of neon are at a temperature such that the root mean square (r.m.s.) speed of its atoms is  $400 \text{ ms}^{-1}$ .

What will be the r.m.s. speed of molecules of hydrogen at the same temperature?

Mass of neon atom = 20 u.

Mass of hydrogen molecule = 2 u.

- A  $130 \text{ ms}^{-1}$       B  $400 \text{ ms}^{-1}$       C  $1300 \text{ ms}^{-1}$       D  $4000 \text{ ms}^{-1}$
- 35 Which statement about protons and neutrons is correct?
- A Protons and neutrons are both classified as leptons.
  - B Protons and neutrons contain the same number of up quarks.
  - C Protons and neutrons have the same baryon number.
  - D Protons and neutrons have the same charge.
- 36 Which statement about nuclear physics is **not** correct?
- A  $\beta^-$  decay occurs when a down quark changes to an up quark inside a proton.
  - B Nuclear fusion reactions are responsible for creating heavier nuclei from lighter nuclei.
  - C The binding energy of a nucleus is equal to the work that must be done to separate a nucleus into nucleons.
  - D The minimum amount of energy released when an electron and an anti-electron annihilate is  $2m_e c^2$ .

- 37 Meteorites collected in Antarctica can be used to date the solar system by using the radioactive decay of rubidium-87 to strontium-87. The half-life for this decay is  $4.88 \times 10^{10}$  years.

In a particular meteorite the present ratio of strontium-87 to rubidium-87, after correcting for the presence of strontium when the meteorite formed, is 0.072.

How old is the meteorite?

- A  $3.51 \times 10^9$  years  
 B  $4.89 \times 10^9$  years  
 C  $5.26 \times 10^9$  years  
 D  $4.52 \times 10^{10}$  years
- 38 An electron in a hydrogen atom falls from the  $n = 3$  energy state to the ground state.

The energy levels of the hydrogen atom can be described by the empirical equation

$$E_n = \frac{-13.6\text{eV}}{n^2}.$$

What is the wavelength of the photon emitted?

- A 91 nm                      B 100 nm                      C 140 nm                      D 820 nm
- 39 The Hubble constant has a value of approximately  $70 \text{ km s}^{-1} \text{ Mpc}^{-1}$ . A galaxy is receding from the Earth at a speed of  $0.30c$ , where  $c$  is the speed of light.

What is the best estimate of the distance of the galaxy from the Earth?

- A  $1.3 \times 10^3 \text{ Mpc}$   
 B  $1.3 \times 10^6 \text{ Mpc}$   
 C  $6.3 \times 10^9 \text{ Mpc}$   
 D  $6.3 \times 10^{12} \text{ Mpc}$
- 40 Astronomers observing a distant star measured its luminous flux  $F$  and its surface temperature  $T$ . The star is one of a cluster at distance  $d$  from the Earth.

What is the radius of the star?

- A  $4\pi d^2 F$                       B  $\sqrt{\frac{F}{4\pi d \sigma T^2}}$                       C  $\sqrt{\frac{F}{4\pi \sigma T^4}}$                       D  $\sqrt{\frac{Fd^2}{\sigma T^4}}$



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