Higher Physics

Christmas homework

My gift to you this year!!

DATA SHEET

COMMON PHYSICAL QUANTITIES

Quantity	*Symbol*	*Value*	*Quantity*	*Symbol*	*Value*
Speed of light in vacuum	c	$3{\cdot}00 \times 10^{8}\ \text{m s}^{-1}$	Planck's constant	h	$6{\cdot}63 \times 10^{-34}\ \text{J s}$
Magnitude of the charge on an electron	e	$1{\cdot}60 \times 10^{-19}\ \text{C}$	Mass of electron	m_e	$9{\cdot}11 \times 10^{-31}\ \text{kg}$
Universal Constant of Gravitation	G	$6{\cdot}67 \times 10^{-11}\ \text{m}^3\ \text{kg}^{-1}\ \text{s}^{-2}$	Mass of neutron	m_n	$1{\cdot}675 \times 10^{-27}\ \text{kg}$
Gravitational acceleration on Earth	g	$9{\cdot}8\ \text{m s}^{-2}$	Mass of proton	m_p	$1{\cdot}673 \times 10^{-27}\ \text{kg}$
Hubble's constant	H_0	$2{\cdot}3 \times 10^{-18}\ \text{s}^{-1}$			

REFRACTIVE INDICES

The refractive indices refer to sodium light of wavelength 589 nm and to substances at a temperature of 273 K.

Substance	*Refractive index*	*Substance*	*Refractive index*
Diamond	2·42	Water	1·33
Crown glass	1·50	Air	1·00

SPECTRAL LINES

Element	*Wavelength*/nm	*Colour*
Hydrogen	656	Red
	486	Blue-green
	434	Blue-violet
	410	Violet
	397	Ultraviolet
	389	Ultraviolet
Sodium	589	Yellow

Element	*Wavelength*/nm	*Colour*
Cadmium	644	Red
	509	Green
	480	Blue

Lasers

Element	*Wavelength*/nm	*Colour*
Carbon dioxide	9550 } 10590 }	Infrared
Helium-neon	633	Red

PROPERTIES OF SELECTED MATERIALS

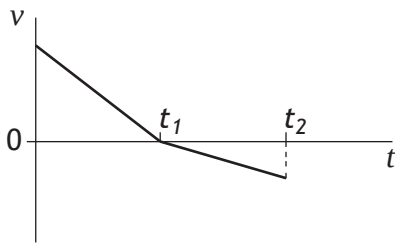
Substance	*Density*/kg m^{-3}	*Melting Point*/K	*Boiling Point*/K
Aluminium	$2{\cdot}70 \times 10^{3}$	933	2623
Copper	$8{\cdot}96 \times 10^{3}$	1357	2853
Ice	$9{\cdot}20 \times 10^{2}$	273	. . . .
Sea Water	$1{\cdot}02 \times 10^{3}$	264	377
Water	$1{\cdot}00 \times 10^{3}$	273	373
Air	1·29	. . . .	. . . .
Hydrogen	$9{\cdot}0 \times 10^{-2}$	14	20

The gas densities refer to a temperature of 273 K and a pressure of $1{\cdot}01 \times 10^{5}$.Pa

Attempt ALL questions

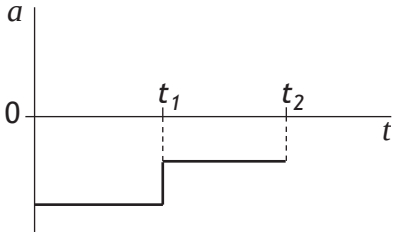
1. A trolley travels along a straight track.

The graph shows how the velocity v of the trolley varies with time t.

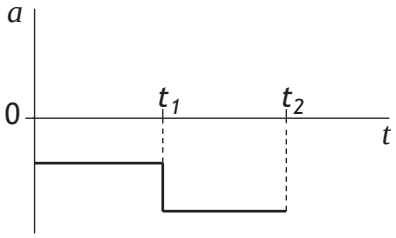


Which graph shows how the acceleration a of the trolley varies with time t?

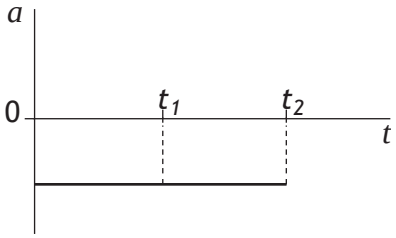
A



B



C



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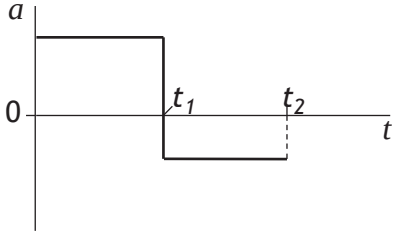
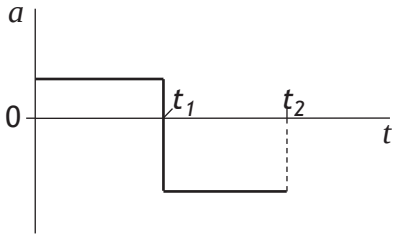


E



2. Two identical metal spheres X and Y are dropped onto a horizontal surface. The distance Y falls is double the distance X falls.

The effects of air resistance are negligible.

Which of the following statements is/are correct?

I The maximum kinetic energy of Y is double that of X.

II The maximum speed of Y is double the maximum speed of X.

III Y takes twice as long to fall as X.

A I only

B II only

C III only

D II and III only

E I, II and III

3. Two blocks are linked by a newton balance of negligible mass.

The blocks are placed on a level, frictionless surface. A force of 18·0 N is applied to the blocks as shown.

The reading on the newton balance is

A 7·2 N

B 9·0 N

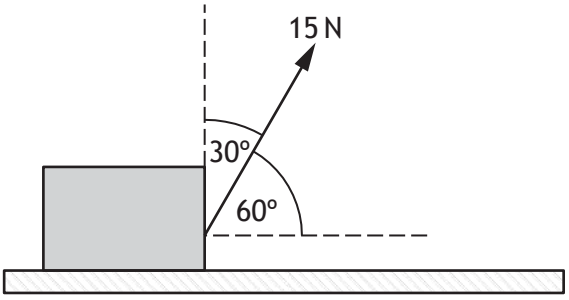
C 10·8 N

D 18·0 N

E 40·0 N.

4. A box is placed on a horizontal surface.

A force of 15 N acts on the box as shown.

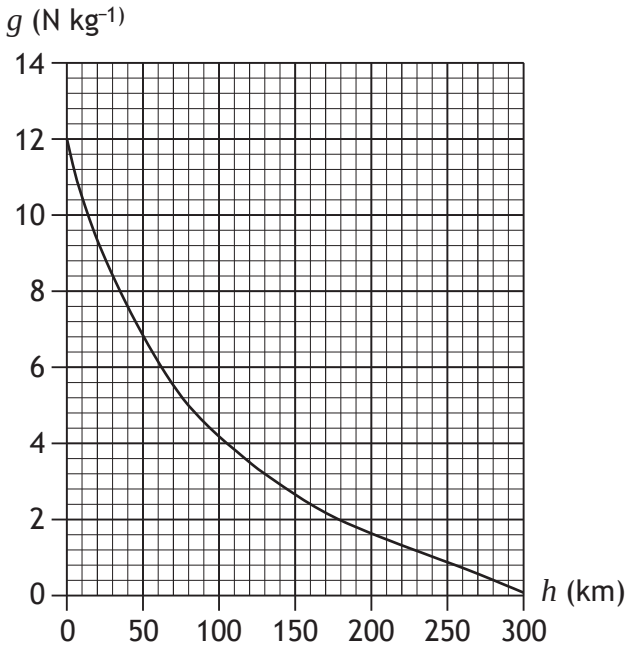


Which entry in the table shows the horizontal and vertical components of the force?

	Horizontal Component (N)	*Vertical Component* (N)
A	15 sin 60°	15 sin 30°
B	15 cos 60°	15 sin 30°
C	15 sin 60°	15 cos 60°
D	15 cos 30°	15 sin 30°
E	15 cos 60°	15 sin 60°

5. A rock of mass 0·80 kg falls towards the surface of a planet.

The graph shows how the gravitational field strength, g, of the planet varies with height, h, above the surface of the planet.



At one point during its fall the weight of the rock is 4·0 N. The height of this point above the surface of the planet is

A 15 km

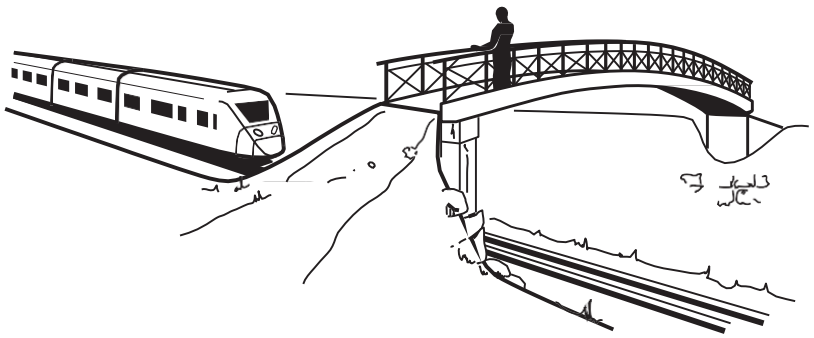
B 80 km

C 105 km

D 130 km

E 255 km.

6. A train is travelling at a constant speed of 16·0 $m\,s^{-1}$ as it approaches a bridge.



A horn on the train emits sound of frequency 277 Hz.

The sound is heard by a person standing on the bridge.

The speed of sound in air is 340 $m\,s^{-1}$.

The frequency of the sound heard by the person on the bridge is

A 265 Hz

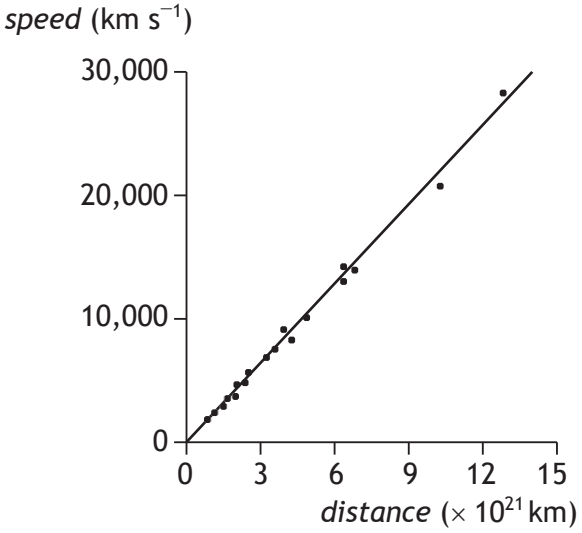
B 277 Hz

C 291 Hz

D 357 Hz

E 361 Hz.

7. Galaxies at different distances from the Earth have been found to have different speeds. The graph shows data for some distant galaxies.



A student studies this graph and makes the following statements.

I The speed of distant galaxies varies inversely with their distance from the Earth.

II The gradient of the line gives the value of Hubble's constant.

III The unit for Hubble's constant is s^{-1}.

Which of these statements is/are correct?

A I only

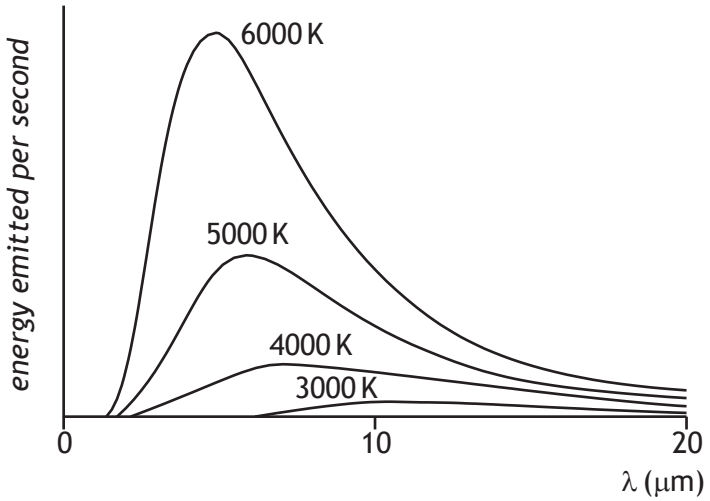
B II only

C III only

D I and II only

E II and III only

8. The graph shows how the energy emitted per second from the surface of a hot object varies with the wavelength, λ, of the emitted radiation at different temperatures.



Astudent makes the following statements based on the information shown in the graph.

I As the temperature of the object increases, the total energy emitted per second decreases.

II As the temperature of the object increases, the peak wavelength of the emitted radiation decreases.

III The frequency of the emitted radiation steadily increases as the emitted energy per second decreases.

Which of these statements is/are correct?

A I only

B II only

C III only

D I and II only

E II and III only

9. The cooling of the Universe and cosmic microwave background radiation provide evidence for

A the photoelectric effect

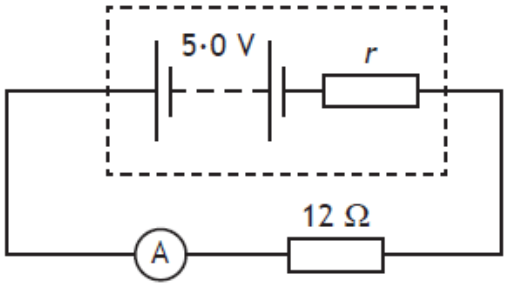
B the Bohr model of the atom

C the theory of special relativity

D the Big Bang theory

E Newton's Universal Law of Gravitation.

10. A circuit is set up as shown.



The e.m.f. of the battery is 5·0 V.

The reading on the ammeter is 0·35 A.

The internal resistance r of the battery is

A 0·28 Ω

B 0·80 Ω

C 1·15 Ω

D 2·3 Ω

E 3·2 Ω.

11. The e.m.f. of a battery is

A the total energy supplied by the battery

B the voltage lost due to the internal resistance of the battery

C the total charge that passes through the battery

D the number of coulombs of charge passing through the battery per second

E the energy supplied to each coulomb of charge passing through the battery.

12. The r.m.s. voltage of the mains supply is 230 V.

The approximate value of the peak voltage is

A 115 V

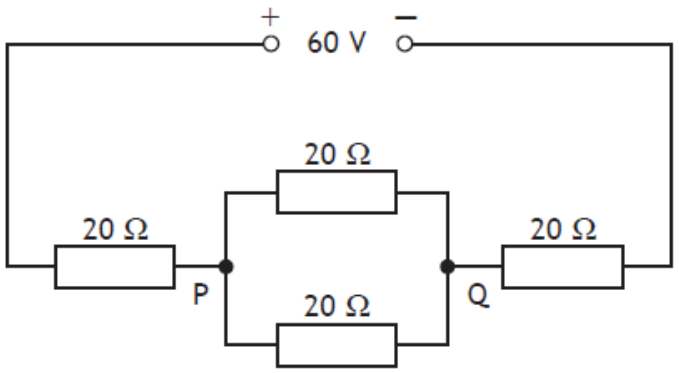
B 163 V

C 325 V

D 460 V

E 651 V.

13. Four resistors each of resistance 20 Ω are connected to a 60 V supply of negligible internal resistance as shown.



The potential difference across PQ is

A 12 V

B 15 V

C 20 V

D 24 V

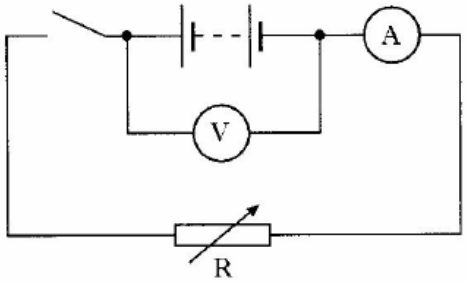
E 30 V.

MARKS

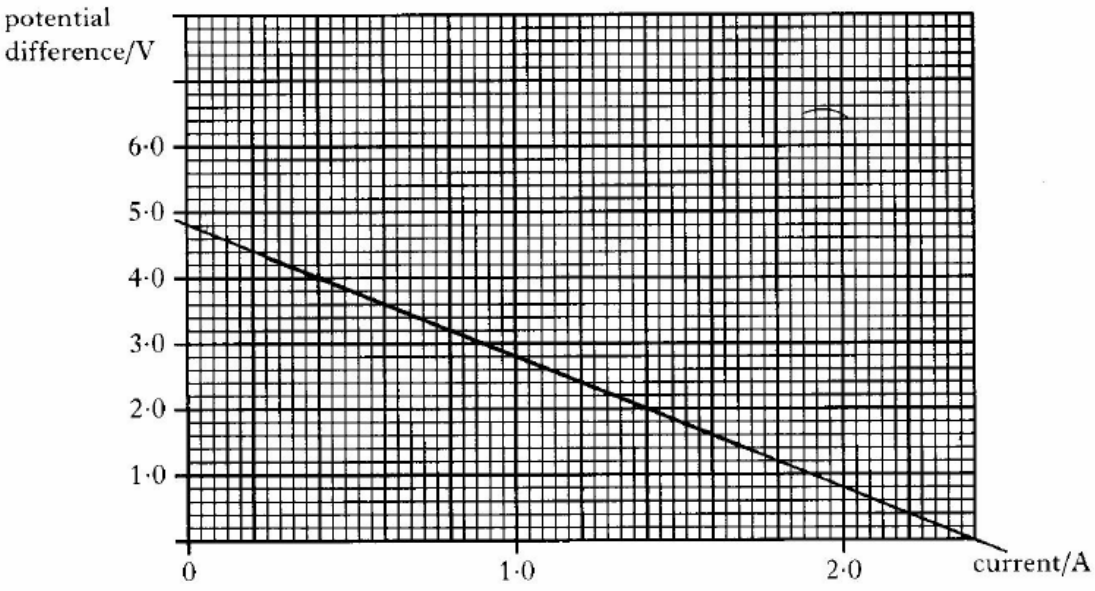
DO NOT WRITE IN THIS MARGIN

Attempt ALL questions

1. (*a*) The following circuit is used to measure the e.m.f. and the internal resistance of a battery.



Readings of current and potential difference from this circuit are used to produce the following graph.



Use information from the graph to find:

(i) the e.m.f. of the battery, in volts; 1

(ii) the internal resistance of the battery. 3

(*b*) A car battery has an e.m.f. of 12 V and an internal resistance of 0·050 Ω.

(i) Calculate the short circuit current for this battery. 3

(ii) The battery is now connected in series with a lamp. The resistance of the lamp is 2·5 Ω. Calculate the power dissipated in the lamp. 3

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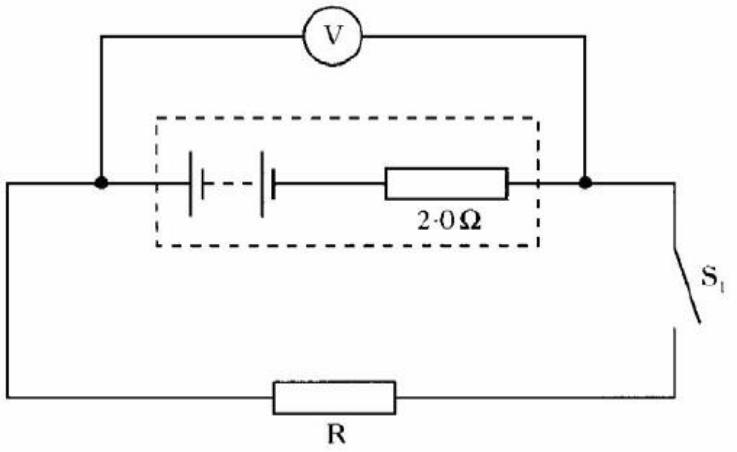
2. A student sets up the circuit shown.



The internal resistance of the battery is 2·0 Ω.

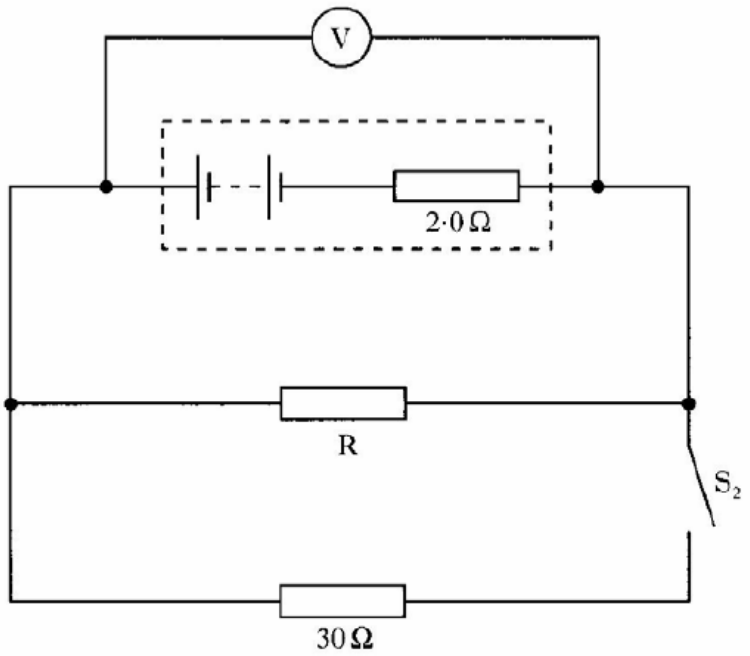
With S_1 open, the student notes that the reading on the voltmeter is 9·0 V.

The student closes S_1 and notes that the reading on the voltmeter is now 7·8 V.

(*a*) (i) Calculate the resistance of resistor R. 3

(ii) Explain why the reading on the voltmeter decreases when S_1 is closed. 2

(*b*) The student adds a 30 Ω resistor and a switch S_2 to the circuit as shown

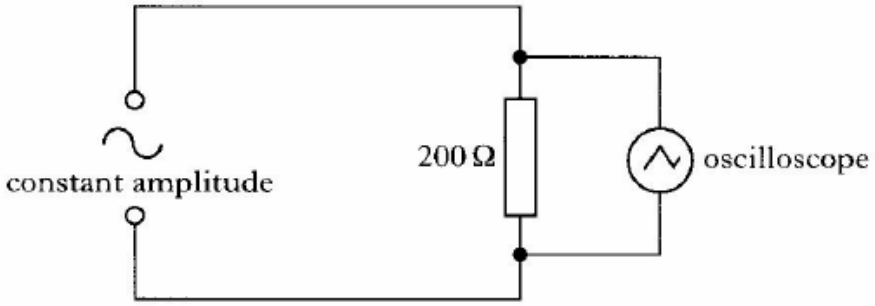


The student now closes S_2.

Explain what happens to the reading on the voltmeter. 3

DO NOT WRITE IN THIS MARGIN

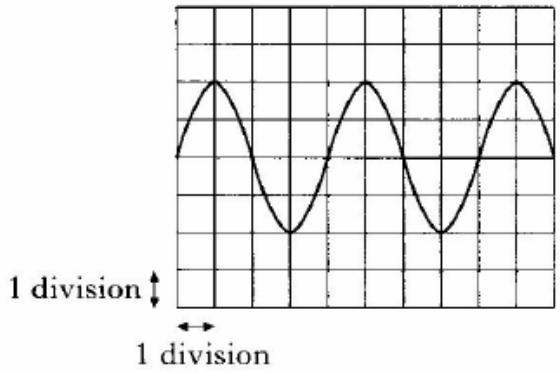
3. A circuit is set up as shown below. The amplitude of the output voltage of the a.c. supply is kept constant.



The settings of the controls on the oscilloscope are as follows:

y-gain setting = 5 V/division
time-base setting = 2·5 ms/division

The following trace is displayed on the oscilloscope screen.

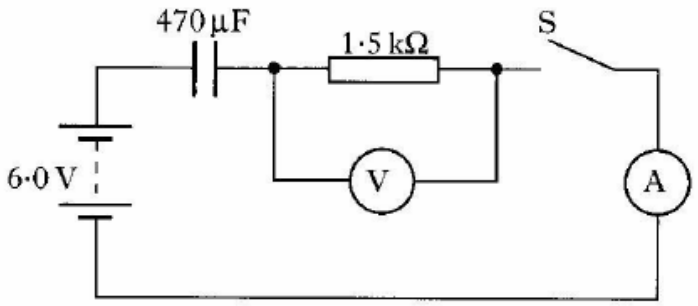


(*a*) (i) Calculate the frequency of the output from the a.c. supply. 3

(ii) Calculate the **r.m.s. current** in the 200 Ω resistor. 4

DO NOT WRITE IN THIS MARGIN

4. (*a*) The following diagram shows a circuit that is used to investigate the charging of a capacitor.



The capacitor is initially uncharged.

The capacitor has a capacitance of 470 μF and the resistor has a resistance of 1·5 kΩ.

The battery has an e.m.f. of 6·0 V and negligible internal resistance.

(i) Switch S is now closed. What is the initial current in the circuit? 1

(ii) How much energy is stored in the capacitor when it is fully charged? 3

(iii) What change could be made to this circuit to ensure that the **same** capacitor stores **more** energy? 1

(*b*) A capacitor is used to provide the energy for an electronic flash in a camera.

When the flash is fired, $6{\cdot}35 \times 10^{-3}$ J of the stored energy is emitted as light.

The mean value of the frequency of photons of light from the flash is $5{\cdot}80 \times 10^{14}$ Hz.

Calculate the number of photons emitted in each flash of light. 4

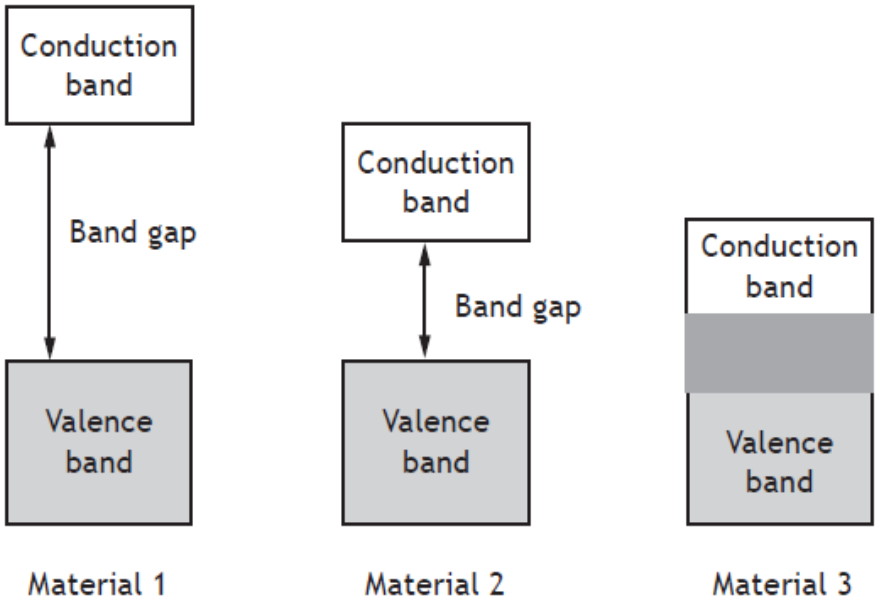
DO NOT WRITE IN THIS MARGIN

5. The electrical conductivity of solids can be explained by band theory.

The diagrams below show the distributions of the valence and conduction bands of materials classified as *conductors*, *insulators* and *semiconductors*.

Shaded areas represent bands occupied by electrons.

The band gap is also indicated.

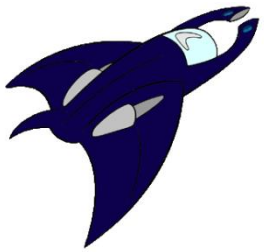


(a) State which material is a semiconductor. 1

(b) A sample of pure semiconductor is heated. Use band theory to explain what happens to the resistance of the sample as it is heated. 2

DO NOT WRITE IN THIS MARGIN

6. A stationary spacecraft has a length of 26 m when measured on Earth.



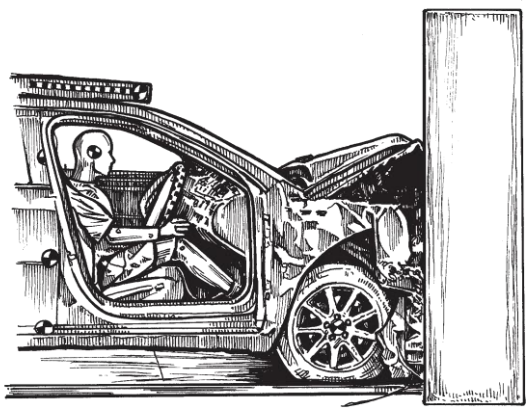
a) During a test flight the spacecraft passes close to the Earth with a speed of 0·45c. A physicist monitors the test flight from Earth. Calculate the length of the spacecraft as measured by the physicist on Earth. **3**

b) The spacecraft emits flashes of light. An astronaut in the spacecraft measures the time interval between these flashes. Is the time interval measured by the physicist on Earth smaller than, the same as or greater than that measured by the astronaut? **1**

(4)

7. The force applied by a seat belt on a crash test dummy is being investigated. The crash test dummy is placed in a car.

The car then travels along a test track at a speed of 13·4 m s^{-1}, collides with a wall and comes to rest.



(a) State the law of conservation of linear momentum. **2**

(b) The total mass of the car and dummy is 1200 kg.

Calculate the change in momentum of the car and dummy in the collision. **3**

Space for working and answer

7. (continued)

(c) The crash test dummy has a mass of 75 kg and is wearing a seat belt. During the collision the dummy travels a distance of 0·48 m while coming to rest.

Calculate the average force exerted on the dummy by the seat belt. **4**

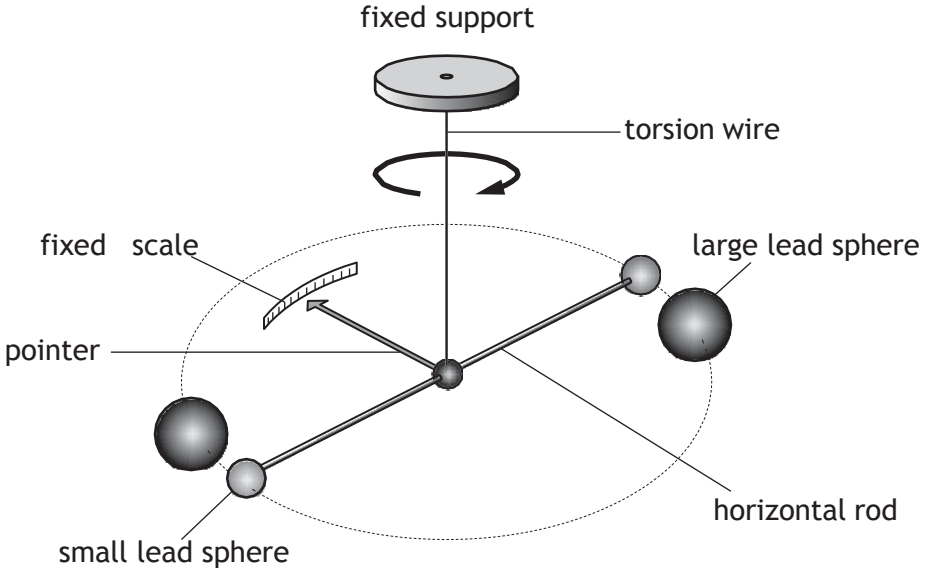
Space for working and answer

(d) This seatbelt is designed to stretch slightly during the collision.

Explain, in terms of forces, an advantage of this design. **3**

8. A student carries out an experiment to measure the Universal Constant of Gravitation.

The apparatus consists of a horizontal rod with small lead spheres at each end. The rod is suspended from its centre by a thin torsion wire. The student places a large lead sphere near each of the small spheres. The gravitational attraction between each pair of large and small spheres causes the torsion wire to twist. The angle of twist is indicated on a fixed scale by the position of a pointer attached to the rod.



The torsion wire twists by one degree when each small lead sphere experiences a force of $1{\cdot}56 \times 10^{-9}$ N.

(a) (i) The student measures the angle of twist to be 0·45°.

Show that the gravitational force between one pair of large and small spheres is $7{\cdot}0 \times 10^{-10}$ N. **1**

Space for working and answer

8. (a) (continued)

(ii) The small lead spheres each have a mass of 0·0148 kg.

The large lead spheres each have a mass of 1·52 kg.

The student measures the distance from the centre of mass of each of the large spheres to the centre of mass of its adjacent small sphere to be 46·5 mm.

Determine the value for the Universal Constant of Gravitation the student obtains from these results. **3**

(b) The manufacturer of the apparatus claims that this experiment can achieve an accuracy to within ±2·5% of the accepted value for the Universal Constant of Gravitation.

State whether or not the student's value for the Universal Constant of Gravitation agrees with this claim.

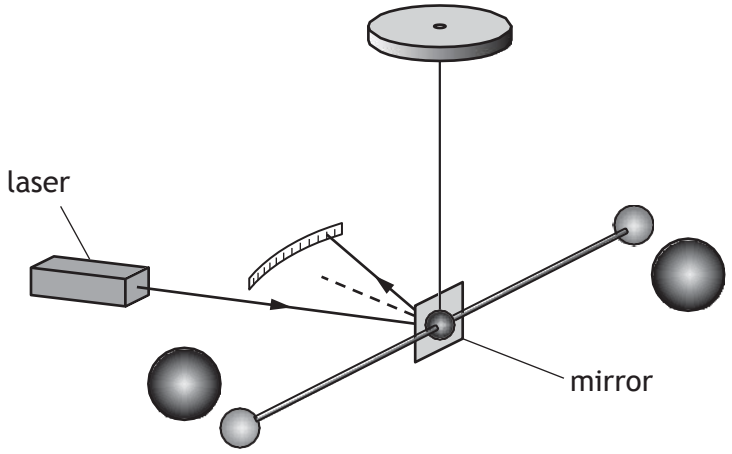
You must justify your answer by calculation. **3**

Space for working and answer

MARKS

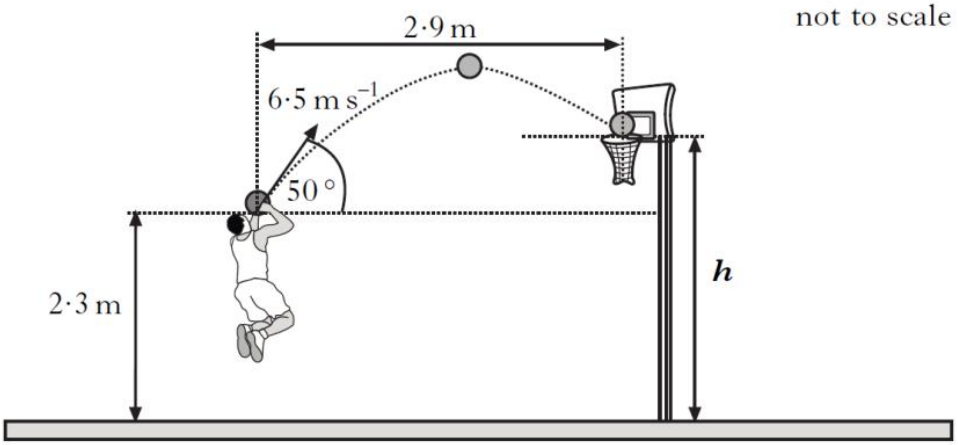
8. (continued)

(c) The student now decides to replace the pointer on the horizontal rod with a small mirror. A laser beam is then directed at the mirror in such a way that the beam is reflected onto the scale as shown.



Explain how this modification improves the accuracy of the experiment. **2**

9 A basketball player throws a ball with an initial velocity of 6.5ms^{-1} at an angle of 50° to the horizontal. The ball is 2.3m above the ground when released.



The ball travels a horizontal distance of 2.9m to reach the top of the basket.
The effects of air resistance can be ignored.

a) Calculate:

i) the horizontal component of the initial velocity of the ball; 1

ii) the vertical component of the initial velocity of the ball. 1

b) Show that the time taken for the ball to reach the basket is 0.69 s. 2

c) Calculate the height ***h*** of the top of the basket. 3

A student observing the player makes the following statement.

"*The player should throw the ball with a higher speed at the same angle. The ball would then land in the basket as before but it would take a shorter time to travel the 2·9 metres.*"

d) **Explain** why the student's statement is incorrect. 3

(10)

10. (a) In 1929 Edwin Hubble suggested that distant galaxies are moving away (receding) from our own galaxy with velocities that are directly proportional to the distance to the galaxy. This is known as Hubble's Law.

Some data collected by Hubble are given in the table below.

galaxy	distance to galaxy /light years	velocity of recession /m s^{-1}
NGC 221	$9{\cdot}0 \times 10^5$	$2{\cdot}0 \times 10^5$
NGC 379	$2{\cdot}3 \times 10^7$	$2{\cdot}2 \times 10^6$
Gemini cluster	$1{\cdot}4 \times 10^8$	$2{\cdot}3 \times 10^7$

(i) Using **all** of the data, determine whether or not this data supports Hubble's Law. 3

(ii) Use the data on the Gemini cluster given in the table to calculate a value for the Hubble constant, H_o. 3

(iii) Comment on how this early value for the Hubble constant compares to the accepted value today. 1

(b) The speed of recession of the galaxies is found from observations of redshift.

(i) State what is meant by the term *redshift*. 1

(ii) Explain why the expansion of space will cause light from more distant galaxies to show a greater redshift. 2

(10)

Total of 95 Marks

Well done!! You have now finished and deserve a rest for all of your hard work!!