SECTION A

You should spend a maximum of 25 minutes on this section.

You should put the letter of the correct answer in the box provided.

Answer **all** the questions.

1 Here is a list of combinations of base units of the SI system.
Which combination gives the correct units of momentum?

A kg m s^{-1}

B kg m s^{-2}

C kg m^{-1} s^{-2}

D kg m^{-2} s^{-2}

$p = mv$
$= Kg \times ms^{-1}$
$= Kgms^{-1}$

Your answer A

[1]

2 Here is a list of combinations of base units of the SI system.
Which combination of units is equivalent to pascal, Pa?

A kg m s^{-1}

B kg m s^{-2}

C kg m^{-2} s^{-2}

D kg m^{-1} s^{-2}

$Pa = Nm^{-2}$
$F = ma \therefore N = Kgms^{-2}$
$\therefore Pa = Kgms^{-2} m^{-2}$
$= Kgm^{-1}s^{-2}$

Your answer D

[1]

3 Polythene, a polymer, is strong and flexible. Which one of the following statements is correct?

A All polymers are flexible. ×

B Polymers do not extend plastically. ×

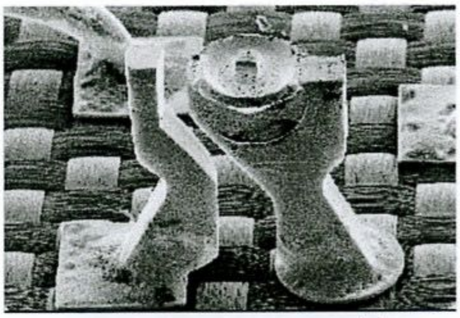
C The bonds in polythene molecules can rotate as the material is stretched. ✓

D Mobile dislocations weaken polymers. × that's metals

Your answer C

[1]

4 The image shown is of an LED and is 290 x 195 pixels. 6 bits per pixel are used for the greyscale levels.



What is the best estimate for the total information in bytes in the uncompressed image? ÷8

A 2^6

B 4.2×10^4

C 5.7×10^4

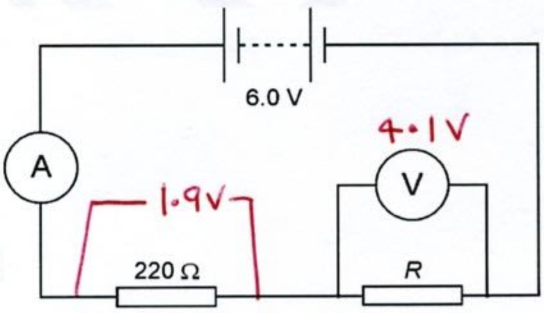
D 3.4×10^5

$$\frac{290 \times 195 \times 6}{8} = 42413 \text{ bytes}$$
$$= 4.2 \times 10^3 \text{ bytes}$$

Your answer B

[1]

5 An unknown resistor R and a 220 Ω resistor are connected to a 6.0 V battery of negligible internal resistance as shown.



The reading on the voltmeter is 4.1 V.
What should be the reading on the ammeter?

A 8.6 mA

B 13 mA

C 19 mA

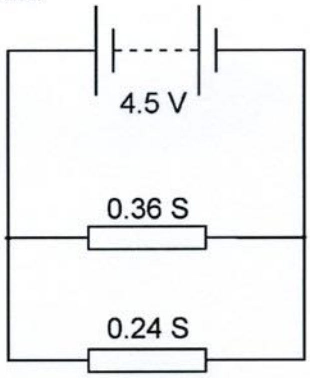
D 27 mA

$$I = V/R = \frac{1.9}{220} = 8.6\,\text{mA}$$

Your answer A

[1]

6 Two conductors of conductances 0.24 S and 0.36 S are connected in parallel to a 4.5 V battery of negligible internal resistance as shown.



In parallel
$G_T = G_1 + G_2$
$= 0.36 + 0.24$
$= 0.6$ S

What is the power dissipated in the two conductors?

A 2.9 W

B 4.9 W

C 7.3 W

D 12 W

$R = 1/G = 1/0.6 = 1.67\ \Omega$

$I = V/R = 4.5/1.67 = 2.7$ A

$P = IV = 4.5 \times 2.7 = 12.15$ W

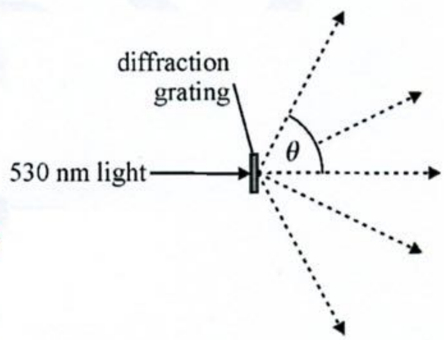
Your answer D

[1]

7 A diffraction grating which has 830 lines mm^{-1} is illuminated with light of wavelength 530 nm.

$d = \frac{1 \times 10^{-3}\ m}{830}$

$= 1.205 \times 10^{-6}$ m



What is the angle θ of the second-order diffraction maximum shown, expressed to two significant figures?

A 0.46 rad

B 1.1 rad

C 26 rad

D 62 rad

$n\lambda = d \sin\theta$

$\sin\theta = \frac{n\lambda}{d} = \frac{2 \times 530 \times 10^{-9}}{1.205 \times 10^{-6}}$

$\sin\theta = 0.88$

$\theta = \sin^{-1} 0.88$ *

$= 1.1$ rad

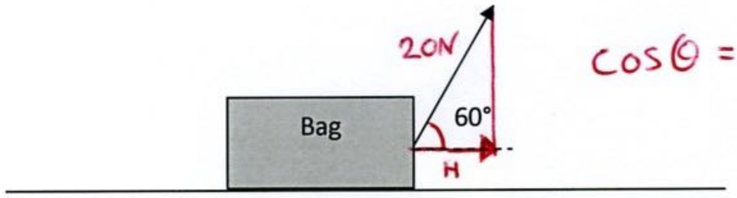
Your answer B

[1]

* put calc in RAD mode.

* put calc in DEG mode

8 A bag weighing 50 N is pulled along the ground with a force of 20 N at an angle of 60° to the horizontal as shown in the diagram.



$\cos\theta = \frac{adj}{hyp}$

The bag is pulled through a horizontal distance of 6.0 m. How much work has been done pulling the bag?

A 60 J

B 104 J

C 120 J

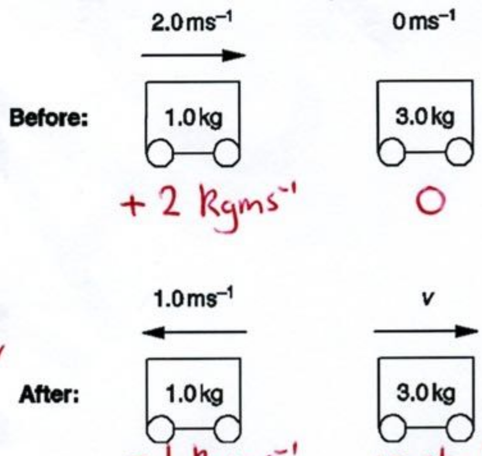
D 300 J

Horizontal component, H = 20 cos 60° *
= 10 N
W = F × d = 10N × 6 m = 60 J

Your answer [A]

[1]

9 The diagram shows the speed and direction of two trolleys before and after a collision:



+ →

momentum conserved

must be +3 kgms⁻¹ so total p remains at +2 kgms⁻¹.

What is the velocity, v, of the 3 kg trolley after the collision?

A 0.33 ms^{-1}

B 1.0 ms^{-1}

C 2.3 ms^{-1}

D 3.0 ms^{-1}

$v = \frac{p}{m} = \frac{3}{3} = 1\ ms^{-1}$

Your answer [B]

[1]

10 Which of these statements correctly describes the properties of a ceramic material?

A Ceramics are hard, stiff and tough.

B Ceramics are weak, stiff and ductile.

C Ceramics are strong, stiff and brittle.

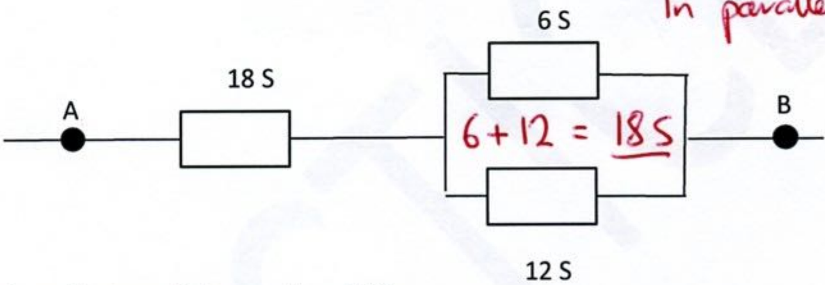
D Ceramics are strong, flexible and tough.

Your answer C

[1]

11 The diagram shows part of an electrical circuit. The conductances of the three components have been labelled.

In parallel $G_T = G_1 + G_2$



What is the total conductance between **A** and **B**?

A 9 S

B 18 S

C 22 S

D 36 S

In series $\frac{1}{G_T} = \frac{1}{G_1} + \frac{1}{G_2} = \frac{1}{18} + \frac{1}{18} = \frac{2}{18}$

$\therefore G_T = \frac{18}{2} = 9S$

Your answer A

[1]

$u = -0.5m$

12 A lamp is placed 0.50 m from a converging lens. The power of the lens is +5.0 D. $\therefore \frac{1}{f} = +5$
What is the distance from the lens to the focused image?

$u = -0.5m$

A 0.14 m

B 0.20 m

C 0.33 m

D 0.45 m

$\frac{1}{v} = \frac{1}{u} + \frac{1}{f} = \frac{1}{-0.5} + 5$

$\frac{1}{v} = -2 + 5 = 3$

$\therefore v = \frac{1}{3} m = 33 cm$

Your answer C

[1]

13 A resistor R dissipates power P when a p.d. V is connected across it. How will the power dissipated change when both the resistance and the p.d. are halved?

A The power doubles

B The power remains the same

C The power halves

D The power quarters

$P = IV$ & $I = \frac{V}{R}$

$\therefore P = \frac{V^2}{R}$ → V halved $V^2 \times \frac{1}{4} \therefore P \times \frac{1}{4}$; R → R halved $P \times 2$

$\times \frac{1}{4} \times \times 2 = \times \frac{1}{2}$

Your answer C

[1]

14 A battery of e.m.f 6.0 V is connected to a 4.0 Ω resistor. The p.d. across the terminals of the battery is 5.8 V. What is the internal resistance of the battery?

A 0.03 Ω

B 0.05 Ω

C 0.14 Ω

D 0.16 Ω

$I = V/R = 5.8/4 = 1.45A$

$V = \mathcal{E} - Ir$

$5.8 = 6.0 - 1.45r$

$0.2 = 1.45r$

$r = 0.2/1.45 = 0.138\Omega$

Your answer C

[1]

15 An elastic spring, of force constant k = 200 N m^{-1}, is extended by 7 cm. What is the energy stored in the spring at this extension?

A 0.49 J

B 0.98 J

C 7.0 J

D 14.0 J

$7cm = 0.07m$

$E = \frac{1}{2}kx^2$

$= \frac{1}{2} \times 200 \times 0.07^2$

$= 0.49 J$

Your answer A

[1]

$\lambda = \frac{h}{p} = \frac{h}{mv}$

16 An electron of kinetic energy E has a de Broglie wavelength λ. What is the de Broglie wavelength of an electron of kinetic energy $2E$?

A 2λ

B $\sqrt{2}\lambda$

C $\lambda/\sqrt{2}$

D $\lambda/2$

If KE $\left(\frac{mv^2}{2}\right)$ is double then v is $\sqrt{2}\times$ larger
If v is $\sqrt{2}\times$ larger p is $\sqrt{2}\times$ larger
so λ must be $\sqrt{2}\times$ smaller as $\lambda = \frac{h}{p}$

Your answer C

[1]

$r = 0.36\times10^{-3}/2 = 1.8\times10^{-4}$ m

17 A wire of length 2.000 m extends to 2.005 m when a 19.6 N weight is hung from it. The diameter of the wire is 0.36 mm. What is the Young modulus of the material of the wire?

A 3.5×10^{6} Pa

B 1.4×10^{7} Pa

C 1.9×10^{10} Pa

D 7.7×10^{10} Pa

$A = \pi r^2 = \pi \times (1.8\times10^{-4})^2 = 1.018\times10^{-7}$ m^2

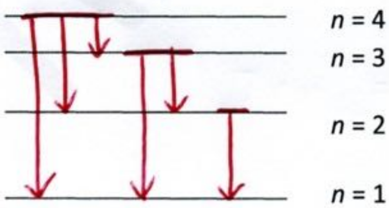
$E = \frac{\text{stress}}{\text{strain}} = \frac{F/A}{x/L} = \frac{FL}{Ax} = \frac{19.6\times2}{1.018\times10^{-7}\times0.005}$

$= 7.7\times10^{10}$ Pa

Your answer D

[1]

18 Figure 18 shows four electron energy levels. Photons are released when an electron drops from one level to another. How many different frequencies of photons can be released from transitions between the energy levels shown?



A 3

B 4

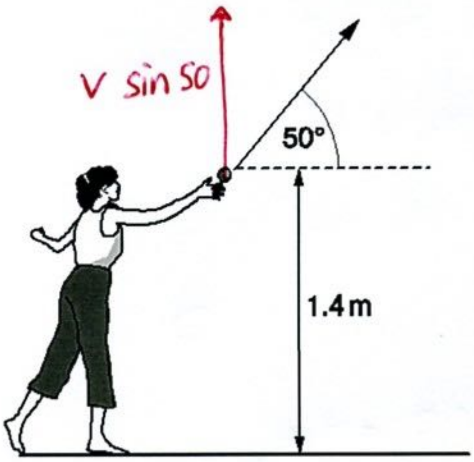
C 5

D 6 ✓

Your answer D

[1]

19 A ball is thrown at an angle of 50° from a height of 1.4 m with an initial velocity of 15 m s^{-1}.
What is the maximum height reached by the ball?



Vertical component = 15 sin 50
= 11.5 ms^{-1}

KE = GPE $\therefore \frac{mv^2}{2} = mgh$

$\therefore h = \frac{v^2}{2g} = \frac{11.5^2}{2 \times 9.81} = 6.74$ m

Initial height = 1.4 m
$\therefore$ Max height = 6.74 + 1.4
= 8.14 m

A 3.3 m

B 4.7 m

C 6.7 m

D 8.1 m

Your answer D

[1]

20 Which of these terms relates to the force per unit area at which a material begins to deform ie yield
plastically?

F/A = stress

A Breaking stress

B Breaking strain

C Yield stress

D Yield strain

Your answer C

[1]

SECTION B

Answer **all** the questions.

21 The speed of light in a glass block is 2.0×10^8 m s^{-1}. Calculate the angle of refraction in the glass for an angle of incidence in air of 40°.

$c = 3.0 \times 10^8$ m s^{-1}

$n = \frac{\sin i}{\sin r} = \frac{c_{1st}}{c_{2nd}}$

$\therefore \sin r = \sin i \frac{c_{2nd}}{c_{1st}} = \sin 40 \times \frac{2\times10^8}{3\times10^8} = 0.4285$

$\therefore r = \sin^{-1} 0.4285$

(calc in deg mode)

angle of refraction = ...25.4...... ° **[2]**

22 A high definition video stream transfers data at 5 Mbit s^{-1}.

A film lasts 90 minutes. Calculate the amount of data transferred when this film is streamed in high definition.

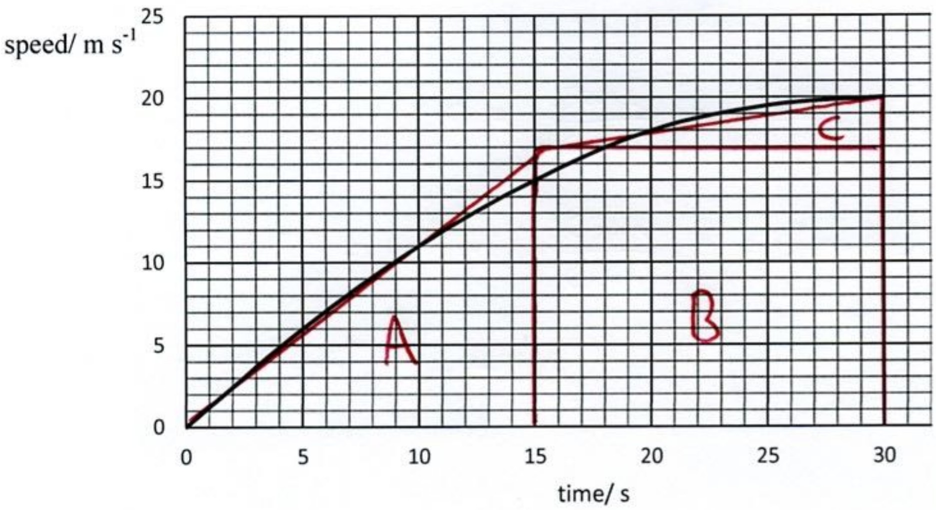
$5 \times 10^6 \times 90 \times 60 = 2.7 \times 10^{10}$ bit

= 27 Gbit

data transferred = ...27......units ......Gbit...... **[2]**

or 3.375 GByte etc.

23 A car accelerates from rest to a speed of 20 m s^{-1} as shown in Fig. 23.



$A = \frac{1}{2} \times 15 \times 17$

$B = 15 \times 17$

$C = \frac{1}{2} \times 15 \times 3$

Fig. 23

(a) Calculate the average acceleration of the car in the first 30 s of the journey.

$a = \frac{\Delta v}{\Delta t} = \frac{20 \text{ ms}^{-1}}{30 \text{ s}} =$

acceleration = ...0.67.... m s^{-2} **[2]**

(b) Use the graph to find the distance travelled by the car in the first 30 s of the journey. Make your method clear.

Area under curve $= A + B + C =$

$= 127.5 + 255 + 22.5 =$

distance travelled = ...405....m **[2]**

OR

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

$s = 0 + \frac{1}{2} \times 0.67 \times 30^2 = \underline{302 \text{ m}}$

24 An LDR is used in the light-sensing circuit shown in the Fig. 24.

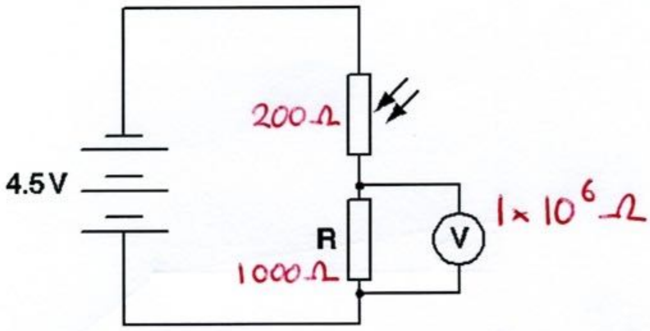


Fig. 24

In bright light conditions, the resistance of the LDR is 200 Ω.
The fixed resistor R has a resistance of 1000 Ω. The cells have negligible internal resistance.

→ large so can ignore

(a) Show that the reading on the high-resistance voltmeter (resistance = 1 MΩ) in bright light conditions is about 4 V.

$$V_{OUT} = \frac{R_2}{R_1 + R_2} V_{IN} = 4.5 \times \frac{1000}{1200} = 3.75\,V$$

[2]

(b) Explain how the reading on the voltmeter would differ if a voltmeter of resistance 2000 Ω was used? Explain your reasoning.

V goes down as R + Rv combined is reduced so proportion of p.d. across R (& voltmeter) goes down.

OR Combined resistance: $\frac{1}{R_T} = \frac{1}{1000} + \frac{1}{2000} = 3/2000$

$\therefore R_T = 2000/3 = 667\,\Omega$

$$V_{OUT} = 4.5 \times \frac{667}{867} = 3.46\,V$$

[2]

25 The graph in Fig. 25 shows the variation of current in an LED with potential difference across it.

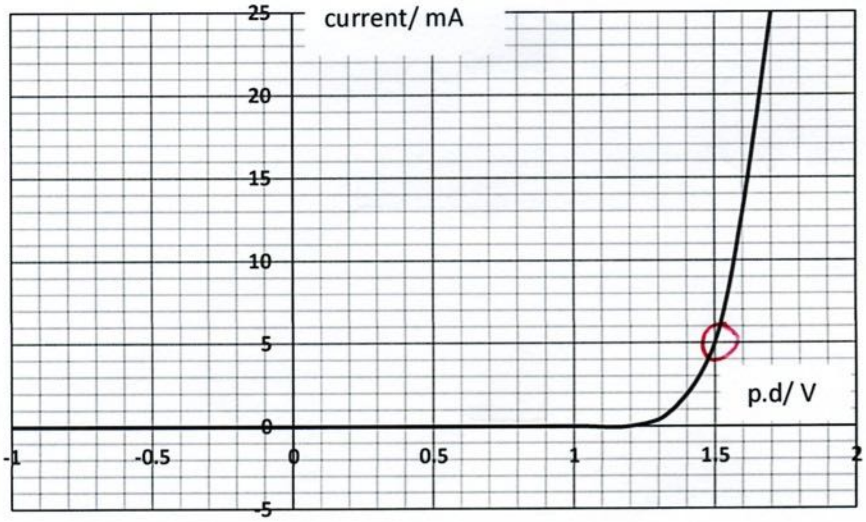


Fig. 25

(a) Describe the variation of conductance of the diode over the range of p.d. shown on the graph.

Conductance is zero from −1 V to 1.2 V.
It then increases from 1.2V to 1.5V and
then continues to rise at a steady rate from 1.5 V **[2]**

(b) Calculate the conductance of the diode at a p.d. of 1.5 V.

$$G = I/V = \frac{5 \times 10^{-3}}{1.5} =$$

conductance = 3.3×10^{-3} S **[2]**

26 A motor cyclist maintains a speed of 25 m s^{-1} along a level road. The total resistive force acting against the cyclist is 250N.

(a) Calculate the power required to maintain the steady speed against the resistive force.

$P = Fv = 250 \times 25 =$

power = ...6250... W **[2]**

(b) The kinetic energy of the bike and rider is 50 000 J. The bike has a mass of 90 kg. Calculate the mass of the rider.

$E_K = \frac{mv^2}{2} \quad \therefore \quad m = \frac{2E_K}{V^2} = \frac{2 \times 50000}{25^2}$

$= 160$ kg $\quad 160 - 90 =$

mass of rider = ...70...... kg **[2]** or $v^2 - u^2 = 2as$

$u = 0 \therefore v^2 = 2as$

SECTION C

$v = \sqrt{2as}$

Answer **all** the questions.

$= \sqrt{2gh}$

27 An egg of mass 0.055 kg is dropped, with no initial velocity, from a height of 1.5 m. It strikes a hard surface and breaks on first contact with the ground.

(a) Calculate the momentum of the egg at the instant it strikes the floor.

$mgh = \frac{mv^2}{2} \therefore v = \sqrt{2gh} = \sqrt{2 \times 9.81 \times 1.5}$

$= 5.425 ms^{-1}$

$p = mv = 0.055 \times 5.425 =$

momentum = ...0.30...... kg m s^{-1} **[3]**

(b) **(i)** The duration of impact with the hard surface is 0.04 s. Calculate the average force on the egg during the impact.

$F = \frac{\Delta(mv)}{\Delta t} = \frac{0.30}{0.04} = 7.46\ N$

average force = ...7.5......N **[2]**

(ii) Experiments suggest that it takes about 25 N to break an egg. Suggest and explain why an egg breaks when dropped from 1.5 m onto a hard surface.

Average force is 7.5 N but peak force is could be much higher. When dropped the force may be acting on a very small area resulting in a large stress.

[2]

(c) Explain why an egg dropped from the same height onto a soft foam mat does not break on impact.

Even though the change in momentum is the same the time of the impact is longer which results in the force being lower as $\Delta p = Ft \therefore F = \Delta p / t$

[3]

28 This question is about the photoelectric effect.

When electromagnetic radiation of frequency 4.7 x 10^{14} Hz strikes a particular metal surface, photoelectrons are released with a maximum kinetic energy of 0.18 eV. There is no appreciable time delay between the incident radiation striking the surface and the release of photoelectrons.

The maximum kinetic energy of the ~~photons~~ electrons, $k.e._{\max}$ is given by Einstein's equation:

$$k.e._{\max} = hf - \phi$$

where h is the Planck constant and f is the frequency of the incident radiation. The work function ϕ is the minimum energy required to eject an electron from the metal surface.

(a) **(i)** State what hf represents.

photon energy

[1]

(ii) Calculate the work function of the metal.

$E_K = 0.18\,\text{eV} \times 1.6\times10^{-19} = 2.88\times10^{-20}$ J

$hf = 6.63\times10^{-34}\,\text{Js} \times 4.7\times10^{14}\,\text{Hz} = 3.12\times10^{-19}$ J

$\phi = hf - E_K = 3.12\times10^{-19} - 2.88\times10^{-20} =$

ϕ = 2.8×10^{-19} J **[2]**

(b) The maximum kinetic energy of the ejected electrons is observed to be independent of the intensity of the incident radiation.

(i) Explain what is meant by 'intensity' in the sentence above and explain why the wave model of electromagnetic radiation cannot explain the experimental observations.

Intensity = power per m^2 ($J\,s^{-1}\,m^{-2}$)

The wave model would predict that higher intensity radiation would emit electrons with a higher maximum kinetic energy. This does not happen. (Also there would be a delay before electrons would be emitted)

[3]

(ii) The number of photoelectrons emitted each second is proportional to the intensity of light. Explain this observation using the photon model of light.

Intensity is proportional to photons per sec. and one photon emitts one electron so electrons emitted per second is proportional to intensity.

[2]

29 This question is about measuring the acceleration of a ball rolling down a ramp.

Fig. 29.1 shows the experimental arrangement.

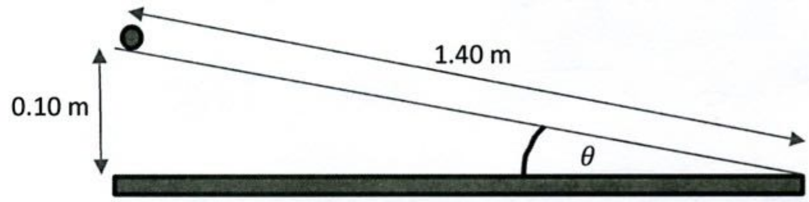


Fig. 29.1 (not to scale)

(a) Show that the angle θ is about 4^o.

$\sin\theta = \frac{opp}{hyp} \therefore \theta = \sin^{-1}\frac{0.1}{0.4} = 4.1^o$

[1]

(b) Students film the ball rolling down the ramp from rest and obtain the results shown on the graph in Fig. 29.2.

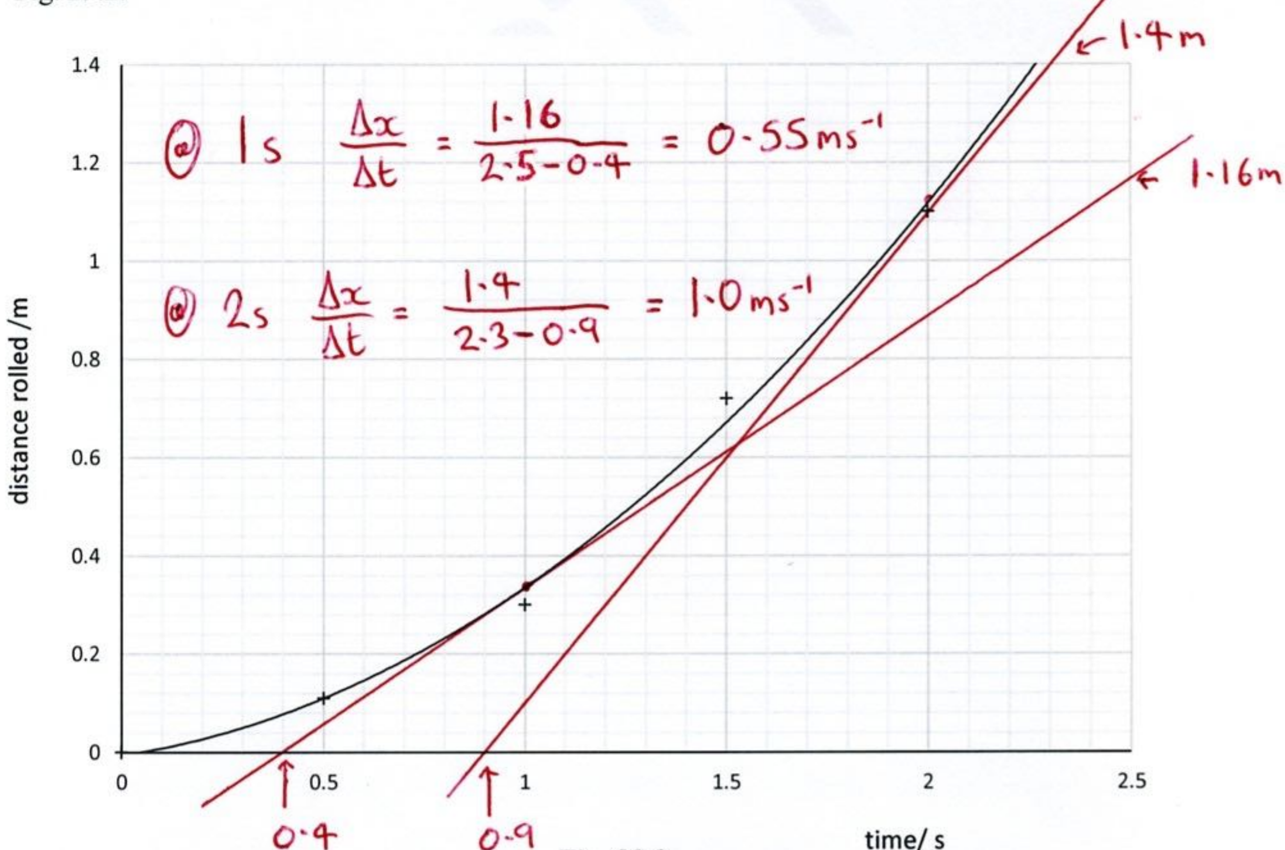


Fig. 29.2

From the graph find the velocity of the ball at 1.0 s and 2.0 s. Show your method clearly.
Use these results to calculate the acceleration of the ball.

(allow 0.48 – 0.60) velocity at 1.0 s = ...0.55...... m s^{-1}

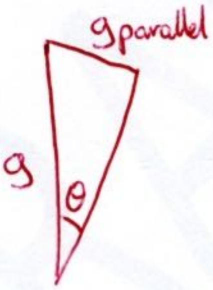
(allow 0.96 – 1.04) velocity at 2.0 s = ...1.0...... m s^{-1}

$$a = \frac{\Delta v}{\Delta t} = \frac{1 - 0.55}{1} =$$

(allow 0.4 to 0.56) acceleration = ...0.45...... m s^{-2}

[4]

(c) (i) Show that the component of the gravitational field strength, *g*, acting parallel to the slope, is about 0. 7 N kg^{-1}.



$$\sin\theta = \frac{g_P}{g}$$

$$\therefore g_P = g \sin\theta$$

$$= 9.81 \sin 4.1^\circ$$

$$= 0.701 \text{ N kg}^{-1}$$

[2]

(ii) Use this value to calculate the time taken for the ball to roll 1.4 m down the slope from rest.

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

$$1.40 = \tfrac{1}{2} \times 0.70 \times t^2$$

$$t = \sqrt{\frac{1.4 \times 2}{0.7}} =$$

time = ...2.0...... s

[2]

(iii) Compare your value from **c(ii)** to that obtained in the experiment, suggesting reasons for any difference.

Experimental value of 2.25 s is larger than the calculated value of 2.0 s probably due to air resistance & friction resulting in lower acceleration.

[3]

(Also some GPE ends up as rotational KE and not all ends up as linear KE as is assumed)

END OF QUESTION PAPER

↑ beyond spec.