MINISTRY OF EDUCATION, SINGAPORE
in collaboration with
CAMBRIDGE ASSESSMENT INTERNATIONAL EDUCATION
General Certificate of Education Advanced Level
Higher 2

CANDIDATE NAME

CENTRE NUMBER S

INDEX NUMBER

PHYSICS

9749/02

Paper 2 Structured Questions

October/November 2020

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, index number and name in the spaces at the top of this page.
Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE ON ANY BARCODES.

The use of an approved scientific calculator is expected, where appropriate.
Answer **all** questions.

The number of marks is given in brackets [ ] at the end of each question or part question.

PILOT
The Centre of Physics

© UCLES & MOE 2020

[Turn over

Printed and published by Singapore Asia Publishers Pte Ltd
for the Singapore Examinations and Assessment Board under licence from the Chancellor, Masters and Scholars of the University of Cambridge (acting through the University of Cambridge International Examinations Syndicate) either solely or jointly with the Government of Singapore (acting through the Ministry of Education, Singapore).

Answer **all** questions in the spaces provided.

1 **(a)** A cyclist travels at constant speed along horizontal ground. Frictional forces oppose the motion of the cyclist.

Use Newton's first law of motion to explain why the cyclist travels at constant speed.

The cyclist forward driving force equals to the opposing frictional forces. Hence the net force is 0. By Newton's 1st law, an object will continue its state of uniform motion in a straight line unless an external net force acts on it.

[2]

(b) The drag force F acting on the cyclist at speed v is given by

$$F = \frac{1}{2} c_D \rho A v^2$$

where c_D is the drag coefficient, ρ is the density of air and A is the frontal area of the cyclist.

Data for the moving cyclist is shown in Table 1.1.

Table 1.1

quantity	magnitude	uncertainty
F/N	22	±2
c_D	0.88	±0.01
ρ/kg m^{-3}	1.2	±0.1
A/m^2	0.32	±0.02

$F = 22 \pm 2$
$C_D = 0.88 \pm 0.01$
$\rho = 1.2 \pm 0.1$
$A = 0.32 \pm 0.02$

Determine the speed of the cyclist, with its actual uncertainty. Give your answer to an appropriate number of significant figures.

$F = \frac{1}{2} C_D \rho A v^2 \quad \therefore v^2 = \frac{2F}{C_D \rho A}$

Hence $v_{true} = \sqrt{\frac{2(22)}{(0.88)(1.2)(0.32)}} = 11.4108$

$\therefore \frac{\Delta v}{v} = \frac{\Delta F}{F} + \frac{\Delta C_D}{C_D} + \frac{\Delta \rho}{\rho} + \frac{\Delta A}{A}$

$\therefore \Delta v = \frac{1}{2}\left[\frac{2}{22} + \frac{0.01}{0.88} + \frac{0.1}{1.2} + \frac{0.02}{0.32}\right](11.4108)$

$= 1.4155$

$\therefore 11.4108 \pm 1.4155$

$\therefore 11 \pm 1$

speed = 11 ± 1 m s^{-1} [4]

© UCLES & MOE 2020
Printed and published by Singapore Asia Publishers Pte Ltd

The Centre of Physics

(c) (i) Derive, from the definition of work done, an expression for power output for the cyclist in terms of velocity v.

Work done is defined as the product of the force and the distance moved in the direction of the force, ie $WD = F \cdot d$

$$P = \frac{\Delta Energy}{t} = \frac{WD}{t} = \frac{F \cdot d}{t} = Fv$$ #

[2]

(ii) Calculate the power output P of the cyclist at the speed calculated in **(b)**.

$P = Fv = (22)(11.4108)$

$= 251.0376$

$= 251\ W\ (3sf)$ #

$P =$ 251 W [1]

[Total: 9]

The Centre of Physics VIOT

© UCLES & MOE 2020

Printed and published by Singapore Asia Publishers Pte Ltd

2 **(a)** Define *gravitational potential* at a point.

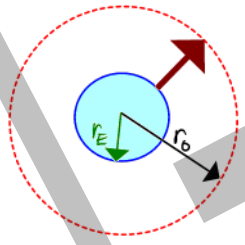
Gravitational potential at a point in a gravitational field is defined as the work done by an external agent in bringing unit mass from infinity to that point, without acceleration. [1]

(b) The Earth, of radius 6400 km, has mass 6.0×10^{24} kg.

A global positioning satellite of mass 1600 kg is in an orbit of radius 2.7×10^{7} m about the centre of the Earth. The satellite is launched from the Earth's surface.

Calculate the change in gravitational potential energy ΔE_P for this satellite.

$r_E = 6.4 \times 10^6$ m
$M_E = 6 \times 10^{24}$ kg
$m_S = 1600$ kg
$r_0 = 2.7 \times 10^7$ m
$\phi = -\frac{GM}{r}$



$\Delta U = m\Delta\phi = m(\phi_f - \phi_i) = m(\phi_0 - \phi_E) = m\left(-\frac{GM}{r_0} + \frac{GM}{r_E}\right)$

$\therefore \Delta U = GMm\left[\frac{1}{r_E} - \frac{1}{r_0}\right] = (6.67\times10^{-11})(6\times10^{24})(1600)\left[\frac{1}{6.4\times10^{6}} - \frac{1}{2.7\times10^{7}}\right]$

$= 7.633 \times 10^{10}$
$= 7.63 \times 10^{10}$ J (3sf)

$\Delta E_P =$ 7.63 × 10^10 J [2]

(c) **(i)** A satellite of mass *m* orbits a planet of mass *M*. The mass of the planet may be assumed to be a point mass at its centre.

Show that the kinetic energy E_k of the satellite in an orbit of radius *r* is given by

$$E_k = \frac{GMm}{2r}.$$

Since satellite orbits planet,
$F_G = F_C$

$\frac{GMm}{r^2} = \frac{mv^2}{r}$ $\therefore v^2 = \frac{GM}{r}$ — ①

$KE = \frac{1}{2}mv^2$ — ②

Sub ① into ②

$\therefore KE = \frac{1}{2}m\left(\frac{GM}{r}\right) = \frac{GMm}{2r}$ # shown.

[2]

(ii) Use the information in **(b)** and the expression in **(c)(i)** to calculate the kinetic energy E_K of the global positioning satellite in its orbit.

$\therefore KE = \frac{GMm}{2r} = \frac{(6.67\times10^{-11})(6\times10^{24})(1600)}{2(2.7\times10^{7})} = 1.1857\times10^{10}\text{ J} = 1.19\times10^{10}\text{ J (3sf)}$

$E_K =$ 1.19 × 10^10 J [1]

(iii) A student wants to calculate the change in kinetic energy of a satellite launched from the Earth to its orbit. The student calculates the initial and final kinetic energies using the expression in **(c)(i)**.

Suggest and explain whether the student's method is correct.

Incorrect. The expression in (c)(i) is only used when the object is moving in orbital or circular motion. If a satellite is launched from Earth surface to the orbit, there is a change in height and thus potential energy. Therefore, conservation of energy needs to be employed. [2]

[Total: 8]

© UCLES & MOE 2020
Printed and published by Singapore Asia Publishers Pte Ltd

The Centre of Physics
DRAFT

3 Two parallel plates are in a vacuum. One plate is positively charged and the other plate is earthed.

A rectangular conductor of width x is placed midway between the plates so that its faces are a distance x from each plate, as shown in Fig. 3.1.

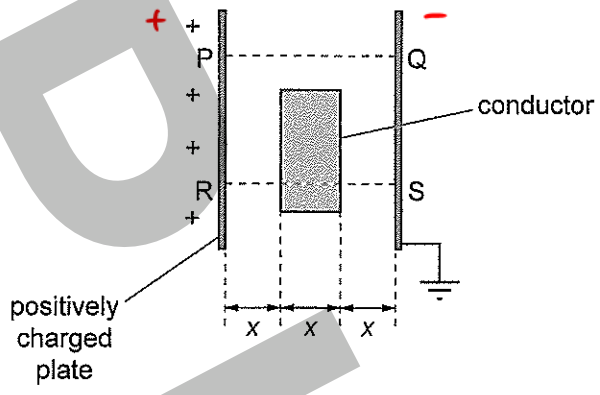


Fig. 3.1

(a) The variation with distance from P to Q of the electric potential along line PQ is shown in Fig. 3.2.

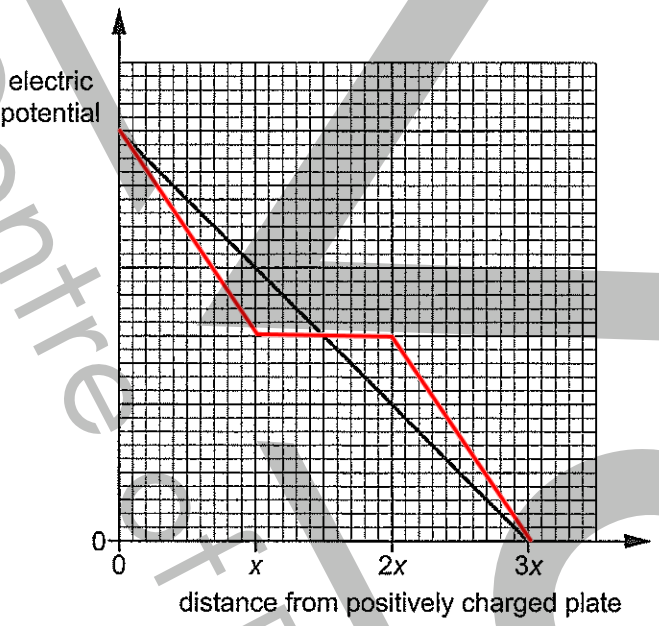


Fig. 3.2

On Fig. 3.2, draw a line to show the variation with distance from R to S of the electric potential along the line RS. [2]

© UCLES & MOE 2020
Printed and published by Singapore Asia Publishers Pte Ltd

(b) The variation with distance from P to Q of the electric field strength along line PQ is shown in Fig. 3.3.

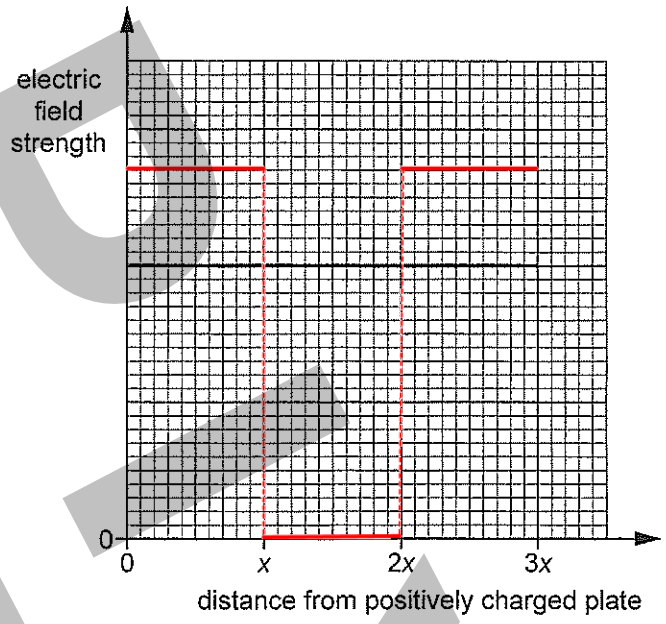


Fig. 3.3

On Fig. 3.3, draw a line to show the variation with distance from R to S of the electric field strength along the line RS. [3]

[Total: 5]

© UCLES & MOE 2020

Printed and published by Singapore Asia Publishers Pte Ltd

PIVOT
The Centre of Physics

4 **(a)** Explain what is meant by the term *diffraction*.

Diffraction refers to the spreading of the wavefronts when a wave passes through an aperture (slit) or around an obstacle [1]

(b) State two conditions necessary for two-source interference fringes to be observed.

1. The waves from the 2 sources must be emitted from coherent sources to ensure constant phase difference.
2. The waves from the 2 sources must have roughly the same intensities.

[2]

(c) A laser is used to produce two-source interference fringes on a screen.

The incident laser light is normal to the plane of a double slit. The plane of the double slit is parallel to the screen.

The variation of the fringe width x with distance D between the double slit and the screen is shown in Fig. 4.1.

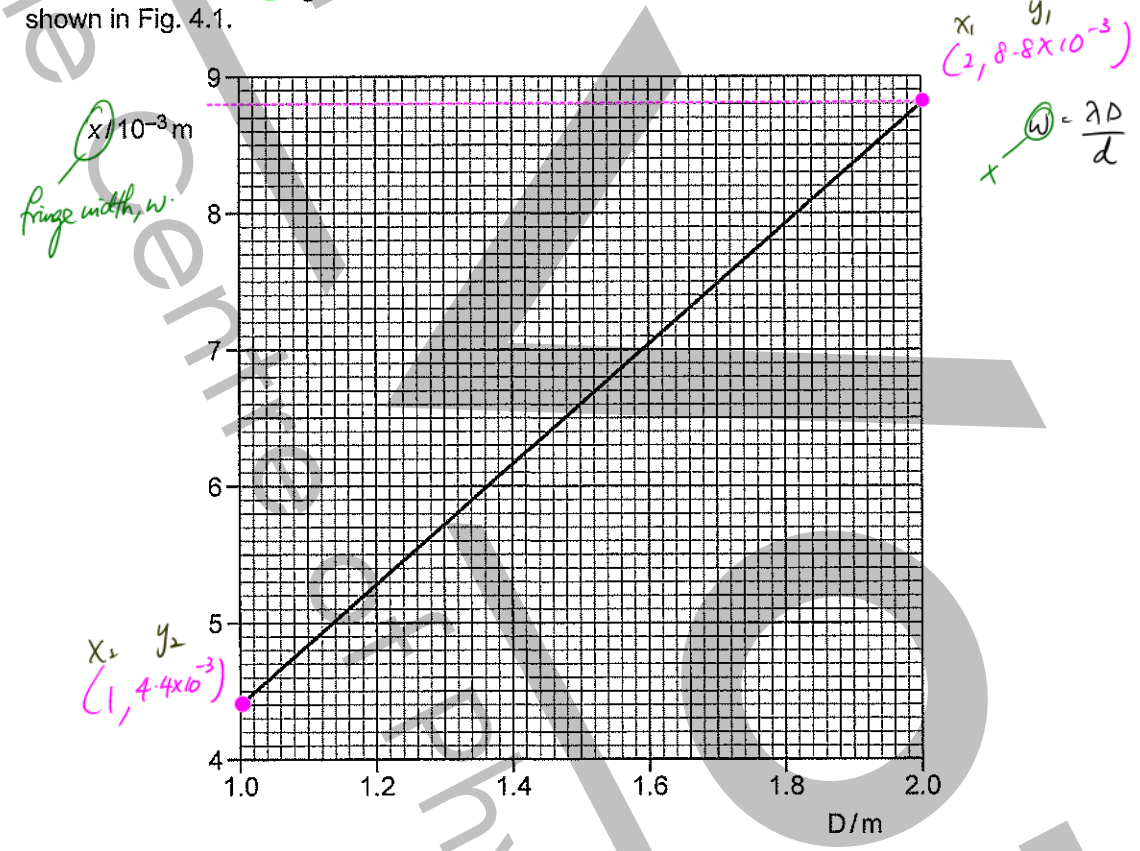


Fig. 4.1

The separation a of the slits is 0.12 mm.

$d = 0{\cdot}12\text{mm}$

© UCLES & MOE 2020

Printed and published by Singapore Asia Publishers Pte Ltd

The Centre for Physics DRAFT

(i) Calculate the wavelength λ of the laser light.

$$\text{Slope} = \frac{y_2 - y_1}{x_2 - x_1} = \frac{\lambda}{d}$$

$$\frac{(4.4 - 8.8)10^{-3}}{1 - 2} = \frac{\lambda}{0.12 \times 10^{-3}}$$

$\therefore \lambda = 528\text{ nm}$ * (3sf)

$\lambda =$ 528 nm m [2]

(ii) A filter is used so that the amplitude of the light from one slit is halved.

Calculate the ratio

$$\frac{\text{maximum intensity of central bright fringe}}{\text{maximum intensity of adjacent dark fringe}}.$$

$A_{central_initial} = 2A$

$A_{central_final} = 1.5A$

$A_{1st_dark_initial} = 0$

$A_{1st_dark_final} = 0.5A$, due to incomplete cancellations

$$\therefore \text{Ratio} = \left(\frac{1.5A}{0.5A}\right)^2 = 9.00 \text{ (3sf)}$$ *

ratio = 9.00 [3]

[Total: 8]

PLYOT
The Centre of Physics

© UCLES & MOE 2020

Printed and published by Singapore Asia Publishers Pte Ltd

5 **(a)** A silver wire of length 0.42 m has diameter 0.38 mm. The number density of free electrons in silver is $5.9 \times 10^{28}\,m^{-3}$. The drift velocity of electrons in the wire is $7.2 \times 10^{-5}\,m\,s^{-1}$.

Calculate the charge Q passing a point in the wire in a time of 30 minutes.

$r = 0.19\,mm$
$n = 5.9 \times 10^{28}$
$v_d = 7.2 \times 10^{-5}$
$t = 30 \times 60$

$I = \frac{Q}{t} = nAv_d q$

$\therefore Q = nAv_d qt = (5.9\times10^{28})(\pi)(0.19\times10^{-3})^2(7.2\times10^{-5})(1.6\times10^{-19})(30\times60) = 138.75\,C$
$= 139\,C$ (3sf) #

Q = 139 C [2]

(b) An a.c. power supply is connected to three resistors, as shown in Fig. 5.1.

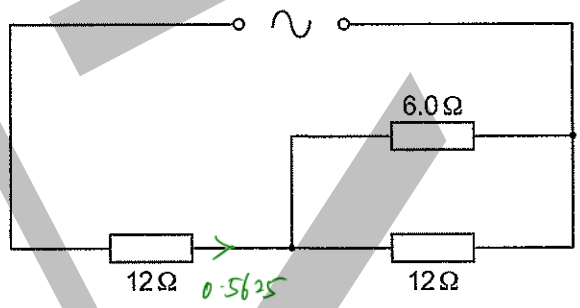


Fig. 5.1

The variation with time t of the voltage V of the power supply is given by the expression shown.

V_0 $\omega = 2\pi f$

$V = 9.0 \sin 120\pi t$

(i) For the power supply determine:

1. the frequency f

$\therefore f = \frac{\omega}{2\pi} = \frac{120\pi}{2\pi} = 60.0\,Hz$ (3sf) #

f = 60.0 Hz [1]

2. the root-mean-square (r.m.s.) voltage V_{rms}.

$V_{rms} = \frac{V_0}{\sqrt{2}} = \frac{9}{\sqrt{2}} = 6.3639$
$= 6.36\,V$ (3sf) #

V_{rms} = 6.36 V [1]

© UCLES & MOE 2020
Printed and published by Singapore Asia Publishers Pte Ltd

PJC The Centre of Physics

(ii) 1. Calculate the peak current I_o from the power supply.

$I_o = \frac{V_o}{R_{eff}} = \frac{9}{12 + 6 \,//\, 12} = 0.5625 = 0.563\ A$ # (3sf)

I_o = ... 0.563 ..... A [3]

2. Calculate the mean power P dissipated in the resistor of resistance 6.0 Ω.

By current divider law, $I_{6\Omega} = \frac{12}{12+6} \times 0.5625 = 0.375$

$P_{rms} = I_{rms}^2 \cdot R = \left(\frac{I_o}{\sqrt{2}}\right)^2 R = \left(\frac{0.375}{\sqrt{2}}\right)^2 (6)$

$= 0.4218$

$= 0.422\ W$ # (3sf)

P = ... 0.422 ..... W [2]

[Total: 9]

PILOT
The Centre of Physics

© UCLES & MOE 2020
Printed and published by Singapore Asia Publishers Pte Ltd

$F = BIL$, $B = \frac{F}{IL}$

6 **(a)** Define *magnetic flux density*.

The magnetic force acting on unit length of a long conductor carrying unit current, placed perpendicular to the uniform magnetic field. [1]

(b) A long solenoid of diameter 4.0 cm has 520 turns of insulated copper wire. The diameter of the wire is 0.46 mm. The wire is wrapped in a single layer with no gaps between each of the turns. The copper wire has resistivity $1.7 \times 10^{-8}\,\Omega\text{m}$.

Calculate the resistance R of the wire of the solenoid.

$B_{sol} = \frac{\mu_0 I N}{L}$

$r_{sol} = 2\text{ cm}$

$N = 520$

$r_{wire} = 0.23\text{ mm}$

$\rho_{Cu} = 1.7 \times 10^{-8}$

$R = \frac{\rho_{Cu} L_{wire\ used}}{A_{wire}} = \frac{\rho_{Cu}(2\pi r_{sol})(N)}{\pi r_{wire}^2} = \frac{(1.7\times10^{-8})(2)(2\times10^{-2})(520)}{(0.23\times10^{-3})^2}$

$= 6.6843$

$= 6.68\,\Omega$ (3sf)

$R =$ 6.68 Ω [3]

(c) The solenoid in **(b)** is connected to a 24 V supply.

Use information from **(b)** to calculate the magnetic flux density B along the axis of the solenoid, at its centre.

$B_{sol} = \frac{\mu_0 I N}{L} = \frac{\mu_0 V N}{R \cdot D_{wire} N} = \frac{(4\pi\times10^{-7})(24)}{(6.6843)(0.46\times10^{-3})} = 9.8085\times10^{-3}\,T$

$= 9.81\text{ mT}$ (3sf)

$B =$ 9.81m T [3]

(d) A current-carrying wire is placed inside, and along the axis of the solenoid in **(b)**. The solenoid remains connected to the 24 V supply.

State and explain the magnitude of the force, if any, experienced by the wire.

Force is 0. The current in the wire is parallel to the field of the solenoid. According to Fleming's Left-Hand rule, the force is 0. [1]

[Total: 8]

© UCLES & MOE 2020
Printed and published by Singapore Asia Publishers Pte Ltd

The Centre of Physics
SAMPLE

7 **(a)** Explain what is meant by a *photon*.

Discrete packet or quantum of Electromagnetic (EM) radiation with each packet having energy $E = hf$, where h is the Planck Constant and f is the frequency of the incoming EM radiation [2]

(b) A beam of white light passes through a cloud of gas. The spectrum of the transmitted light contains a number of dark lines. Absorption Spectrum

Explain why these dark lines occur.

This is an absorption spectrum. After white light passes through the cool gas, the remaining outgoing light passes through a spectroscope, revealing dark lines on a coloured background. The incident photons from the incoming white light, whose energies are exactly equal to the difference between the discrete energy levels in the atoms of the cool gas are absorbed by the cool gas. The electrons from the lower energy levels are excited to the higher energy levels. Being in the unstable states, these electrons subsequently de-excite back to the lower, more stable energy levels, thereby releasing photons in random directions that do not pass through the spectroscopy. Since the atom energy levels are discrete, only photons of certain frequencies are absorbed. As these frequencies of light are now missing, they account for the dark lines in a continuous coloured spectrum. [4]

(c) Some electron energy levels in a hydrogen atom are illustrated in Fig. 7.1.

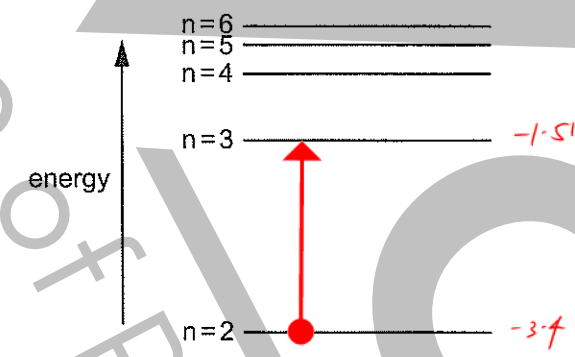


Fig. 7.1

The energy E in eV of each energy level may be determined using the expression

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

where n is the energy level.

© UCLES & MOE 2020
Printed and published by Singapore Asia Publishers Pte Ltd

PRELIM
The Centre of Physics

(i) Calculate the energy, in eV, of energy level $n = 2$.

$E_2 = \frac{-13.6\,eV}{2^2} = -3.40\,eV\ (3sf)$ #

energy = ... -3.40 ..... eV [1]

(ii) Determine the wavelength λ of light absorbed when an electron in energy level $n = 2$ is excited to energy level $n = 3$.

$\therefore |\Delta E| = \frac{hc}{\lambda} \qquad \therefore \lambda = \frac{hc}{|\Delta E|}$

$\therefore \lambda = \frac{(1.989 \times 10^{-25})}{\left|(3.40 - 1.511) \times 1.6 \times 10^{-19}\right|} = 6.58125 \times 10^{-7} = 658\,nm\ (3sf)$ #

λ = ... 658n ..... m [3]

(iii) Explain why the energy of each energy level is negative.

The electrical potential energy (EPE) of electrons in each energy level is defined as the work done by the external agent to bring the electron from infinity to that state without acceleration. Since the electric force is attractive, the work done by the external agent is negative. Moreover, by convention, EPE at infinity is 0. [1]

[Total: 11]

PI/OT
The Centre of Physics

© UCLES & MOE 2020

Printed and published by Singapore Asia Publishers Pte Ltd

8 Read the passage below and answer the questions that follow.

Racing competitions, such as Formula 1, have led to advances in technology that eventually make their way into road vehicles. Formula 1 teams compete to make the fastest vehicle possible within strict rules.

Formula 1 drivers experience large accelerations and decelerations. A Formula 1 car can stop in a straight-line distance of 80 m from a maximum speed of 185 km h^{-1}.

High accelerations and decelerations are limited by the friction F between the tyres and the road. This is related to the weight W of the car by the equation

$$F = \mu W$$

where μ is the coefficient of friction.

Before use in a race, tyres are kept warm in special tyre blankets. The coefficient of friction varies with the tyre surface temperature, as shown in Fig. 8.1.

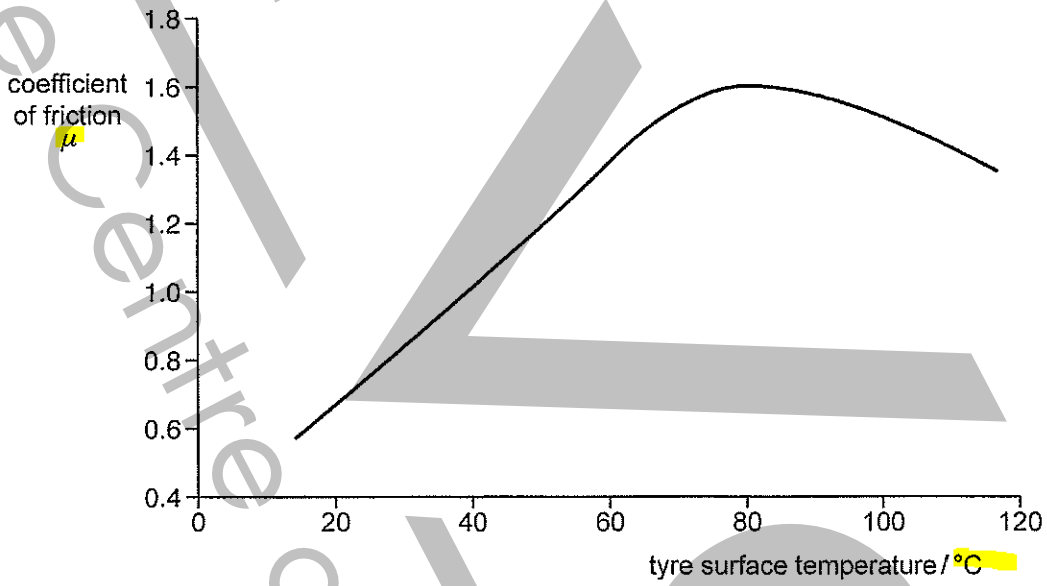


Fig. 8.1

A section through the road surface and a tyre at 20 °C in contact with the road is shown in Fig. 8.2.

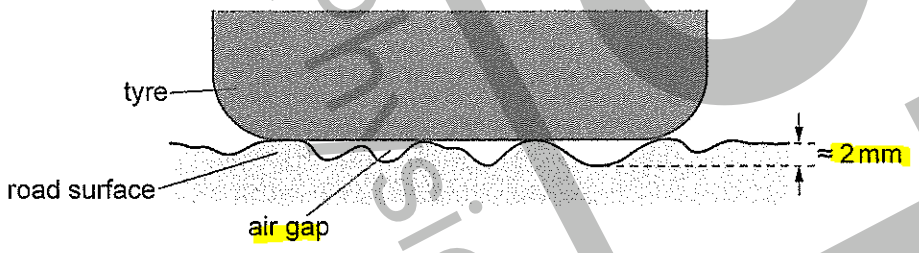


Fig. 8.2 (not to scale)

© UCLES & MOE 2020
Printed and published by Singapore Asia Publishers Pte Ltd

PI NOT the Centre of Physics

When the tyre is heated with the tyre blanket, the compound of the tyre becomes softer, increasing the contact area.

In order to make the tightest circular corner in the Singapore Street Circuit, drivers decelerate from 220 km h^{-1} to make it around the corner of radius 30 m. The tyres have to withstand lateral (sideways) accelerations of up to 4*g* during cornering.

The mass of a typical Formula 1 car is about 750 kg. Greater accelerations and cornering speeds may be achieved with greater friction between the tyres and the track. Features of the car, such as rear wings, appear to increase the weight of the car.

When a Formula 1 car accelerates, the weight distribution between the front and rear wheels changes. The cars are rear-wheel drive, which means the accelerating force is provided through the rear wheels. When accelerating, the contact force experienced by the rear wheels increases and this is called 'weight transfer'.

The brakes used on Formula 1 cars consist of carbon fibre discs and pads. There is one set for each of the four wheels. Each set has a mass of 1.2 kg. There are at least 1000 small holes drilled into each disc. These brakes operate more effectively at high temperatures than materials used for the brakes on road vehicles. It is predicted that brakes made from carbon fibre discs and pads will be the next big change to reach the everyday car market.

(a) Calculate the maximum deceleration a Formula 1 driver experiences while braking to rest in a straight line.

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

$\therefore a = \dfrac{v^2 - u^2}{2s} = \dfrac{0 - \left(\frac{185 \times 1000}{3600}\right)^2}{2(80)} = -16.505 = -16.5\ \text{m s}^{-2}$ (3 sf)

deceleration = 16.5 m s^{-2} [2]

(b) **(i)** Determine the maximum speed a Formula 1 car can travel around the tightest circular corner at the Singapore Street Circuit.

$a_c = 4g = \dfrac{v^2}{r}$

$\therefore v_{max\text{-}circular} = \sqrt{a_c r} = \sqrt{4(9.81)(30)} = 34.3103 = 34.3\ \text{m/s}$ (3 sf)

maximum speed = 34.3 m s^{-1} [3]

© UCLES & MOE 2020

Printed and published by Singapore Asia Publishers Pte Ltd

The Centre of Physics
DO NOT

(ii) By reference to Fig. 8.1 and Fig. 8.2, suggest and explain why the tyres are heated before use.

When the tyres are heated, the tyre compound becomes softer, thereby increasing the contact area by filling up the air gaps between the tyres and the ground, thus improving the grip between the tyres and the ground. Moreover, with a larger temperature, the coefficient of friction increases, thereby increasing the friction between the tyres and the ground. This helps to achieve greater cornering speeds and larger accelerations.

..... [3]

(c) A cross-section of the rear wing on a Formula 1 car is shown in Fig. 8.3.

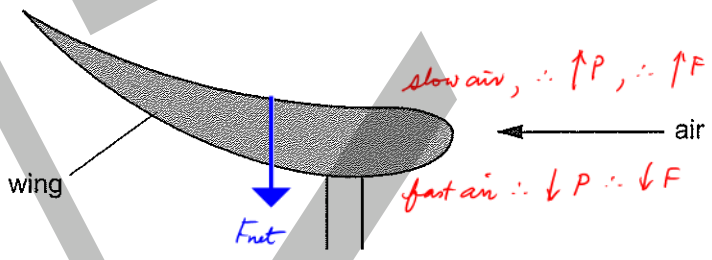


Fig. 8.3

The wing deflects air when the car is moving.

Explain, by reference to the change in momentum of the air, why this air flow appears to increase the weight of the car.

At the lower side of the wing, the air moves faster, suggesting lower pressure and thus smaller upward force, which means the rate of change of momentum of the air on the lower side of the wings must be smaller. On the upper side of the wing, the air moves slower, suggesting higher pressure, and larger downward force, which means that the rate of change of momentum of the air on the upper side of the wings must be larger. By Bernoulli's principle, this creates a larger downward net force to add traction to the car, thus appearing to increase the weight of the car. [2]

© UCLES & MOE 2020
Printed and published by Singapore Asia Publishers Pte Ltd

The Centre of Physics
DO NOT

(d) Some of the forces acting on a Formula 1 car while accelerating from rest are shown in Fig. 8.4.

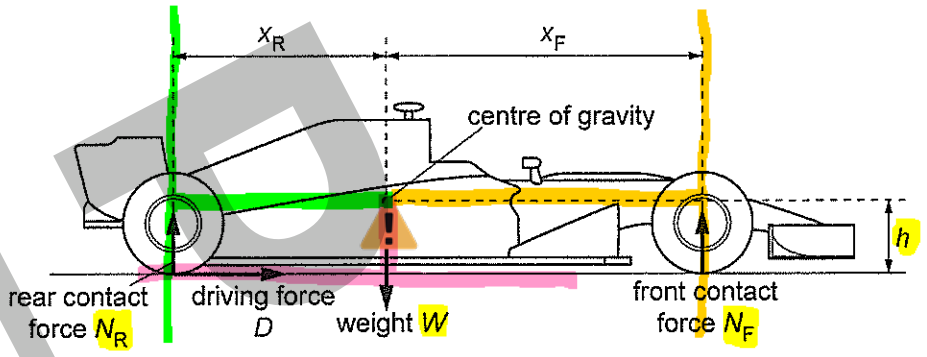


Fig. 8.4

N_R and N_F are the contact forces acting on the rear and front wheels, respectively. W is the weight of the car. D is the driving force acting on the rear wheels.

The centre of gravity is a vertical distance h above the ground. The centre of gravity is a horizontal distance x_R from the rear wheels and a horizontal distance x_F from the front wheels.

For the car accelerating from rest:

(i) take moments about the centre of gravity, to show that

$$N_R = \frac{Wx_F + Dh}{x_F + x_R}$$

$N_R + N_F = W$ — ①

Tot. CW = Tot. ACW.

$\therefore N_R x_R = N_F x_F + Dh$ — ②

From ①

$N_F = W - N_R$ — ③

sub ③ into ②

$\therefore N_R x_R = (W - N_R) x_F + Dh$

$N_R x_R = Wx_F - N_R x_F + Dh$

$\therefore N_R (x_R + x_F) = Wx_F + Dh$

and $N_R = \dfrac{Wx_F + Dh}{x_R + x_F}$ # shown.

[3]

© UCLES & MOE 2020

Printed and published by Singapore Asia Publishers Pte Ltd

PYOT The Centre of Physics

(ii) determine a similar expression to that in **(d)(i)** for N_F.

$N_R + N_F = W$ — ①

$N_R x_R = N_F x_F + Dh$ — ②

From ①

$\therefore N_R = W - N_F$ — ③

sub ③ into ②

$\therefore \quad W x_R - N_F x_R = N_F x_F + Dh$

$\therefore N_F = \dfrac{W x_R - Dh}{x_R + x_F}$ #

[1]

(iii) Use your expressions in **(d)(i)** and **(d)(ii)** to show that there is weight transfer between the front and rear wheels.

$N_R = \dfrac{Wx_R + Dh}{x_R + x_F}$ and $N_F = \dfrac{Wx_R - Dh}{x_R + x_F}$. When the car accelerates, $D \neq 0$, and N_R increases by $\dfrac{Dh}{x_R + x_F}$ whereas N_F decreases by $\dfrac{Dh}{x_R + x_F}$, thereby causing weight transfer to the rear wheels.

[2]

(e) **(i)** Calculate the maximum temperature increase $\Delta\theta$ of the carbon fibre brakes when a Formula 1 car brakes to rest from 185 km h^{-1}.

The average specific heat capacity of carbon fibre is 1130 J kg^{-1} K^{-1}.

By COE, $\Delta KE = Q = mc \cdot \Delta\theta$

$\frac{1}{2} m_{car} (v_f - v_i)^2 = m_{pad} \cdot N \cdot c \cdot \Delta\theta$

Hence, $\Delta\theta = \dfrac{m_{car}(v_f - v_i)^2}{2 \cdot m_{pad} \cdot N \cdot c}$

So, $\Delta\theta = \dfrac{(750)\left(0 - \frac{185(1000)}{3600}\right)^2}{2(1.2)(4)(1130)} = 182.57$

$= 183\ K$

$= 183\ ^\circ C$ (3 sf) #

$\Delta\theta =$ 183 °C [3]

(ii) State an assumption you have made in **(e)(i)**.

The entire kinetic energy loss of the car goes entirely into raising the temperature of the 4 brake pads and there are no energy losses. [1]

(iii) Suggest two reasons why the discs have many small holes.

1. To allow for a more effective heat dissipation

2. To allow water to be ejected out during rainy weather.

[2]

[Total: 22]

Permission to reproduce items where third-party owned material protected by copyright is included has been sought and cleared where possible. Every reasonable effort has been made by the publisher (UCLES) to trace copyright holders, but if any items requiring clearance have unwittingly been included, the publisher will be pleased to make amends at the earliest possible opportunity.

Cambridge Assessment International Education is part of the Cambridge Assessment Group. Cambridge Assessment is the brand name of the University of Cambridge Local Examinations Syndicate (UCLES), which is itself a department of the University of Cambridge.

© UCLES & MOE 2020

Printed and published by Singapore Asia Publishers Pte Ltd

PI NOT The Centre of Physics