Name:		Index Number:		Class:	

DUNMAN HIGH SCHOOL
Promotional Examination
Year 5

H2 PHYSICS

9749

Multiple Choice and Structured Questions

2 October 2020

2 hours

Additional Materials:
Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write your class, index number and name on all the work you hand in.
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.
The use of an approved scientific calculator is expected, where appropriate.

Section A

You are advised not to spend more than **30 minutes** on Section A.
There are **fifteen** questions in this section.
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.

Section B

You are advised not to spend more than **1 hour 30 min** on Section B.
Answer **all** questions.
At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
Section A	
MCQ	/15
Section B	
1	/8
2	/8
3	/8
4	/7
5	/5
6	/12
7	/12
s.f.	/-1
Total	/75

Data

speed of light in free space,	c =	3.00×10^{8} m s^{-1}
permeability of free space,	μ_o =	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	ε_o =	8.85×10^{-12} F m^{-1}
	=	$(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge,	e =	1.60×10^{-19} C
the Planck constant,	h =	6.63×10^{-34} J s
unified atomic mass constant,	u =	1.66×10^{-27} kg
rest mass of electron,	m_e =	9.11×10^{-31} kg
rest mass of proton,	m_p =	1.67×10^{-27} kg
molar gas constant	R =	8.31 J K^{-1} mol^{-1}
the Avogadro constant,	N_A =	6.02×10^{23} mol^{-1}
the Boltzmann constant,	k =	1.38×10^{-23} J K^{-1}
gravitational constant,	G =	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall,	g =	9.81 m s^{-2}

Formulae

uniformly accelerated motion,	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas,	W	=	$p\Delta V$
hydrostatic pressure,	p	=	ρgh
gravitational potential,	ϕ	=	$-Gm/r$
temperature,	T/K	=	T/°C + 273.15
pressure of an ideal gas,	p	=	$\frac{1}{3}\frac{Nm}{V}\langle c^2\rangle$
mean translational kinetic energy of an ideal gas molecule,	E	=	$\frac{3}{2}kT$
displacement of particle in s.h.m.,	x	=	$x_0 \sin \omega t$
velocity of particle in s.h.m.,	v	=	$v_0 \cos \omega t$
		=	$\pm\omega\sqrt{x_o^2 - x^2}$
electric current,	I	=	$Anvq$
resistors in series,	R	=	$R_1 + R_2 + \ldots$
resistors in parallel,	$1/R$	=	$1/R_1 + 1/R_2 + \ldots$
electric potential,	V	=	$\frac{Q}{4\pi\varepsilon_o r}$
alternating current / voltage,	x	=	$x_0 \sin \omega t$
magnetic flux density due to a long straight wire,	B	=	$\frac{\mu_0 I}{2\pi d}$
magnetic flux denxity due to a flat circular coil,	B	=	$\frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid,	B	=	$\mu_0 nI$
radioactive decay,	x	=	$x_0 \exp(-\lambda t)$
decay constant,	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

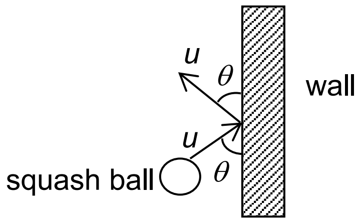
Section A

Answer **all** the questions.

1 Decimal sub-multiples and multiples of units are indicated using a prefix to the unit. Which row gives the sub-multiples or multiples represented by pico (p) and Tera (T)?

	pico (p)	Tera (T)
A	10^{-9}	10^{9}
B	10^{-9}	10^{12}
C	10^{-12}	10^{9}
D	10^{-12}	10^{12}

2 A squash ball hits the wall with an instantaneous speed u at an angle θ from the vertical. It then rebounds from the wall symmetrically with an equal instantaneous speed as shown.



What is the direction and magnitude of the change in velocity of the ball respectively?

A upwards, $2u \cos \theta$

B leftwards, $2u \sin \theta$

C rightwards, $2u \sin \theta$

D downwards, $2u \cos \theta$

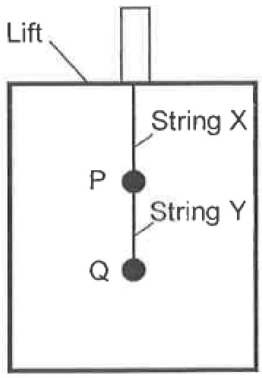
3 A skydiver falls from an aircraft that is moving horizontally. Air resistance is **not** negligible. The vertical component of the velocity of the skydiver is *v*. The vertical component of the acceleration of the skydiver is *a*.

What are the variations of *v* and *a* during the subsequent fall of the skydiver?

	v	*a*
A	constant	constant
B	constant	decreasing
C	increasing	constant
D	increasing	decreasing

4 Two objects, P and Q, each of mass 1.0 kg, are suspended one below the other from the ceiling of a lift by two light, inextensible strings X and Y as shown below. What are the tensions in X and Y when the lift is accelerating upwards at 2.0 m s^{-2}?

Take *g* to be 10 m s^{-2} for this question.



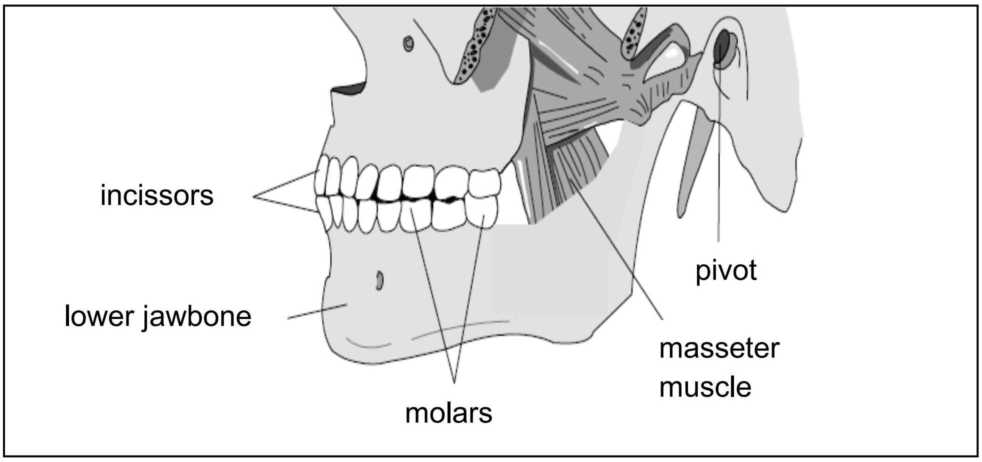
	tension in X / N	tension in Y / N
A	12	10
B	24	10
C	22	12
D	24	12

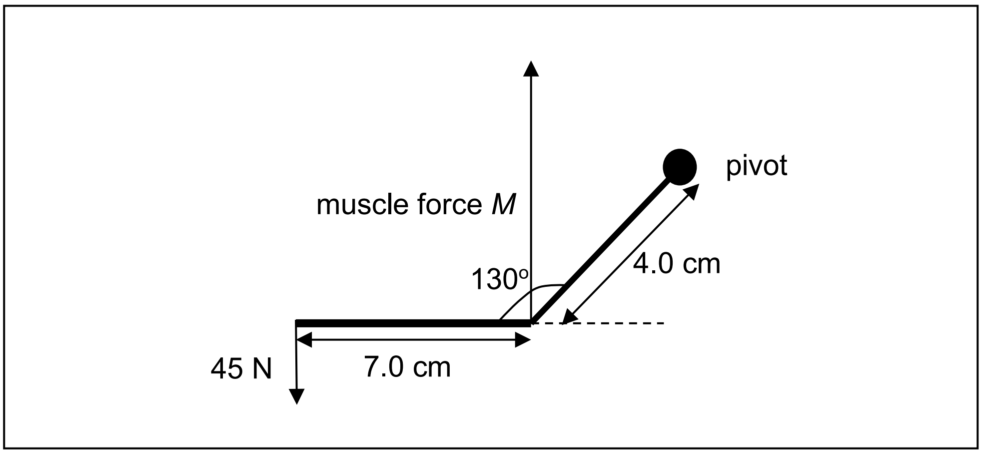
5 An incompressible liquid of density ρ is contained in a vessel of uniform cross-sectional area A. The atmospheric pressure is P.

What is the force acting on a horizontal plane of area x, at a depth h in the liquid?

A $\dfrac{P}{A}+\dfrac{\rho gh}{x}$ **B** $A(\rho gh+P)$ **C** $x(\rho gh+P)$ **D** $x\rho gh+AP$

6 The diagram below shows the position of a person's lower jawbone and a simplified free-body diagram of the forces acting on it.





The jawbone has negligible mass. It consists of two straight parts of length 7.0 cm and 4.0 cm making an angle of 130° with each other. During one particular bite, a force of 45 N is applied by the teeth at the front of the jawbone.

What is the force M exerted by the masseter muscle?

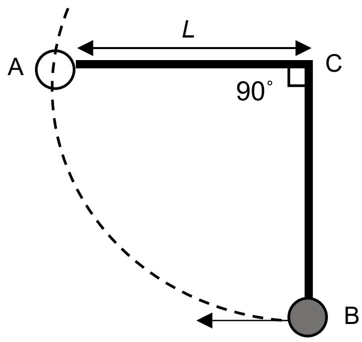
A 120 N **B** 140 N **C** 150 N **D** 170 N

7 An electric motor produces 120 W of useful mechanical output power. The efficiency of the motor is 60 %.

Which row is correct?

	electrical power input / W	waste heat power output / W
A	72	48
B	192	72
C	200	72
D	200	80

8 A simple pendulum consists of a bob of mass *m* at the end of a light and inextensible thread of length *L*. The other end of the thread is fixed at C. the bob swings through point B with a speed *v* and just reaches A.



What is the tension in the thread when the bob is at position B?

A mg **B** $2mg$ **C** $3mg$ **D** $4mg$

9 The gravitational field strength on the surface of planet P is one tenth of that on the surface of planet Q. On the surface of P, a body has a mass of 1.0 kg and a weight of 1.0 N.

What are the mass and weight of the same body on the surface of planet Q?

	mass on Q / kg	weight on Q / N
A	1.0	0.1
B	1.0	10
C	10	10
D	10	100

10 An object placed on a horizontal platform is vibrating vertically in simple harmonic motion with a frequency of 2.0 Hz. The maximum amplitude of oscillation which will allow the object to remain in contact with the platform throughout the motion is

A 6.2 cm **B** 2.5 cm **C** 1.6 cm **D** 0.78 cm

11 The density of argon at a pressure of 1.00×10^5 Pa and temperature of 300 K is 1.60 kg m^{-3}.

What is the root-mean-square speed of the argon molecules at this temperature?

A 216 m s^{-1} **B** 250 m s^{-1} **C** 306 m s^{-1} **D** 433 m s^{-1}

12 A 1.50 kg metal block at a temperature of 400 K is placed into a container containing 10.0 kg of water at a temperature of 300 K. The specific heat capacities of water and the block are 4200 J K^{-1} kg^{-1} and 2500 J K^{-1} kg^{-1} respectively. Assume that the heat capacity of the container is negligible.

What is the temperature when they have reached thermal equilibrium?

A 308 K **B** 320 K **C** 350 K **D** 700 K

13 The internal energy of a fixed mass of an ideal gas depends on

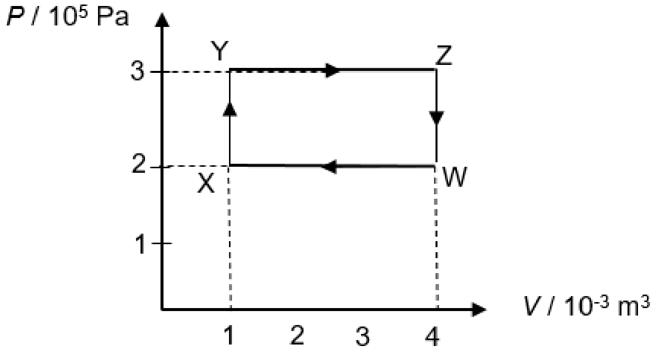
A pressure, but not volume or temperature.

B temperature, but not pressure or volume.

C volume, but not pressure or temperature.

D pressure and temperature, but not volume.

14 A gas undergoes the cycle of pressure and volume changes W→X→Y→Z→W as shown in the diagram below.



What is the net work done *on* the gas?

A - 900 J **B** - 300 J **C** 300 J **D** 900 J

15 A system absorbs 80 J through heating while doing 100 J of work.

What is the change in the internal energy of the system?

A -100 J **B** - 20 J **C** 80 J **D** 0.180 J

End of Section A

Section B

Answer **all** the questions.

1 **(a)** Three of the SI base quantities are mass, time and length.

Name two other SI base quantities and their units.

1. quantity…………………………………..………… unit……………………………………...

2. quantity………………………………………….. unit…………………………………..……..

[2]

(b) A metal wire of length L_0 is suspended vertically from a ceiling. The weight of the wire causes it to stretch. The elastic potential energy E stored in this metal wire given by

$$E = C\rho^2 g^2 A L_0^{\,3}$$

where ρ is the density of the metal,
g is the acceleration of free fall,
A is the cross-sectional area of the wire, and
C is a constant.

Determine the SI base units of C.

base units of C = ………………………….[3]

(c) The dimensions of a coin are measured as follows:

diameter d = (20.0 ± 0.2) mm

thickness t = (1.5 ± 0.1) mm

Calculate the volume of the coin with its uncertainty.

V = ……………..±……………… mm^3 [3]

2 A skateboarder starts from rest at point A as shown in Fig. 2.1.

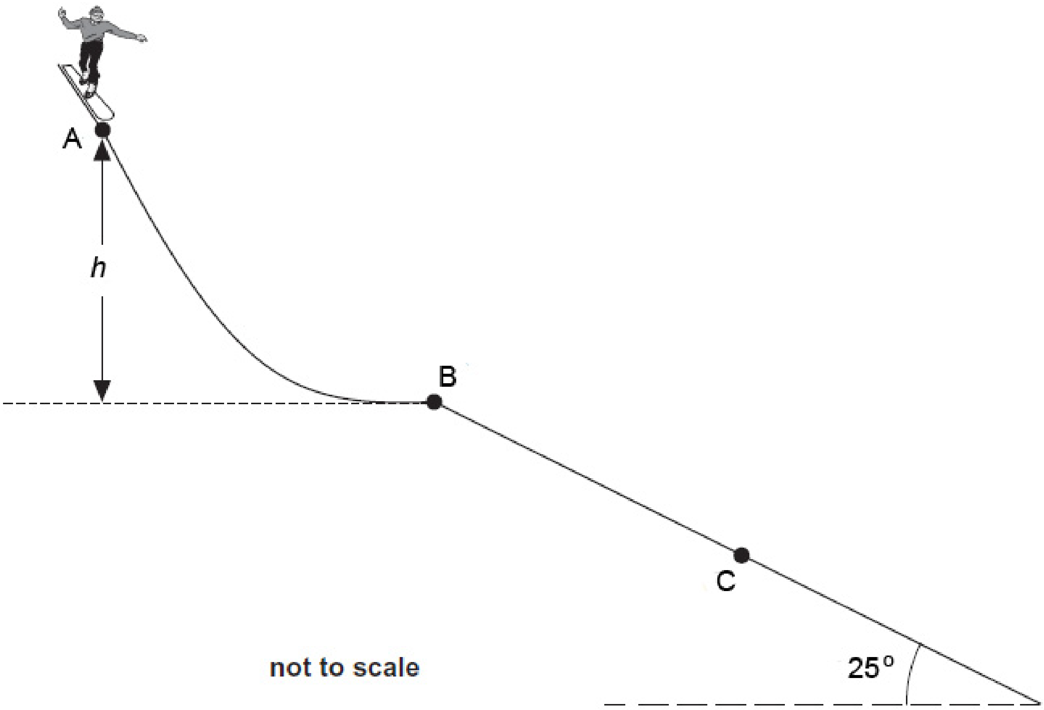


Fig. 2.1

The skateboarder reaches a speed of 17 m s^{-1} at point B.

Consider the skateboarder to be a point mass of 65 kg and ignore the effects of friction and air resistance.

(a) Calculate the height difference, h, between point A and point B.

h = …………………….. m [2]

(b) The skateboarder takes off at point B, travelling horizontally with a velocity of 17 m s^{-1}. He lands at point C after being in the air for 1.6 s.

(i) Calculate v_v, the vertical component of his velocity, just before landing at point C.

v_v = …………………….. m s^{-1} [2]

(ii) On Fig. 2.2**,** sketch the variation with time of the vertical component of the velocity v_v of the skateboarder from point B to point C.

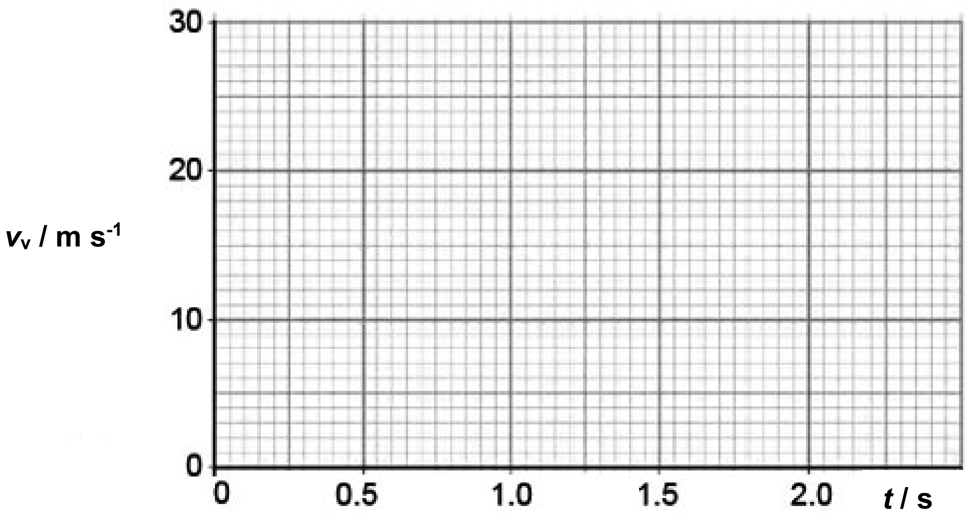


Fig. 2.2

[2]

(iii) Determine the magnitude of the resultant velocity of the skateboarder just before landing at point C.

resultant velocity at point C = …………………….. m s^{-1} [2]

3 An object X of mass 5.2 kg travelling with a velocity of 0.48 m s^{-1} collides with another object Y of mass 2.3 kg travelling with a velocity of 0.76 m s^{-1} in the opposite direction.

This is shown in Fig. 3.1. The collision is perfectly elastic.

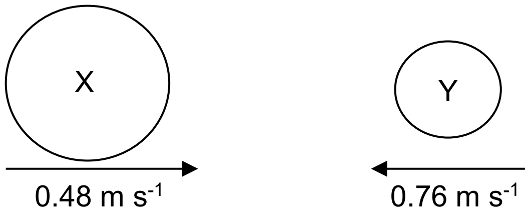


Fig. 3.1

In your answers, take the velocity of X before collision as positive.

(a) Calculate the relative speed of approach of the two objects.

relative speed of approach = …………………… m s^{-1} [1]

(b) Deduce the relative speed of separation of the two objects.

relative speed of separation = …………………… m s^{-1} [1]

(c) Calculate the final velocity of each of the two masses after the collision.

velocity of X after the collision = …………………… m s^{-1}

velocity of Y after the collision = …………………… m s^{-1} [3]

(d) Calculate the impulse object Y exerts on object X during the collision.

impulse = …………………… N s [2]

(e) Deduce the impulse object X exerts on object Y during the collision.

impulse = …………………… N s [1]

4 **(a)** A compact solid block of modelling clay, when placed on water, will sink. When the same block of clay is shaped into a model of a boat, it floats on water.

Explain why the boat model would float on water.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

……………………………………………………………………………………………......[2]

(b) A string supports a solid iron object of mass 200 g. The solid iron object is hence suspended in mid-air.

(i) Calculate the tension in the string when the solid iron object is suspended by the string in mid-air.

tension in the string =…………. N [1]

(ii) Given that the density of iron is 8000 kg m^{-3}, calculate the volume of the solid iron object

volume of solid iron object =………….. m^3 [1]

(c) The iron object in (b) is lowered into a liquid of density 800 kg m^{-3} until it is fully submerged in the liquid. Calculate the new tension in the string.

new tension in string =…………… N [1]

(c) A solid cube with sides of length, *x* is placed on the surface of a fluid. The cube is then slowly pushed downwards into the fluid, as seen in Fig. 4.1. The distance from the base of the cube to the surface of liquid is given by *h*. The cube is pushed downwards until *h* >> *x.*

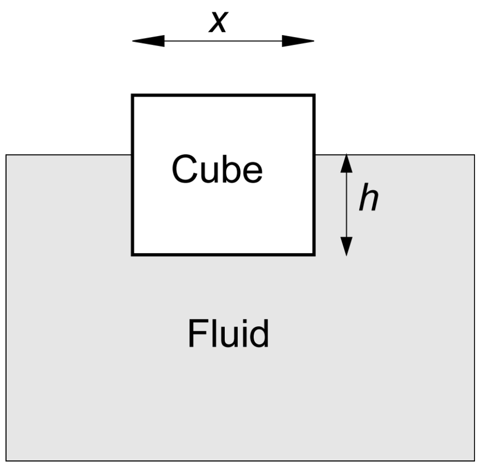


Fig. 4.1

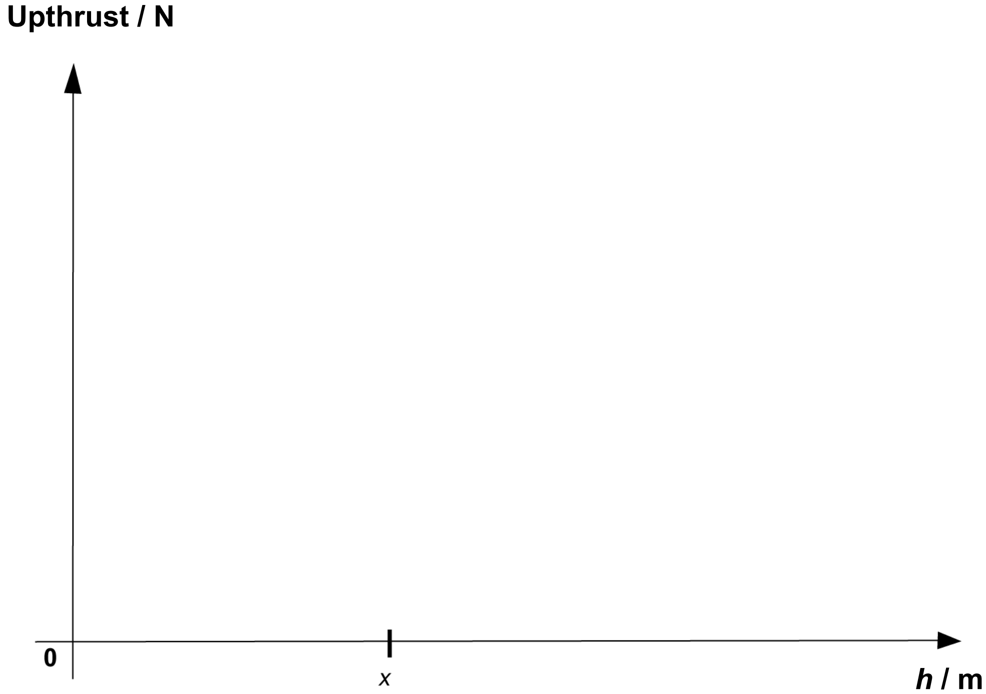


Fig. 4.2

Sketch on Fig. 4.2 the graph of the upthrust acting on cube with *h*.

[2]

5 The power of a car engine in watts is commonly measured in 'horsepower' (hp), an old way of measuring engine powers in comparison to the horse technology of those days.

This power represents the maximum power that the engine can produce when the car is traveling at maximum speed on a level road. The 'horsepower' is defined as follows:

$$1 \text{ hp} = 0.746 \text{ kW}$$

The engine produces power which is then transmitted to the wheels to drive the car, which then has to do work against frictional forces. There are two main frictional forces that the car has to go against – air resistance F and friction with the road R.

Fig. 5.1 shows the values of R and F at various speeds v for a particular model of a Toyota vehicle, according to the manufacturer.

v / m s^{-1}	R / N	F / N	Total Resistance F_T/ N	Power Required / kW
9.0	228	52	280	
18	223	206		
27	219	470		18.6
36	212	834	1046	37.7
45	204	1300	1504	67.7

Fig 5.1

(a) Fill in the blanks in the last 2 columns of the table in Fig. 5.1. [1]

(b) The total resistance F_T can be modelled using the formula below, taking the resistance R to be constant at 220 N:

$$F_T = R + F = 220 + \tfrac{1}{2} CA\rho v^2$$

where A is the cross sectional area, ρ is the density of the air and C is a 'shape constant' called the drag coefficient (a dimensionless constant).

You may take ρ as 1.29 kg m^{-3}.

Using this equation and given that the product CA for the Toyota vehicle is approximately 0.995 m^2, estimate the total resistance F_T acting on the Toyota vehicle when it is traveling at a speed of 32 m s^{-1}.

F_T = ... N [2]

(c) A Toyota vehicle has an engine that can deliver a horsepower of 102 hp when it is traveling at its maximum speed of 45 m s^{-1}.

(i) Calculate the power supplied by the engine in kilowatts.

P = ... kW [1]

(ii) The value calculated in **(c)(i)** is not the same as the required power stated in Fig. 5.1. Suggest a reason for the difference.

....

....

.... [1]

6 **(a)** The Moon orbits about the Earth in a circular orbit of radius 3.82×10^{8} m with a period of 27 days. The mass of the Moon is 7.35×10^{22} kg.

Calculate the magnitude of

(i) the angular velocity of the Moon.

angular velocity = …………………… rad s^{-1} [2]

(ii) the acceleration of the Moon.

acceleration = ……………………. m s^{-2} [2]

(iii) the gravitational force the Earth exerts on the Moon.

gravitational force = ……………………. N [2]

(b) Explain why the acceleration calculated in **(ii)** does not increase the speed of the Moon.

…………………………………………………………………………………………………...

…………………………………………………………………………………………………...

…………………………………………………………………………………………………...

…………………………………………………………………………………………………... [2]

(c) **(i)** The gravitational potential ϕ at a distance r from an isolated point mass m is given by the expression

$$\phi = -G\frac{m}{r}$$

Explain why gravitational potential is negative.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

……………………………………………………………………………………………… [2]

(ii) An object is projected vertically from the surface of the Earth to an altitude of 1.3×10^4 km above the surface. Calculate the change in gravitational potential, given the mass of Earth is 6.0×10^{24} kg and radius of Earth is 6.4×10^3 km.

change in potential = …………………….. J kg^{-1} [2]

7 A light spring stretches by 0.200 m when a stone of mass m = 0.400 kg is hung from its lower end, as shown in Fig. 7.1.

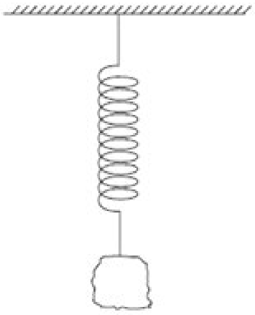


Fig. 7.1

When the stone is further displaced downwards by 0.200 m and released, it undergoes simple harmonic motion. The period of oscillation T is given by the formula

$$T = 2\pi\sqrt{\frac{m}{k}}$$

where k is the spring constant.

(a) Define *simple harmonic motion.*

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..

…………………………………………………………………………………………………[2]

(b) Determine the

(i) spring constant,

spring constant = ……………………. N m^{-1} [1]

(ii) angular frequency of the oscillation,

angular frequency = ……………………. rad s^{-1} [2]

(iii) maximum kinetic energy of the stone,

maximum kinetic energy = ……………………. J [2]

(iv) speed of the stone when it is at the position 0.100 m below the equilibrium position.

speed = ……………………. m s^{-1} [1]

(c) Describe the energy changes as the stone oscillates from the lowest point to the highest point of its motion.

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

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……………………………………………………………………………………………………[4]

END OF PAPER