Dynamics-explaining motion: 3

TOPIC- SI units, different forces, Newton's law, moving through fluids

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

For Examiner's Use

1 A unit is often expressed with a prefix. For example, the gram may be written with the prefix 'kilo' as the kilogram. The prefix represents a power-of-ten. In this case, the power-of-ten is 10^3.

Complete Fig. 1.1 to show each prefix with its symbol and power-of-ten.

prefix	symbol	power-of-ten
kilo	k	10^3
nano	n	.....
centi	.....	10^{-2}
.....	M	10^6
.....	T	10^{12}

Fig. 1.1

[4]

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

For Examiner's Use

02 Make estimates of the following quantities.

(a) the speed of sound in air

speed = ... [1]

(b) the density of air at room temperature and pressure

density = ... [1]

(c) the mass of a protractor

mass = ... [1]

(d) the volume, in cm^3, of the head of an adult person

volume = ... cm^3 [1]

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

For Examiner's Use

0 3 (a) The current in a wire is I. Charge Q passes one point in the wire in time t. State

(i) the relation between I, Q and t,

..... [1]

(ii) which of the quantities I, Q and t are base quantities.

.....

..... [2]

(b) The current in the wire is due to electrons, each with charge q, that move with speed v along the wire. There are n of these electrons per unit volume.
For a wire having a cross-sectional area S, the current I is given by the equation

$$I = nSqv^k,$$

where k is a constant.

(i) State the units of I, n, S, q and v in terms of the base units.

I .....

n .....

S .....

q .....

v .....

[3]

(ii) By considering the homogeneity of the equation, determine the value of k.

k = ... [2]

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

For Examiner's Use

04 **(a)** Two of the SI base quantities are mass and time. State three other SI base quantities.

1. .....

2. .....

3. .....

[3]

(b) A sphere of radius r is moving at speed v through air of density ρ. The resistive force F acting on the sphere is given by the expression

$$F = Br^2\rho v^k$$

where B and k are constants without units.

(i) State the SI base units of F, ρ and v.

F .....

ρ .....

v .....

[3]

(ii) Use base units to determine the value of k.

k = ... [2]

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

05 **(a)** **(i)** Define *pressure*.

.....

.....[1]

(ii) Show that the SI base units of pressure are $kg\,m^{-1}\,s^{-2}$.

[1]

(b) Gas flows through the narrow end (nozzle) of a pipe. Under certain conditions, the mass m of gas that flows through the nozzle in a short time t is given by

$$\frac{m}{t} = kC\sqrt{\rho P}$$

where k is a constant with no units,
C is a quantity that depends on the nozzle size,
ρ is the density of the gas arriving at the nozzle,
P is the pressure of the gas arriving at the nozzle.

Determine the base units of C.

base units .....[3]

[Total: 5]

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

For Examiner's Use

0 6 Make reasonable estimates of the following quantities.

(a) the frequency of an audible sound wave

frequency = ... Hz [1]

(b) the wavelength, in nm, of ultraviolet radiation

wavelength = ... nm [1]

(c) the mass of a plastic 30 cm ruler

mass = ... g [1]

(d) the density of air at atmospheric pressure

density = ... kg m^{-3} [1]

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

For Examiner's Use

0 7 **(a)** Two of the SI base quantities and their units are mass (kg) and length (m).

Name three other SI base quantities and their units.

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

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

3. quantity ..... unit .....

[3]

(b) The pressure p due to a liquid of density ρ is related to the depth h by the expression

$$p = \rho g h,$$

where g is the acceleration of free fall.

Use this expression to determine the derived units of pressure. Explain your working.

[5]

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

0 8 **(a)** The intensity of a progressive wave is defined as the average power transmitted through a surface per unit area.

Show that the SI base units of intensity are $kg\,s^{-3}$.

[2]

(b) **(i)** The intensity I of a sound wave is related to the amplitude x_0 of the wave by

$$I = K\rho c f^2 x_0^2$$

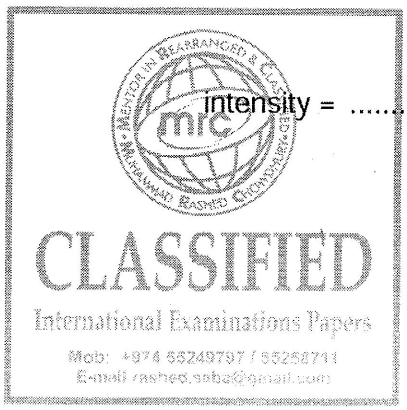
where ρ is the density of the medium through which the sound is passing,
c is the speed of the sound wave,
f is the frequency of the sound wave
and K is a constant.

Show that K has no units.

[2]

(ii) Calculate the intensity, in $pW\,m^{-2}$, of a sound wave where

$K = 20$,
$\rho = 1.2$ in SI base units,
$c = 330$ in SI base units,
$f = 260$ in SI base units
and $x_0 = 0.24\,nm$.



intensity = ...$pW\,m^{-2}$ [3]

0 9 Determine the SI base units of K.

SI base units of K ..... [2]

(ii) Data in SI units for the oscillations of X are shown in Fig. 1.2.

quantity	value	uncertainty
T	0.45	± 2.0%
l	0.892	± 0.2%
M	0.2068	± 0.1%
K	1.48×10^5	± 1.5%

Fig. 1.2

Calculate E and its actual uncertainty.

E = ... ± ..... $kg\,m^{-1}\,s^{-2}$ [4]

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

10 **(a)** The kilogram, metre and second are SI base units.

State two other base units.

1. .....

2. .....

[2]

(b) Determine the SI base units of

(i) stress,

SI base units .....[2]

(ii) the Young modulus.

SI base units .....[1]

For Examiner's Use

11 The time T for a satellite to orbit the Earth is given by

$$T = \sqrt{\left(\frac{KR^3}{M}\right)}$$

where R is the distance of the satellite from the centre of the Earth,
M is the mass of the Earth,
and K is a constant.

(a) Determine the SI base units of K.

SI base units of K ..... [2]

(b) Data for a particular satellite are given in Fig. 2.1.

quantity	measurement	uncertainty
T	8.64×10^4 s	± 0.5%
R	4.23×10^7 m	± 1%
M	6.0×10^{24} kg	± 2%

Fig. 2.1

Calculate K and its actual uncertainty in SI units.

K = ... ± ..... SI units [4]

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

For Examiner's Use

12 **(a)** State the SI base units of force.

.....[1]

(b) Two wires each of length l are placed parallel to each other a distance x apart, as shown in Fig. 1.1.

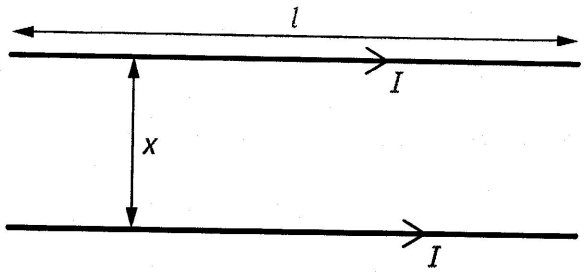


Fig. 1.1

Each wire carries a current I. The currents give rise to a force F on each wire given by

$$F = \frac{KI^2l}{x}$$

where K is a constant.

(i) Determine the SI base units of K.

units of K ..... [2]

(ii) On Fig. 1.2, sketch the variation with x of F. The quantities I and l remain constant.

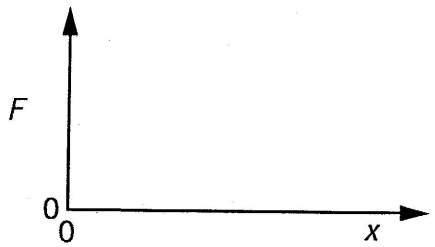


Fig. 1.2 [2]

(iii) The current I in both of the wires is varied.

On Fig. 1.3, sketch the variation with I of F. The quantities x and l remain constant.

For Examiner's Use

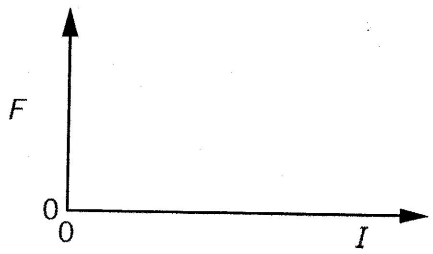
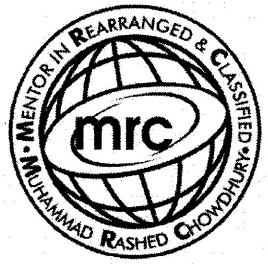


Fig. 1.3

[1]



Dynamics-explaining motion: 3

TOPIC- SI units, different forces, Newton's law, moving through fluids

1 A helicopter has a cable hanging from it towards the sea below, as shown in Fig. 3.1.

For Examiner's Use

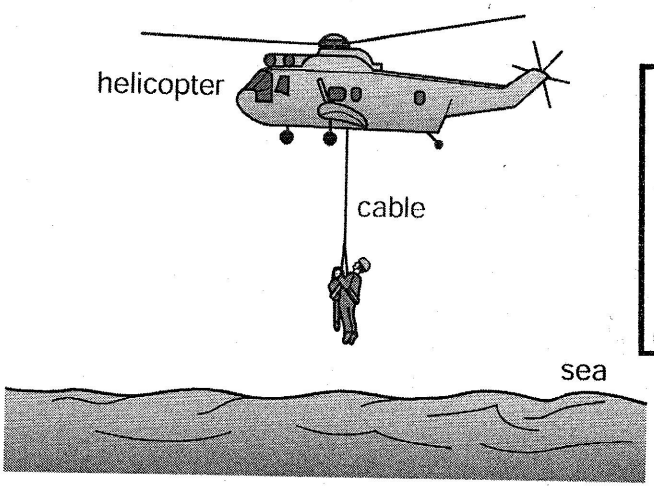


Fig. 3.1

A man of mass 80 kg rescues a child of mass 50.5 kg. The two are attached to the cable and are lifted from the sea to the helicopter. The lifting process consists of an initial uniform acceleration followed by a period of constant velocity and then completed by a final uniform deceleration.

(a) Calculate the combined weight of the man and child.

weight = ... N [1]

(b) Calculate the tension in the cable during

(i) the initial acceleration of 0.570 m s^{-2},

tension = ... N [2]

(ii) the period of constant velocity of 2.00 m s^{-1}.

tension = ... N [1]

(c) During the final deceleration the tension in the cable is 1240N. Calculate this deceleration.

For Examiner's Use

deceleration = ... $m s^{-2}$ [2]

(d) **(i)** Calculate the time over which the man and child are

1. moving with uniform acceleration,

time = ... s [1]

2. moving with uniform deceleration.

time = ... s [1]

(ii) The time over which the man and child are moving with constant velocity is 20s. On Fig. 3.2, sketch a graph to show the variation with time of the velocity of the man and child for the complete lifting process.

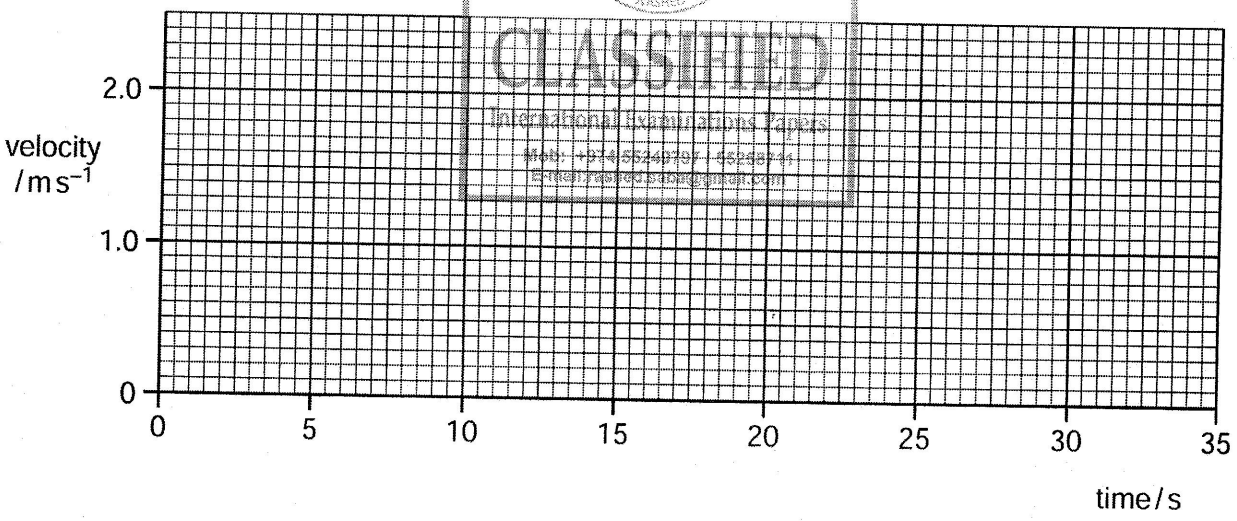


Fig. 3.2

[2]

2 A sky-diver jumps from a high-altitude balloon.

For Examiner's Use

(a) Explain briefly why the acceleration of the sky-diver

(i) decreases with time,

.....

.....

..... [2]

(ii) is $9.8\,m\,s^{-2}$ at the start of the jump.

.....

..... [1]

(b) The variation with time t of the vertical speed v of the sky-diver is shown in Fig. 2.1.

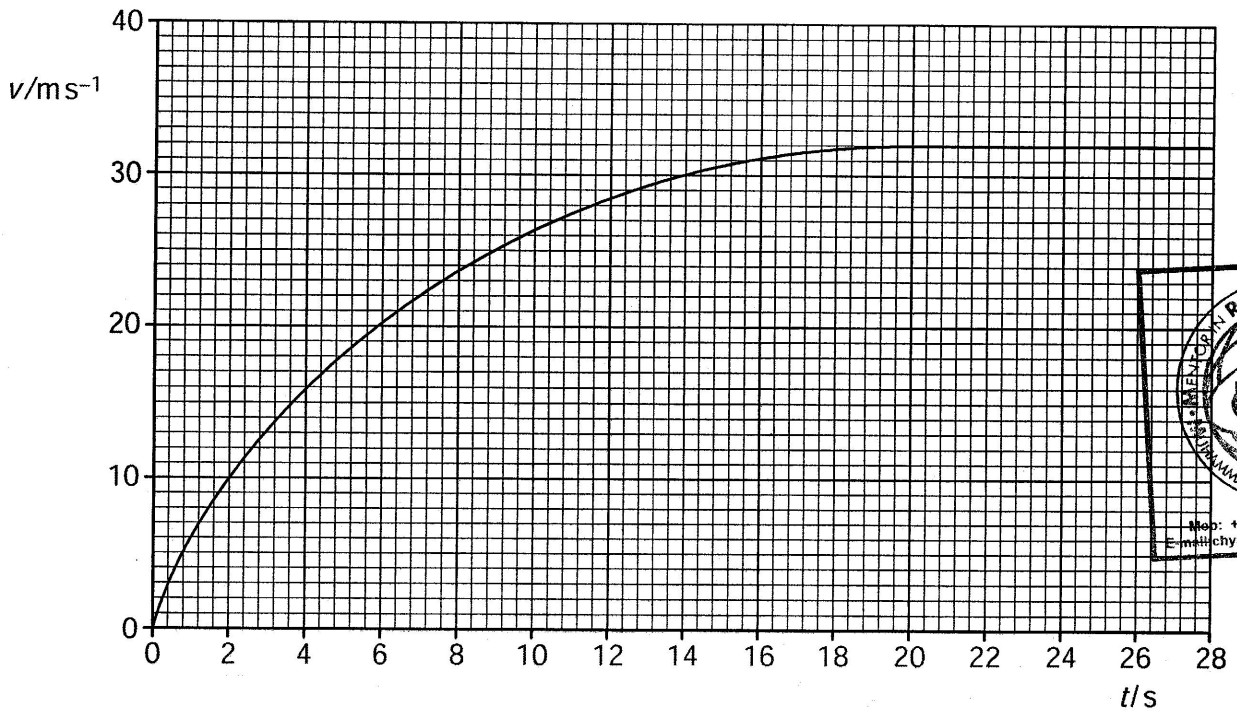


Fig. 2.1

Use Fig. 2.1 to determine the magnitude of the acceleration of the sky-diver at time $t = 6.0\,s$.

For Examiner's Use

acceleration = ... $m\,s^{-2}$ [3]

(c) The sky-diver and his equipment have a total mass of 90 kg.

(i) Calculate, for the sky-diver and his equipment,

1. the total weight,

weight = ... N [1]

2. the accelerating force at time $t = 6.0\,s$.

force = ... N [1]

(ii) Use your answers in **(i)** to determine the total resistive force acting on the sky-diver at time $t = 6.0\,s$.

force = ... N [1]