Percentage	
Grade	

TUTOR ZONE

YOUR STEP TO SUCCESS

A Level Physics

Forces

Duration: 1 hour

Total Marks: 54

Information for Candidates:

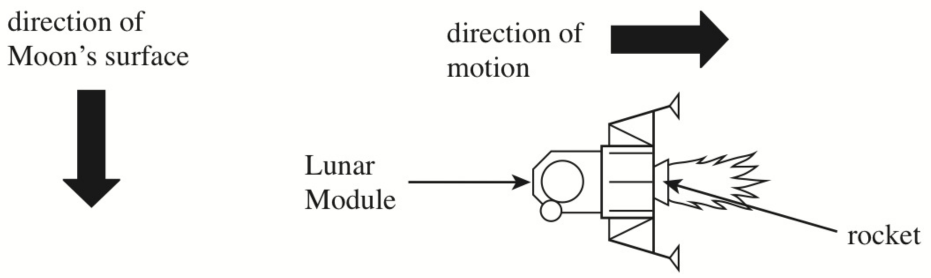
- Use black or blue ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answer to each question in the space provided. If additional paper is used, the question number(s) must be clearly shown
- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- You may use an electronic calculator.
- You are advised to show all the steps in any calculations.

Do not write in this table	
Question	Mark
TOTAL	

box

5 In the 1969 Moon landing, the Lunar Module separated from the Command Module above the surface of the Moon when it was travelling at a horizontal speed of $2040\,ms^{-1}$. In order to descend to the Moon's surface the Lunar Module needed to reduce its speed using its rocket as shown in **Figure 5**.

Figure 5



5 (a) (i) The average thrust from the rocket was 30 kN and the mass of the Lunar Module was 15100 kg. Calculate the horizontal deceleration of the Lunar Module.

answer = ... $m\,s^{-2}$
(2 marks)

5 (a) (ii) Calculate the time for the Lunar Module to slow to the required horizontal velocity of $150\,m\,s^{-1}$. Assume the mass remained constant.

answer = ... s
(2 marks)

5 (b) The rocket was then used to control the velocity of descent so that the Lunar Module descended vertically with a constant velocity as shown in **Figure 6**. Due to the use of fuel during the previous deceleration, the mass of the Lunar Module had fallen by 53%.

Figure 6

acceleration due to gravity near the Moon's surface = $1.61\,\mathrm{m\,s^{-2}}$

5 (b) (i) Draw force vectors on **Figure 6** to show the forces acting on the Lunar Module at this time. Label the vectors.

(2 marks)

5 (b) (ii) Calculate the thrust force needed to maintain a constant vertical downwards velocity.

answer = ... N

(2 marks)

5 (c) When the Lunar Module was 1.2 m from the lunar surface, the rocket was switched off. At this point the vertical velocity was $0.80\,\mathrm{m\,s^{-1}}$. Calculate the vertical velocity at which the Lunar Module reached the lunar surface.

answer = ... $\mathrm{m\,s^{-1}}$

(2 marks)

Turn over for the next question

10

3 **(a)** Define the *newton*.

....

.... **[1]**

(b) State why the equation '$F = ma$' cannot be applied to particles travelling at speeds very close to the speed of light.

....

.... **[1]**

(c) Fig. 3.1 shows the horizontal forces acting on a car of mass 900 kg when it is travelling at a particular velocity on a level-road.

Fig. 3.1

The total forward force between the tyres and the road is 200 N and the air resistance (drag) is 80 N.

(i) Calculate the acceleration of the car.

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

(ii) Explain why we cannot use the equation $v = u + at$ to predict the velocity of the car at a later time even when the forward force is constant.

....

.... **[1]**

(d) Fig. 3.2 shows a person being lifted vertically upwards by a rope.

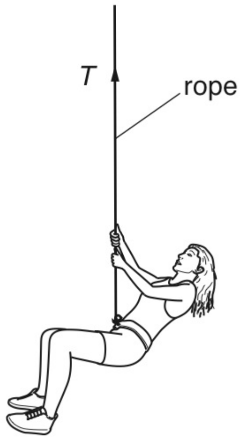


Fig. 3.2

The mass of the person is 72 kg. The upward vertical acceleration of the person is 1.4 m s^{-2}.
Calculate the tension T in the rope.

T = ... N **[3]**

[Total: 8]

4 **(a)** An electron in a particle accelerator experiences a constant force. According to one student, the acceleration of the electron should remain constant because the ratio of force to mass does not change. In reality, experiments show that the acceleration of the electron decreases as its velocity increases. Describe what can be deduced from such experiments about the nature of accelerated electrons.

....

....

....

.... **[2]**

(b) Fig. 4.1 shows the velocity vector for a particle moving at an angle of 31° to the horizontal.

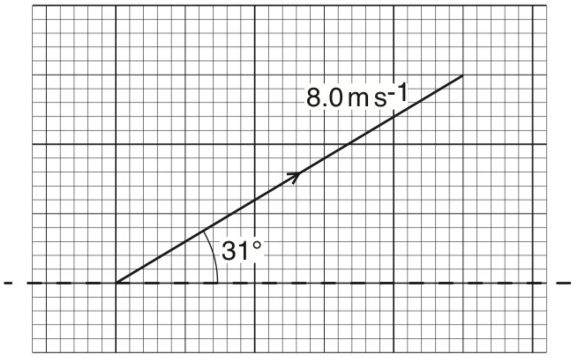


Fig. 4.1

(i) On Fig. 4.1, show the horizontal (*x*-direction) and vertical (*y*-direction) components of the velocity. **[2]**

(ii) Calculate the horizontal (*x*-direction) component of the velocity.

velocity = ... $m\,s^{-1}$ **[1]**

(c) Fig. 4.2 shows a ship **S** being pulled by two tug-boats.

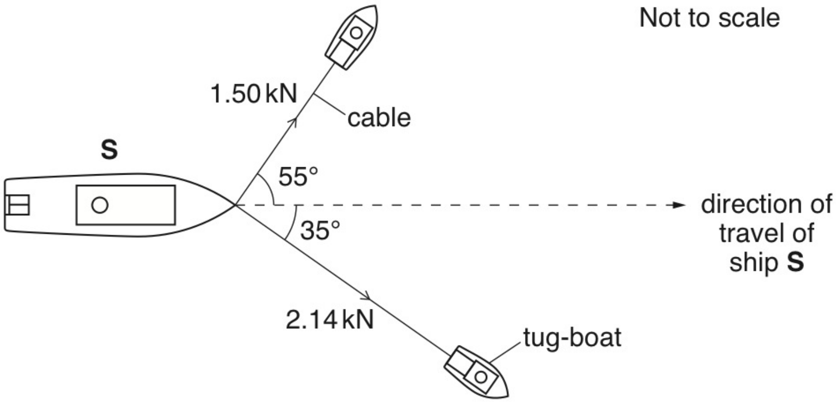


Fig. 4.2

The ship is travelling at a constant velocity. The tensions in the cables and the angles made by these cables to the direction in which the ship travels are shown in Fig. 4.2.

(i) Draw a vector triangle and determine the resultant force provided by the two cables.

resultant force = ... kN **[3]**

(ii) State the value of the drag force acting on the ship **S**. Explain your answer.

....

....

.... **[2]**

[Total: 10]

Answer **all** the questions.

1 **(a)** Complete the table of Fig. 1.1 by stating the value or name of each of the remaining three prefixes.

prefix	value
micro (μ)	10^{-6}
mega (M)	
	10^{-9}
tera (T)	

Fig. 1.1

[3]

(b) Circle all the scalar quantities in the list below.

density **weight** **velocity** **volume** **acceleration**

[1]

(c) The distance between the Sun and the Earth is 1.5×10^{11} m. Calculate the time in minutes for light to travel from the Sun to the Earth. The speed of light is $3.0 \times 10^{8}\,\mathrm{m\,s^{-1}}$.

time = ... min **[2]**

(d) The terminal velocity of a raindrop falling vertically through air is $4.0\,\text{m s}^{-1}$.

(i) In terms of the forces acting on the raindrop, explain why it is at terminal velocity.

....

....

.... **[2]**

(ii) Fig. 1.2 shows a velocity vector diagram for the falling raindrop in a horizontal crosswind of speed $1.5\,\text{m s}^{-1}$.

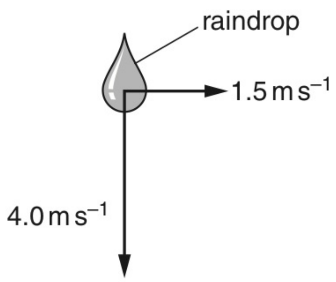


Fig. 1.2

1 On Fig. 1.2, draw an arrow on the raindrop to show the **direction** in which it will travel.

2 Calculate the magnitude of the resultant velocity of the raindrop. Use the space below for your working.

resultant velocity = ... m s^{-1} **[3]**

[Total: 11]

3 **(a)** Define the *newton*.

....

.... **[1]**

(b) Fig. 3.1 shows a spaceship on the surface of the Earth.

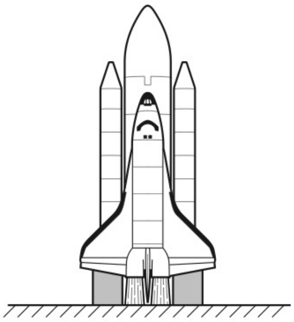


Fig. 3.1

The mass of the spaceship is 1.9×10^6 kg. During lift off, the spaceship rockets produce a vertical upward force of 3.1×10^7 N.

(i) Calculate the weight of the spaceship.

weight = ... N **[1]**

(ii) Calculate the initial vertical acceleration as the spaceship lifts off.

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

(iii) The vertical upward force on the spaceship stays constant. Explain why the acceleration of the spaceship increases after lift off.

....

....

....

.... **[1]**

[Total: 5]

4 **(a)** State two factors that affect the magnitude of the drag force acting on an object falling through air.

1. ....

2. .... **[2]**

(b) Fig. 4.1 shows a skydiver of total mass 75 kg falling vertically towards the ground.

Fig. 4.1

The air resistance, or drag force, D in newtons (N) acting on the skydiver falling through the air is given by the equation

$$D = 0.3v^2$$

where v is the speed in $\mathrm{m\,s^{-1}}$ of the skydiver.

(i) On Fig. 4.1, draw arrows to represent the weight (labelled W) and drag force (labelled D). **[1]**

(ii) Calculate the weight of the skydiver.

weight = ... N **[1]**

(iii) At a particular instant, the speed of the skydiver is $20\,m\,s^{-1}$. Calculate the instantaneous acceleration of the skydiver.

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

(iv) State the relationship between the forces *W* and *D* when the skydiver reaches terminal velocity.

....

.... **[1]**

(v) Determine the terminal velocity of the skydiver.

terminal velocity = ... $m\,s^{-1}$ **[2]**

[Total: 10]