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Level 1 Science 2020

90940 Demonstrate understanding of aspects of mechanics

9.30 a.m. Friday 27 November 2020
Credits: Four

Achievement	Achievement with Merit	Achievement with Excellence
Demonstrate understanding of aspects of mechanics.	Demonstrate in-depth understanding of aspects of mechanics.	Demonstrate comprehensive understanding of aspects of mechanics.

Check that the National Student Number (NSN) on your admission slip is the same as the number at the top of this page.

You should attempt ALL the questions in this booklet.

If you need more room for any answer, use the extra space provided at the back of this booklet and clearly number the question.

Check that this booklet has pages 2–12 in the correct order and that none of these pages is blank.

YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

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You may find the following formulae useful.

$$v = \frac{\Delta d}{\Delta t} \qquad a = \frac{\Delta v}{\Delta t} \qquad F_{\text{net}} = ma \qquad P = \frac{F}{A} \qquad \Delta E_{\text{p}} = mg\Delta h$$

$$E_{\text{k}} = \frac{1}{2}mv^2 \qquad W = Fd \qquad g = 10\ \text{N kg}^{-1} \qquad P = \frac{W}{t}$$

QUESTION ONE

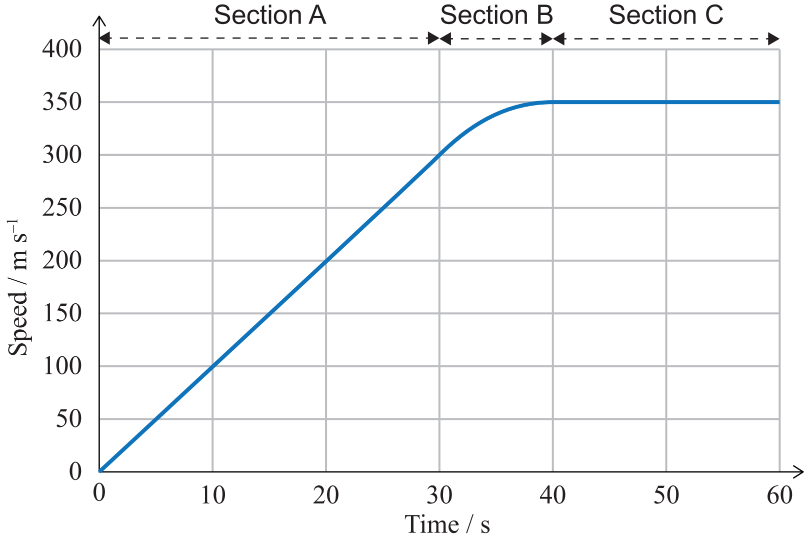
Felix Baumgartner is famous for jumping from a height of 40 km above the Earth.

He fell for over 240 seconds before opening his parachute.

https://cdn.mos.cms.futurecdn.net/9rhbQE95MYfAyRE3YhypCX-1024-80.jpg

Below is a graph of his speed vs time for the first 60 seconds of his jump.

Speed vs time graph for Felix's fall



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(a) Describe Felix's motion in Sections A and C of this graph.

Section A: ______________________________

Section C: ______________________________

(b) State the maximum speed reached by Felix.

______________ m s^{-1}

(c) Use the graph to calculate Felix's acceleration in the first 30 seconds.

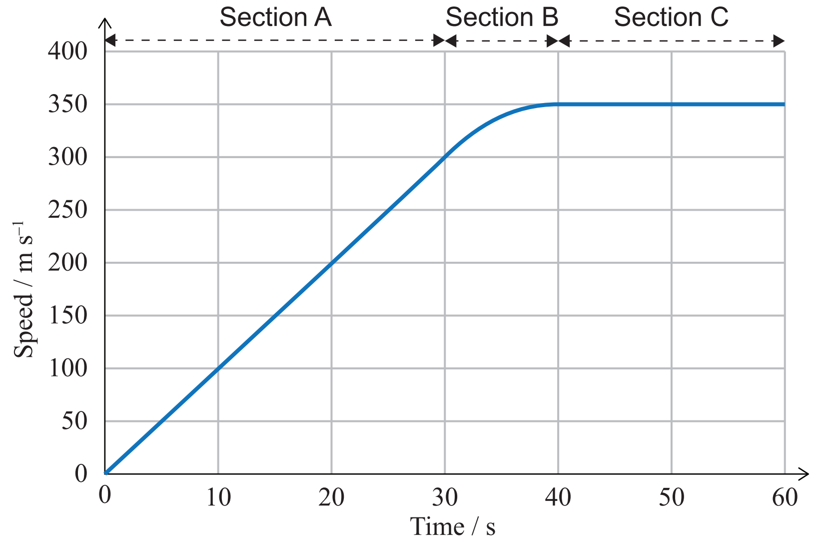
______________ m s^{-2}

(d) Use the graph to calculate how far Felix fell in the first 30 seconds.

______________ m

The graph below is repeated from page 2.

Speed vs time graph for Felix's fall



(e) (i) Draw and label arrows on the diagrams below to show the size and direction of the vertical forces acting on Felix in **Section A** and **Section C** of the graph.

Section A **Section C**

https://o.aolcdn.com/images/dims?quality=85&image_uri=http%3A%2F%2Fwww.blogcdn.com%2Fwww.engadget.com%2Fmedia%2F2012%2F10%2Fstratosfeathedjt1.jpg&client=amp-blogside-v2&signature=2ef362f5e712a85af9aea67599d2991003b162bf

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(ii) Explain the motion in **Section A** and **Section C** by comparing the **vertical forces** acting on Felix.

QUESTION TWO

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Each year firefighters run up the Sky Tower.

Lynley is preparing for this event by running up the stairs in her building.

Each day she climbs to a height of 25 m. Below is data from two of these days.

	Day 1	Day 2
Mass of Lynley and equipment (kg)	80	80
Height (m)	25	25
Time (s) to climb 25 m	50	30

https://therecord.co.nz/2018/05/09/firefighters-challenge/

(a) Compare the **work done** and **power** produced by Lynley on each of these days.

In your answer you should:

- calculate the work done on each day
- calculate the power used on each day.

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(b) Lynley looks into the stairwell and her helmet falls off. The helmet falls between the stairs without touching them.

http://stairstar.ca/the-6-most-common-questions-asked-about-circular-stairs/

She estimates that the helmet would hit the ground at 20 m s^{-1}.

Using conservation of energy, and assuming no other external factors, calculate the height from which the helmet fell.

The mass of the helmet is 1.5 kg.

In your answer you should:

- calculate the kinetic energy of the helmet just before it hits the ground
- describe from which form this kinetic energy has transformed.

(c) Explain why the helmet will not reach a speed of 20 m s^{-1}.

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QUESTION THREE

NASA has revealed a possible vehicle to travel over the Martian surface. Mars is a very dusty planet with much lower gravity than ours. Gravity on Mars is 3.7 N kg^{-1}; on Earth it is 10 N kg^{-1}.

https://boygeniusreport.files.wordpress.com/2017/06/rover.jpg?quality=98&strip=all&w=1564

(a) Define mass and weight.

(b) Explain what 10 N kg^{-1} means.

Question Three continues on the following page.

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(c) Calculate the weight force of the Mars vehicle when it is on Earth and when it is on Mars. The mass of the Mars vehicle is 2500 kg.

(i) Weight of vehicle on Earth, where $g = 10$ N kg^{-1}.

(ii) Weight of vehicle on Mars, where $g = 3.7$ N kg^{-1}.

(d) There are 6 wheels on this vehicle, with a surface area of 0.25 m^2 **per wheel**.

Calculate the total pressure that this vehicle would exert **on Earth.**

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(e) The Mars vehicle is placed on **similar soils** on Earth and on Mars.

Explain why the Mars vehicle will sink to different depths on each planet.

You should support your answer with a calculation.

Extra paper if required.
Write the question number(s) if applicable.

QUESTION NUMBER

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