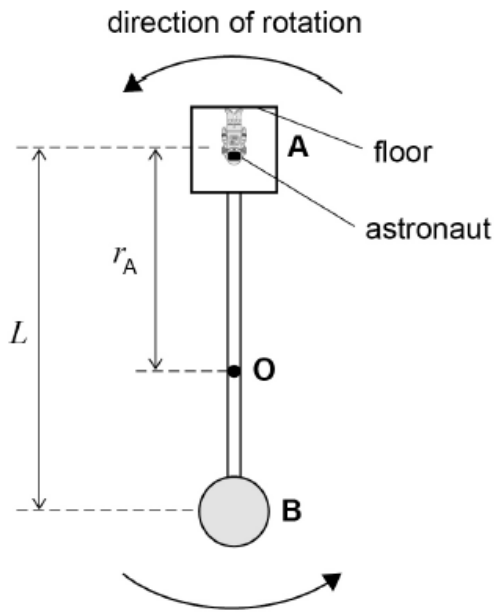
AQA – Periodic motion – A2 Physics P1

1. June/2021/Paper_7408_1/No.04

0 4 **Figure 6** shows a rotating spacecraft that is proposed to carry astronauts to Mars.

Figure 6



The spacecraft consists of two parts **A** and **B** connected by a rigid cylindrical rod. When the spacecraft is travelling, **A** and **B** rotate at a constant angular speed about their common centre of mass **O**.

L is the distance between the centre of mass of **A** and the centre of mass of **B**.
r_A is the distance from **O** to the centre of mass of **A**.

0 4 . 1 As the spacecraft rotates, a force that imitates the effect of gravity acts on an astronaut who is in contact with the floor.

Explain why.

[2 marks]

0 4 . 2 The forces exerted on **A** and **B** by the connecting rod have the same magnitude.

m_A is the mass of **A**
m_B is the mass of **B**

Show, by considering the centripetal forces acting on **A** and **B**, that r_A is given by

$$r_A = \frac{m_B L}{m_A + m_B}$$

[2 marks]

0 4 . 3 In this spacecraft $m_A < m_B$.

Deduce whether the centre of mass of **A** or the centre of mass of **B** rotates with a greater linear speed.

[2 marks]

The astronauts live in **A** and the cargo is stored in **B**.

When loaded,

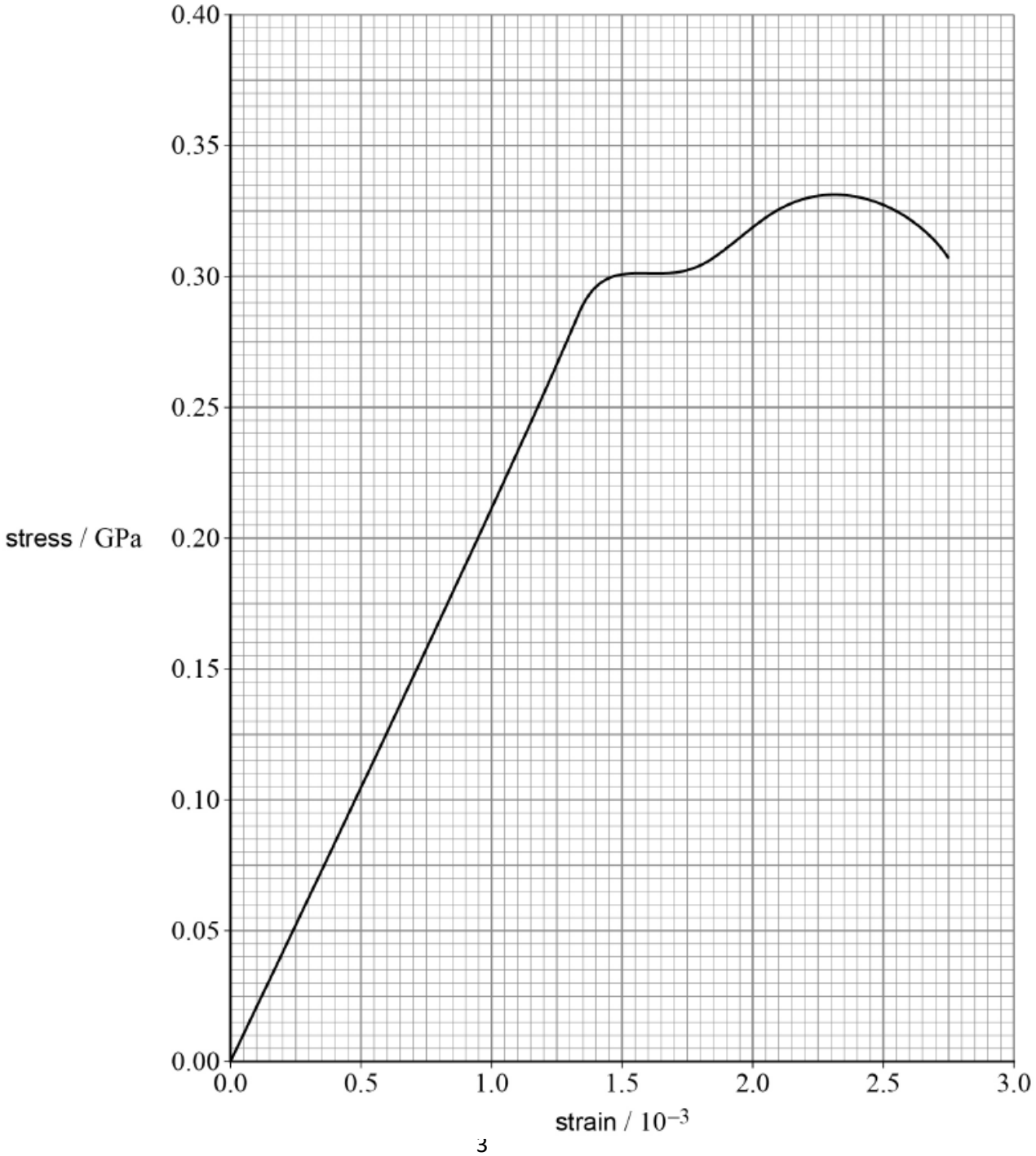
$$m_A = 1.32 \times 10^6 \text{ kg}$$

$$m_B = 3.30 \times 10^6 \text{ kg}.$$

The spacecraft imitates the gravity of Mars where $g = 3.7 \text{ m s}^{-2}$.

Figure 7 shows a stress–strain curve for the metal used for the rigid rod.

Figure 7



0 4 . 4 Suggest a suitable diameter for the rod.
Justify your answer.

[5 marks]

diameter = _____ m

2. June/2021/Paper_7408_1/No.30

A simple pendulum and a mass–spring system each have a time period T on the Earth.

They are taken to the surface of a planet where the acceleration due to gravity is $\frac{g}{4}$.

What are the time periods of the pendulum and the mass–spring system on this planet?

[1 mark

	Simple pendulum	Mass–spring system	
A	$\frac{T}{2}$	T	⬭
B	$2T$	T	⬭
C	$\frac{T}{2}$	$2T$	⬭
D	$2T$	$2T$	⬭

3. June/2021/Paper_7408_1/No.31

A particle of mass m is oscillating with simple harmonic motion.
The period of the oscillation is T and the amplitude is A.

What is the maximum kinetic energy of the particle?

[1 mark]

A $\frac{mA^2}{2T^2}$ ⬭

B $\frac{\pi^2 mA^2}{2T^2}$ ⬭

C $\frac{2mA^2}{T^2}$ ⬭

D $\frac{2\pi^2 mA^2}{T^2}$ ⬭

4. June/2020/Paper_7408_1/No.04.5

0 4 . 5 At bends on motorways the road is sloped so that a car is less likely to slide out of its lane when travelling at a high speed.

Figure 7 shows a car of mass 1200 kg travelling around a curve of radius 200 m. The motorway is sloped at an angle of 5.0°.

Figure 8 shows the weight W and reaction force N acting on the car. The advisory speed for the bend is chosen so that the friction force down the slope is zero.

Figure 7

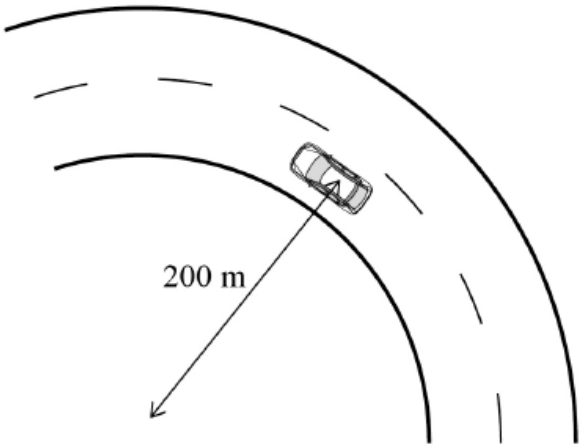
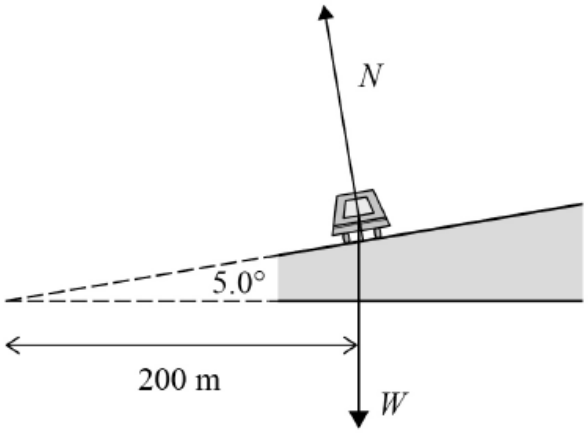


Figure 8



Suggest an appropriate advisory speed for this section of the motorway.

[4 marks

advisory speed = _____ $m\ s^{-1}$

5. June/2020/Paper_7408_1/No.24

A particle of mass m undergoes simple harmonic motion with amplitude A and frequency f.

What is the total energy of the particle?

[1 mark]

A $2\pi mfA^2$ ⬭

B $2\pi^2 mf^2A^2$ ⬭

C $4\pi^2 m^2f^2A$ ⬭

D $4\pi^2 mf^2A^2$ ⬭

6. June/2020/Paper_7408_1/No.25

A mass of $0.90\ \text{kg}$ is suspended from the lower end of a light spring of stiffness $80\ \text{N m}^{-1}$.

When the mass is displaced vertically and released, it undergoes vertical oscillations of small amplitude.

What is the frequency of the oscillations?

[1 mark]

A $0.071\ \text{Hz}$ ⬭

B $0.67\ \text{Hz}$ ⬭

C $1.50\ \text{Hz}$ ⬭

D $14\ \text{Hz}$ ⬭

7. June/2020/Paper_7408_1/No.30

The period of a simple pendulum is doubled when the pendulum length is increased by 1.8 m.

What is the original length of the pendulum?

[1 mark]

A 0.45 m ⬭

B 0.60 m ⬭

C 0.90 m ⬭

D 3.6 m ⬭