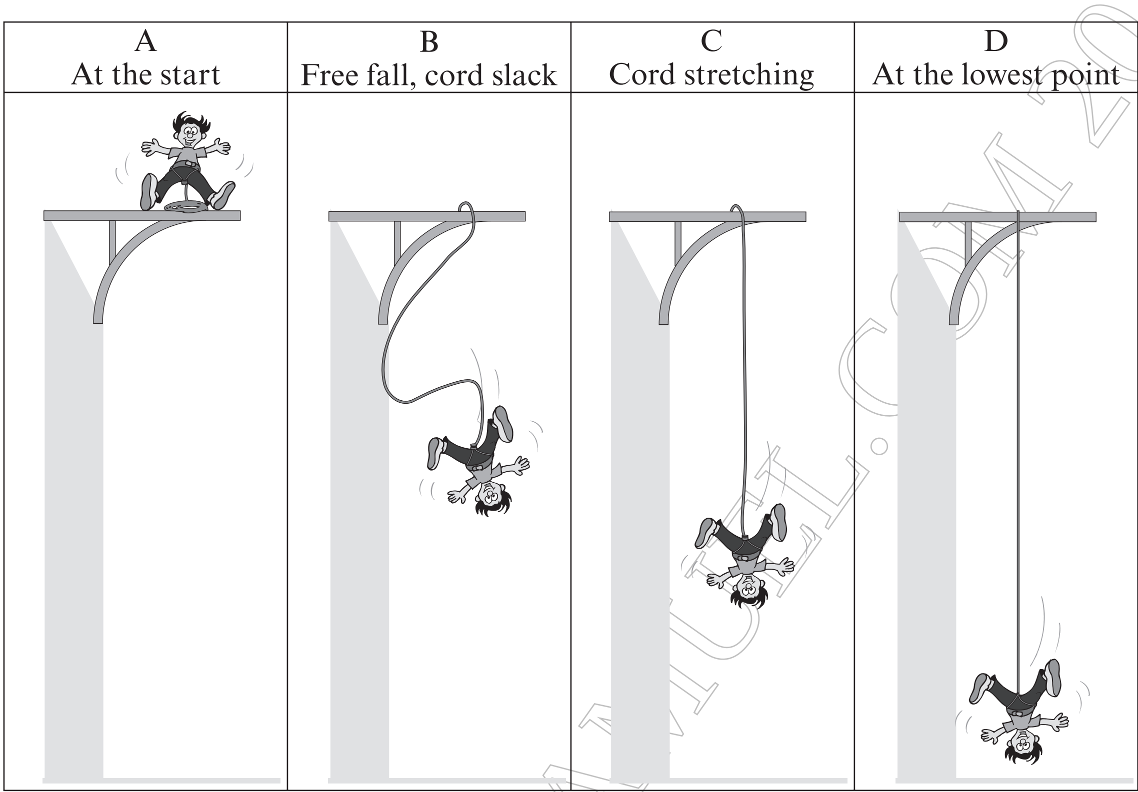
Examiner only

4. *(a)* By referring to the diagrams, discuss some of the energy changes involved in a bungee jump. You should make reference to *gravitational potential energy*, *kinetic energy* and *elastic potential energy* in your answer. [5]



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(b) A bungee jumper of mass 70 kg jumps from a high bridge using a bungee cord of natural length 80 m. When he reaches the lowest point for the first time the length of the cord is 130 m. Calculate

(i) the loss of gravitational potential energy from his position on the bridge to the lowest point for the first time, [2]

(ii) the stiffness constant *(k)* of the bungee cord assuming the cord obeys Hooke's law and that there are no losses due to air resistance, [3]

(iii) the extension of the cord when he finally comes to rest (after having 'bounced' a few times). [2]

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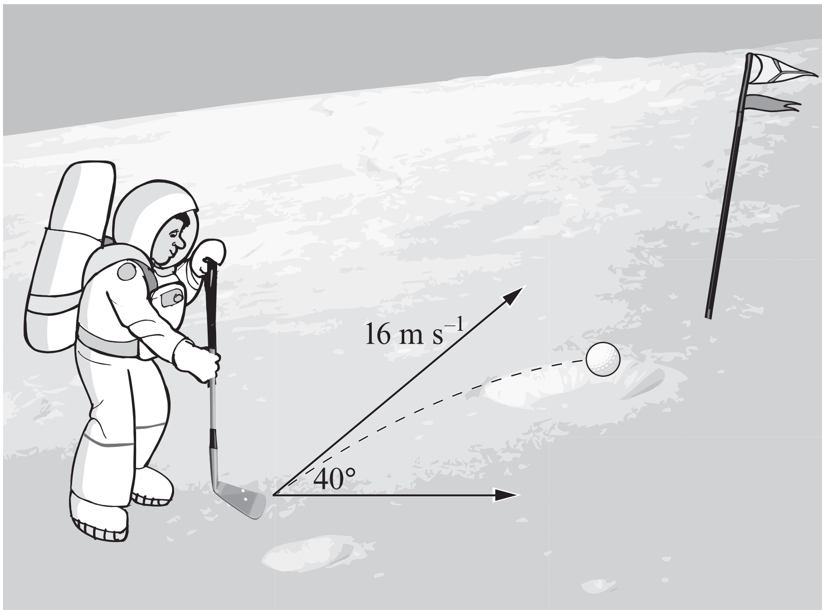
5. The astronauts of Apollo 14 played golf on the Moon. They struck a number of shots such as the one shown below.



(a) (i) Calculate the horizontal and vertical components of velocity of the golf ball at the instant it was struck. [2]

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(ii) Describe the essential difference between the horizontal and vertical components of velocity during the flight of the ball. [1]

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Examiner only

(b) The acceleration due to gravity on the Moon is $1.6\,m\,s^{-2}$. Assuming the shot is played on horizontal ground, calculate

(i) the total time of flight, [3]

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(ii) the horizontal distance the ball travels, [1]

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(iii) the maximum height reached. [2]

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(c) A similar golf shot is played on Earth. Give two reasons why your answer to *(b)*(iii) would be different. [2]

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2. ....

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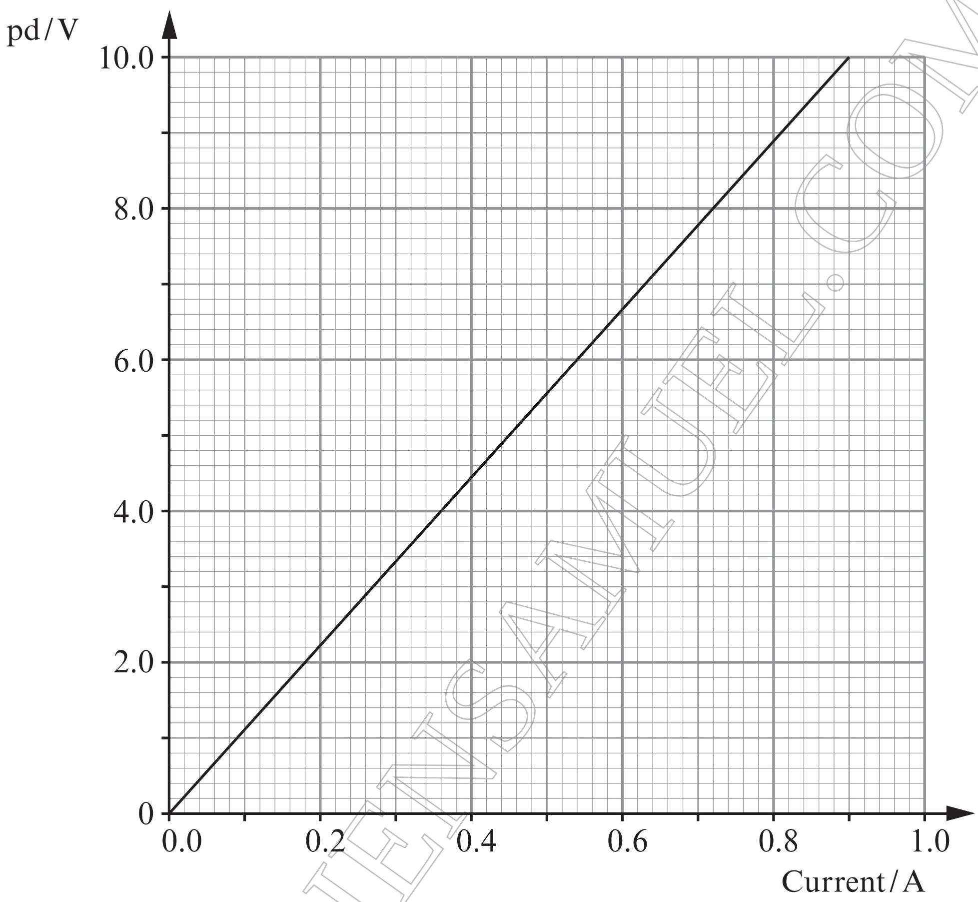
6. Experiments are carried out to determine the material from which a metal wire is made. Initially the resistivity of the metal is found. The wire's density is then determined and the results compared with known values of resistivity and density.

(a) As a first step to finding the resistivity, an experiment investigates the relationship between pd and current for the wire. The results are shown in the graph.



(i) Draw a circuit diagram to show how the above results could be obtained. The apparatus available includes a battery, a switch, a variable resistor, an ammeter and a voltmeter. [2]

7. The force due to air resistance F_{air} exerted on a skydiver due to her motion through the air is given by

$$F_{air} = \frac{\rho D v^2}{2}$$

where ρ is the density of air, v is the speed of the skydiver and D is a constant called the drag factor.

(a) Show that the SI unit of D is **metre^2**. [4]

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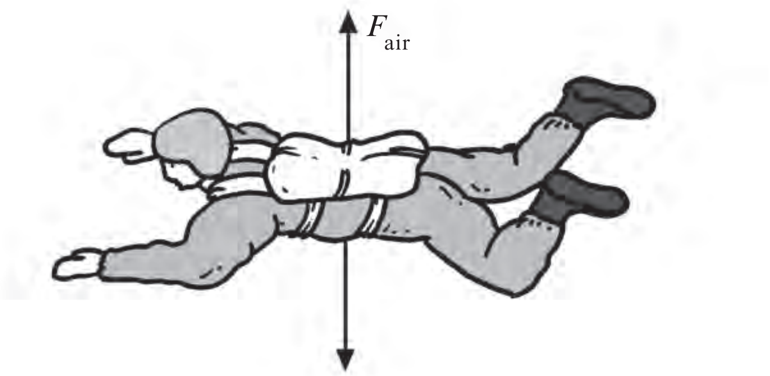
(b) The diagram shows two of the main forces acting on the skydiver during her descent.



(i) Newton's third law concerns pairs of forces. State the law. [1]

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(ii) Give **one** reason why the forces in the diagram are **not** a pair of Newton 3rd law forces. [1]

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(c) The table gives data for the first 16.0 seconds of the jump.

Time / s	0.0	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0
Acceleration / m s^{-2}	9.8	8.8	6.6	4.3	2.5	1.4	0.8	0.4	0.2

(i) The mass of the skydiver is 60 kg. Calculate her weight. [1]

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(ii) Using your answer to *(c)*(i) and the information in the table, calculate the force due to air resistance acting on the skydiver at t = 10.0 s. [3]

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(d) (i) Draw a graph of acceleration (y-axis) against time (x-axis) for the skydiver. [3]

Examiner only

(ii) Use your graph to estimate the velocity of the skydiver at t = 10.0 s. [2]

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(iii) Using your answers to *(c)*(ii), *(d)*(ii) and the equation given at the start of the question, calculate a value for the drag factor, D. Assume $\rho = 1.2\,\text{kg m}^{-3}$ [2]

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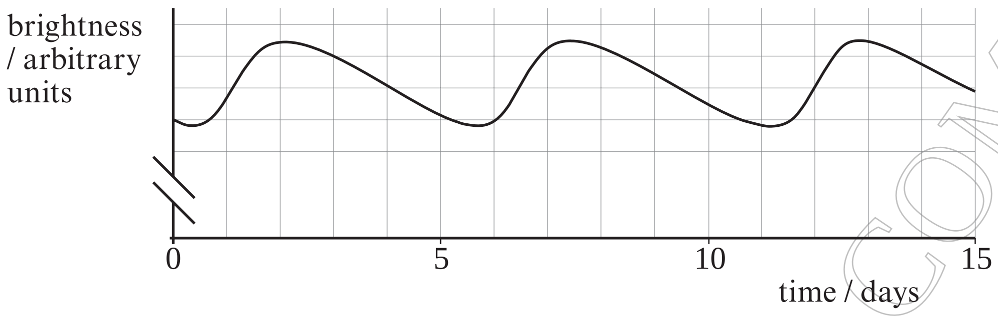
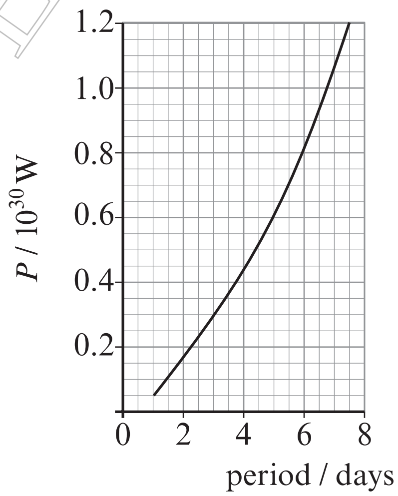
THERE ARE NO MORE QUESTIONS IN THE EXAMINATION.

Examiner only

8. *Cepheid variables* are stars whose brightness varies in a characteristic, regular way. The variation is shown below for one such star.



The mean power, P, emitted as electromagnetic radiation from a Cepheid variable is related to the period of its brightness variation, as shown alongside.



(a) (i) Use the graphs to determine P for the star, showing briefly how you obtained your answer. [2]

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(ii) The mean *intensity* of the radiation from the star, as measured at the Earth is 8.0×10^{-13} W m^{-2}. Using your answer to *(a)*(i), calculate the distance, r, between the star and the Earth. [2]

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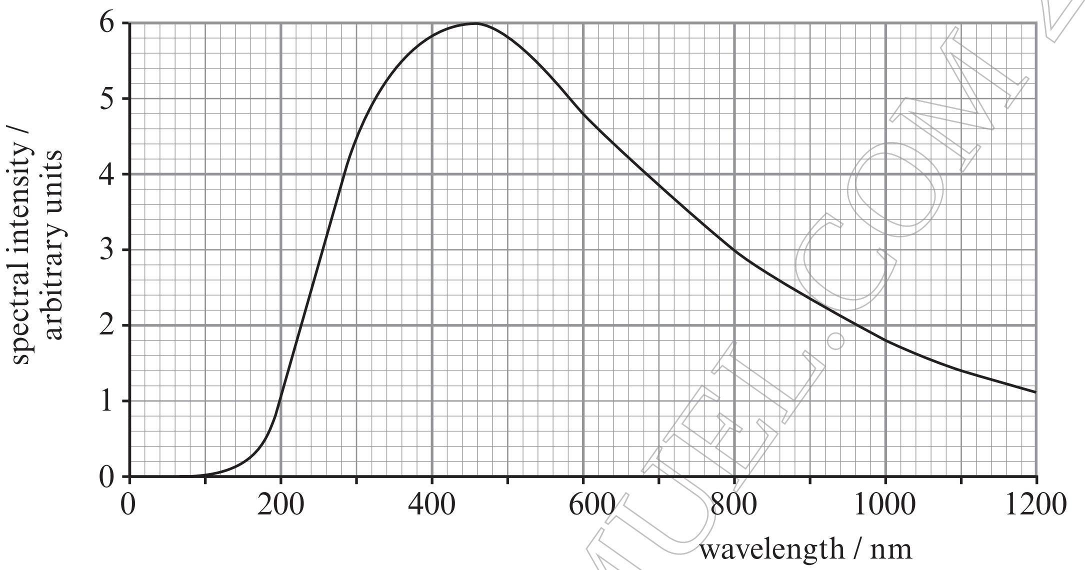
(b) The maximum power emitted by the star during its cycle of variation is estimated to be 9.5×10^{29} W, and the spectrum of its radiation corresponding to this point in its cycle is given below.



(i) Use Wien's law to calculate the temperature of the star. [2]

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(ii) Calculate the **diameter** of the star. [4]

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Examiner only

9. *(a)* An electron and a positron can annihilate (destroy) each other, in this interaction:

$$e^{-} + e^{+} \longrightarrow \gamma + \gamma$$

(i) Explain how *lepton number* is conserved in this interaction. [2]

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(ii) State which force (strong, weak or electromagnetic) is involved in this interaction, giving a reason for your answer. [1]

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(b) A proton and an antiproton can annihilate each other, in this **strong** interaction:

$$p + \bar{p} \longrightarrow \pi^{+} + x$$

By applying conservation rules, suggest the identity of particle x. [2]

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(c) The π^{+} is unstable. It can decay, thus:

$$\pi^{+} \longrightarrow y + \nu_{e}$$

(i) Identify y. [1]

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(ii) Which force is involved? [1]

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(d) Show below, as an equation, how the π^{-} might decay. [1]

$$\ldots\ldots\ldots \longrightarrow \ldots\ldots\ldots + \ldots\ldots\ldots$$

THERE ARE NO MORE QUESTIONS IN THE EXAMINATION.

SOLIDS UNDER STRESS

a) Why is it useful to know the Youngs Modulus of a material? Give an example. [5]

b) Describe some differences between crystalline, amorphous and polymeric.
Give examples of each. [6]

RADIATION FROM STARS

Radiation from a distant star can be intercepted by a gas/dust cloud. What happens to this light and how might it appear in the light we observe?
What can we learn from such light? [8]