Examiner only

4. *(a)* (i) Define *mean speed*. [1]

....

(ii) The distance between two towns, A and B, is 240km. A motorcycle travels from A to B at a mean speed of 80km/h and then back from B to A at a mean speed of 60km/h. Calculate the mean speed for the whole journey. [3]

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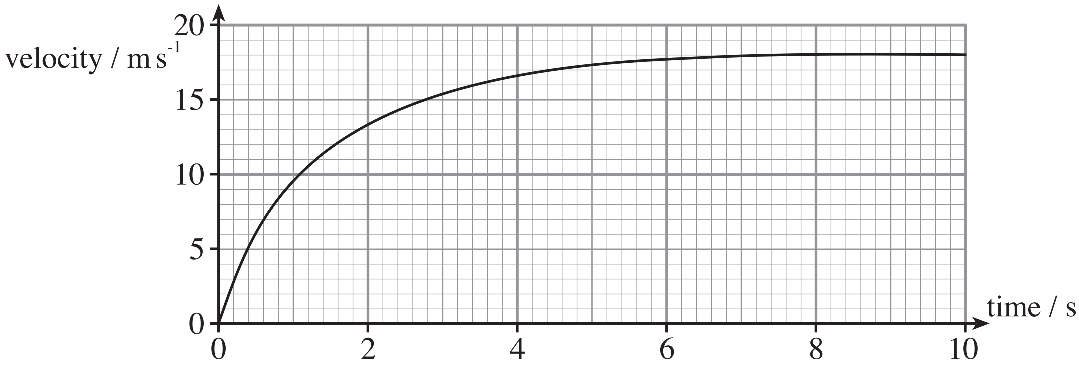
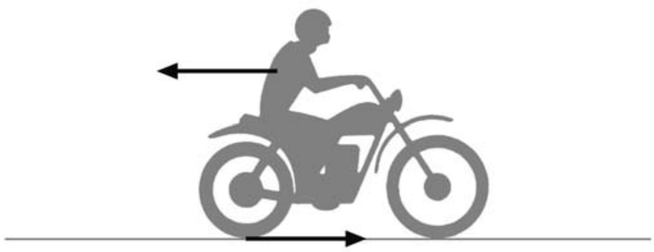
(b) The graph represents the motion of the motorcycle over a 10s period.



(i) Label the forces represented by arrows on the diagram below. [1]



(ii) Describe, without calculation, how the **resultant force** acting on the motorcycle varies over this 10 second interval. [3]

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(iii) By drawing a suitable tangent, determine the resultant force acting on the motorcycle at t = 2.0 s. The mass of the motorcycle and rider is 350kg. [3]

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Examiner only

(c) (i) Define *work done*. [2]

(ii) A force F acts on a body moving with a velocity v. F and v are in the same direction. Starting from the definition of power, show that [2]

$$\text{Power} = Fv$$

(iii) When the motorcycle in part *(b)* is travelling at the steady velocity shown in the graph, the useful power output by the engine is 40 kW. Calculate the **driving force** required to maintain this velocity. [1]

(iv) Assuming this driving force remains constant throughout the motion, calculate the resistive force acting on the motorcycle at $t = 2.0$ s. [1]

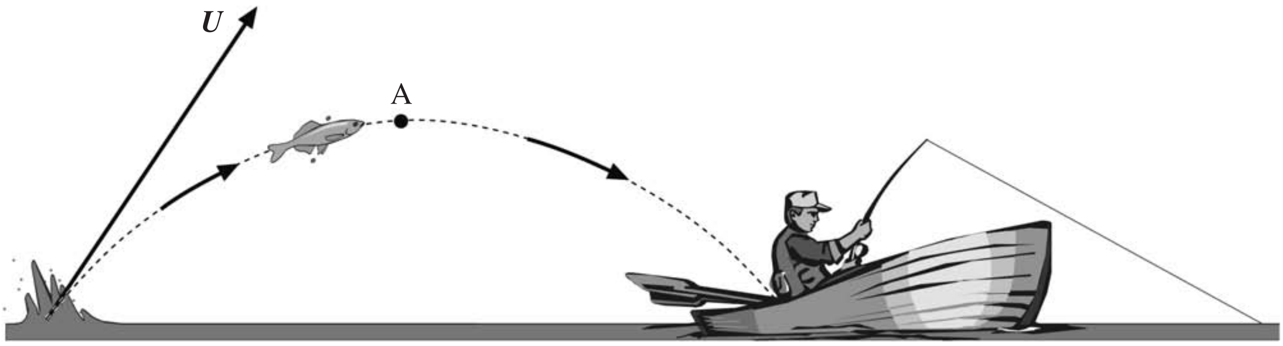
(d) At a later time the motorcycle brakes until it stops. When this happens, brake pads are forced into contact with the wheel discs.

(i) State the Principle of Conservation of Energy. [1]

(ii) Explain what happens to the motorcycle's kinetic energy. [2]

Examiner only

6. The Silver Carp is a fish which was accidentally introduced to the Mississippi river in the 1990s. It has since bred to such an extent that the river has become overpopulated with them. Many are seen to jump out of the water and they sometimes land in the boats of fishermen.
[Ignore air resistance throughout this question].



(a) The trajectory (flight path) of a Silver Carp is shown. Point **A** represents the highest point on the trajectory. Draw arrows at **A** to show

(i) the direction of motion of the Carp at this instant. (Label this arrow **D**);

(ii) the force (or forces) acting on the Carp at this instant. (Label this/these arrow(s) **F**). [2]

(b) A fisherman wishes to determine the velocity with which a Carp left the water (shown by the vector labelled ***U***). The fisherman makes the following estimations:

Horizontal distance travelled by the Carp = 4.50 m
Time of flight = 1.50 s
Maximum height = 2.75 m

Use this information to calculate:

(i) the horizontal component of the velocity of the Carp; [1]

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....

(ii) the initial vertical velocity of the Carp; [3]

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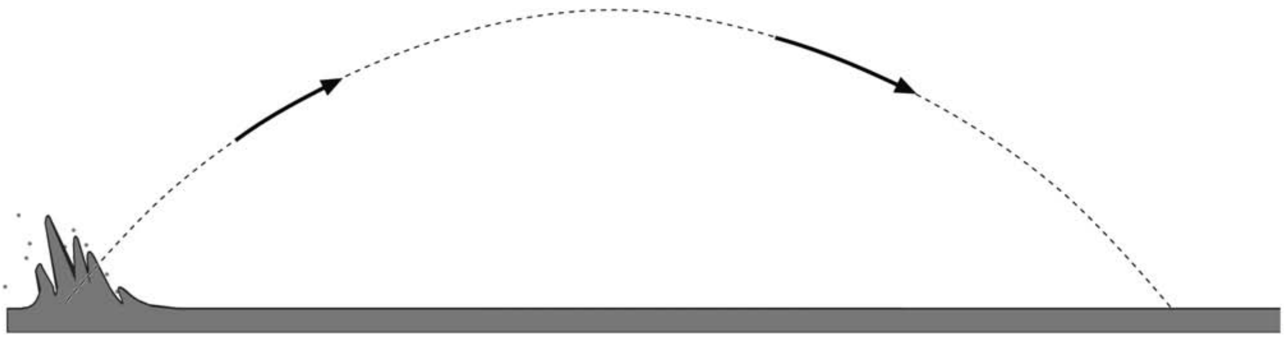
Examiner only

(iii) the magnitude of the velocity (***U***) with which the Carp left the water. [2]

(c) Your answer to *(b)* (iii) can be checked by considering the energy changes that take place during the Carp's flight.

(i) Calculate the **total** energy possessed by the Carp at point **A**. [Assume the Carp has mass 6.0 kg] [3]

(ii) Below is a sketch of the Carp's trajectory but this time without the boat included. Mark on the diagram **two** points where the Carp will have its greatest kinetic energy. [Label both points with a letter **K**]. [1]



(iii) Use your answer to *(c)* (i) to show that the Carp's initial velocity (***U***) is the same as that calculated in *(b)* (iii). [2]

Examiner only

6. *(a)* The quark make-up of a neutron is udd. Explain why only this combination of u and d quarks is possible for a neutron. [1]

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(b) The π^- particle has quark make-up $d\bar{u}$. There is a particle called Δ^- which has quark make-up ddd.

(i) Show that the magnitudes of the charges of the π^- and the Δ^- are equal. [1]

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(ii) Explain in terms of quarks, why the π^- is classed as a meson but the Δ^- as a baryon. [2]

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(c) The Δ^- has a very short lifetime (about 6×10^{-24} s), almost always decaying into a neutron and a π^- as shown.

$$\Delta^- \rightarrow n + \pi^-$$

(i) Show clearly whether or not the following are separately conserved in this decay:

(I) up-quark number, [1]

....

....

(II) down-quark number. [1]

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....

(ii) Give **one** reason for believing this decay **not** to be a *weak force* interaction. [1]

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Examiner only

(d) The Δ^{++} particle is a baryon with a charge equal to that of two protons.

(i) Write down the quark make-up which the Δ^{++} must have. [1]

....

(ii) The Δ^{++} decays into a proton and a pion (π meson) by a similar mechanism to that in *(c)*. Determine the quark make-up of the pion. [1]

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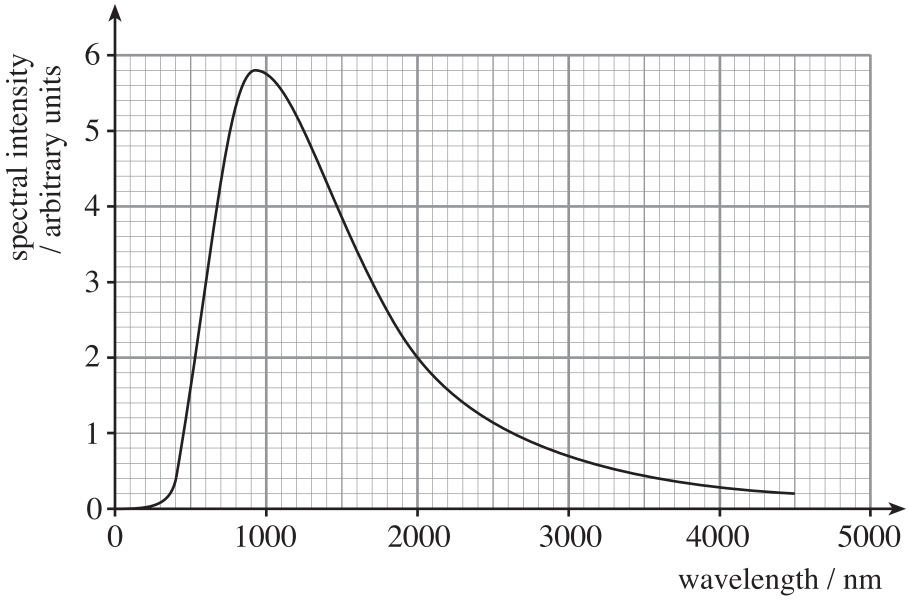
7. The nearest star to the Sun is a 'red dwarf', *Proxima Centauri*. The graph shows its spectrum.



(a) Use *Wien's law* to show clearly that the temperature of the star is about 3000 K. [3]

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(b) The range of visible wavelengths is 400 nm – 700 nm.

(i) Explain why *Proxima Centauri* is described as 'red'. [1]

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(ii) Name the region of the electromagnetic spectrum containing most of the power radiated. [1]

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Examiner only

(iii) (I) Where, apart from at the extremes, is the graph gradient zero? [1]

....

(II) Astrophysicists believe that *Proxima Centauri* will become hotter in the distant future. Estimate the temperature it would have to reach in order for the intensity of its radiation to be roughly the same at each end of the **visible** region of the spectrum (so the star appears white). Show your working clearly. [2]

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(c) Use *Stefan's law* to calculate the total power of electromagnetic radiation emitted from *Proxima Centauri* (at its present temperature) if its effective radius is 1.01×10^8 m. [3]

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SOLIDS UNDER STRESS

a) Sketch the graphs of stress vs strain for a ductile and a brittle material. Describe how they compare and give an example of each type of material. Label any relevant points on your sketch. [5]

b) Describe what can cause a dislocation to move through a material and what happens inside the material as it moves. Also state how we prevent such dislocations from being able to move. [10]

UNITS

By examining the SI units, state whether the following formulae are correct.

a) Acceleration = (2*displacement – 2*initial velocity*time) divided by (time-squared)

b) Mass = (2*force*(distance-squared)) divided by (final velocity-squared – initial velocity-squared) [5]

WORK AND ENERGY

a) For a slide of height H and slanted length 30m, assuming a mass of 75kg for the slider and a final velocity of 20m/s, find H. [2]

b) Now assume friction is 20N throughout the slide and the final speed is 10m/s, find the new value of H. [4]