Work, Energy and Power – 2022 GCE AS Mechanics Further Mathematics A

1. June/2022/Paper_Y533/01/No.2

A hockey puck of mass 0.2 kg is sliding down a rough slope which is inclined at 10° to the horizontal. At the instant that its velocity is $14\,\text{ms}^{-1}$ directly down the slope it is hit by a hockey stick. Immediately after it is hit its velocity is $24\,\text{ms}^{-1}$ directly up the slope.

(a) Find the magnitude of the impulse exerted by the hockey stick on the puck. **[2]**

After it has been hit, the puck first comes to instantaneous rest when it has travelled 15 m up the slope. While the puck is moving up the slope, the resistance to its motion has constant magnitude R N.

(b) Use an energy method to determine the value of R. **[5]**

2. June/2022/Paper_Y533/01/No.4

A cyclist is riding a bicycle along a straight road which is inclined at an angle of 4° to the horizontal. The cyclist is working at a constant rate of 250 W. The combined mass of the cyclist and bicycle is 80 kg and the resistance to their motion is a constant 70 N.

Determine the maximum constant speed at which the cyclist can ride the bicycle

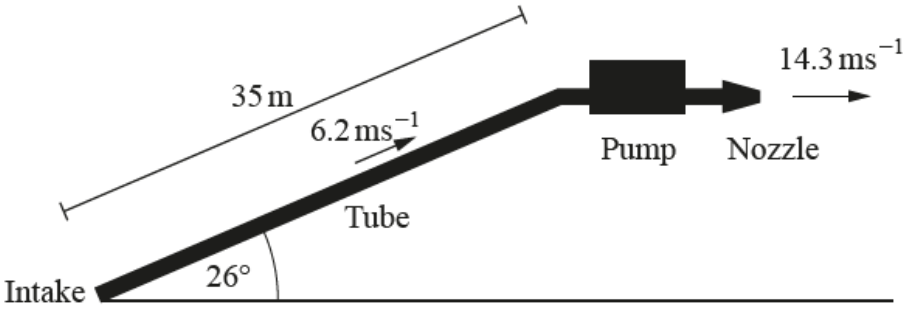
- up the hill, and
- down the hill. **[5]**

3. June/2022/Paper_Y533/01/No.8

As part of an industrial process a single pump causes the intake of a liquid chemical to the bottom end of a tube, draws it up the tube and then discharges it through a nozzle at the top end of the tube.

The tube is straight and narrow, 35 m long and inclined at an angle of 26° to the horizontal. The chemical arrives at the intake at the bottom end of the tube with a speed of $6.2\,\text{ms}^{-1}$. At the top end of the tube the chemical is discharged horizontally with a speed of $14.3\,\text{ms}^{-1}$ (see diagram).

In total, the pump discharges 1500 kg of chemical through the nozzle each hour.



In order to model the changes to the mechanical energy of the chemical during the entire process of intake, drawing and discharge, the following modelling assumptions are made.

- At any instant the total resistance to the motion of all the liquid in the tube is 40 N.
- All other resistances to motion are ignored.
- The liquid in the tube moves at a constant speed of $6.2\,\text{ms}^{-1}$.

(a) State **one** other modelling assumption which is required to model the changes to the mechanical energy of the liquid with the given information. **[1]**

(b) Determine the power at which the pump is working, according to the model. **[5]**

When the power at which the pump is working is measured it is in fact found to be 450 W.

(c) **(i)** Find the difference between the total amount of energy output by the pump each hour and the total amount of mechanical energy gained by the chemical each hour. **[2]**

(ii) Give **one** reason why the model underestimates the power of the engine. **[1]**