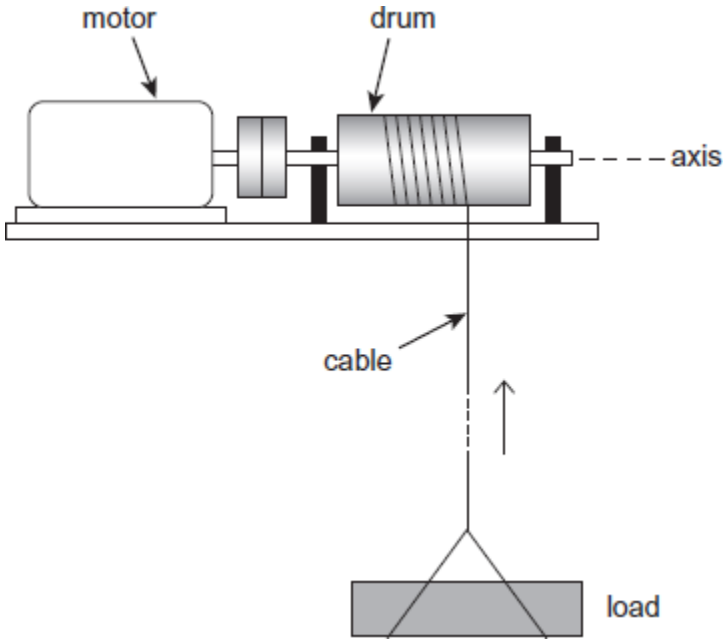
Name of the Student:_____
Max. Marks : 20 Marks **Time : 20 Minutes**

Q1.

The following figure shows a motor-driven winch for raising loads on a building site. As the motor turns the cable is wound around the drum, raising the load.



The drum, axle and other rotating parts have a moment of inertia about the axis of rotation of 7.4 kg m^2, and the mass of the load is 85 kg. The drum has a radius of 0.088 m.

The load is accelerated uniformly from rest to a speed of 2.2 m s^{-1}. When it is accelerating it rises through a height of 3.5 m. It then continues at the constant speed of 2.2 m s^{-1}.

(a) Show that the drum turns through 40 rad as the load accelerates.

(1)

(b) Calculate the angular speed of the drum when the load is moving at 2.2 m s^{-1}.

angular speed _____ rad s^{-1}

(1)

(c) (i) Show that for the time that the load is accelerating the total increase in energy of the load and the rotating parts is about 5400 J.

(3)

(ii) A constant frictional torque of 5.2 N m acts at the bearings of the winch.

Calculate the total work done by the motor to accelerate the load.

Give your answer to an appropriate number of significant figures.

total work done _____ J

(3)

(d) Calculate the **maximum** power developed by the motor.

maximum power _____ W

(2)

(Total 10 marks)

Q2.

(a) Explain what is meant by the coefficient of performance of a heat pump.

_____

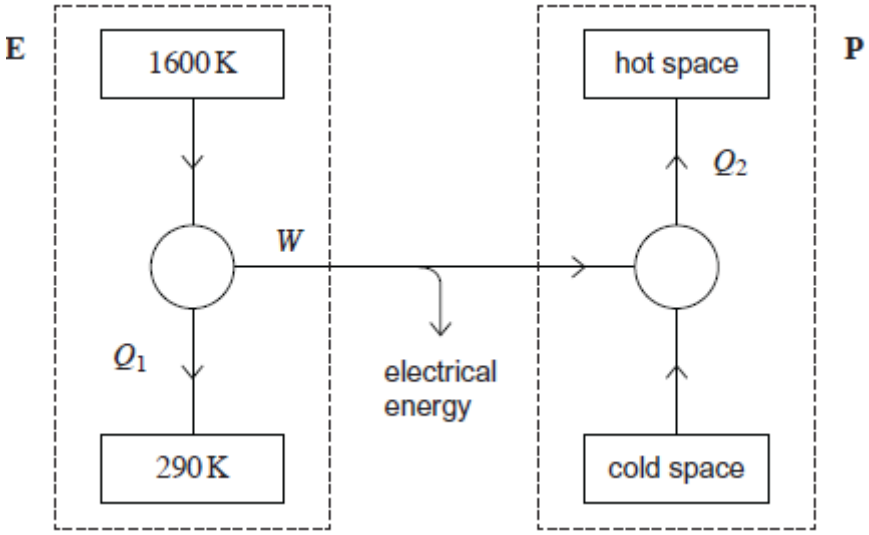
_____

_____

(1)

(b) The box labelled **E** in the figure below shows a diagram of a combined heat and power scheme. The scheme provides electrical energy W from an engine-driven generator and heat Q_1 for buildings situated near to the generator.

Some of the electrical energy is used to drive the heat pump shown in the box labelled **P**. Output Q_2 is also used to heat the buildings.



You may assume that the engine runs at its maximum theoretical efficiency and that the electrical generator is 100% efficient. The output power of the engine-driven generator is 80 kW.

(i) The fuel used in the engine (**E**) is propane of calorific value 49 MJ kg^{-1}. Calculate the rate of flow of propane into the engine. State an appropriate unit.

rate of flow _____ unit _____

(4)

(ii) The heat pump has a coefficient of performance of 2.6.
The power supplied by the electrical generator to the heat pump (**P**) is 16 kW.
Calculate the total rate at which energy is available for heating from both the engine and heat pump.

rate at which energy is available _____ W

(3)

(iii) The conversion of electrical energy to heat is nearly 100% efficient. Explain why the designer has proposed installing a heat pump rather than an electrical heater to provide

the additional heat Q_2.

_____

_____

_____

_____

_____

(2)
(Total 10 marks)