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# Power and efficiency worksheet

AQA AS 7407 and first-year A Level 7408 | OCR A AS H156 and A Level H556

*35–40 minutes independent practice + 15–20 minutes review | 36 marks*

## Specification points covered

- AQA 7407 / 7408: 3.4.1.7 selected power and efficiency; 3.4.1.8 selected energy transfers.
- OCR A H156 / H556: 3.3.3(a)–(c) power, P = Fv derivation and mechanical efficiency.

The Kepler Ridge transport system

An observatory tests an instrument carrier and hoist. Motor output is work by traction; useful hoist output is defined per task.

### 1. From work done to power [4 marks]

(a) State what is meant by power and state what it means for a device to have a power of one watt. [2 marks]

(b) Starting with P = W/t, W = Fs and v = s/t, derive P = Fv for a constant force acting parallel to motion at constant speed. [2 marks]

### 2. Power and efficiency check [5 marks]

*Two separate bench tests check the carrier's actuator at different operating points.*

(a) Test A transfers 72.0 kJ in 45.0 s. Calculate the average power and decide if it exceeds 1.50 kW. [2 marks]

(b) In test B, traction is 850 N at 3.60 m $s^{-1}$. Calculate the mechanical output power. [1 mark]

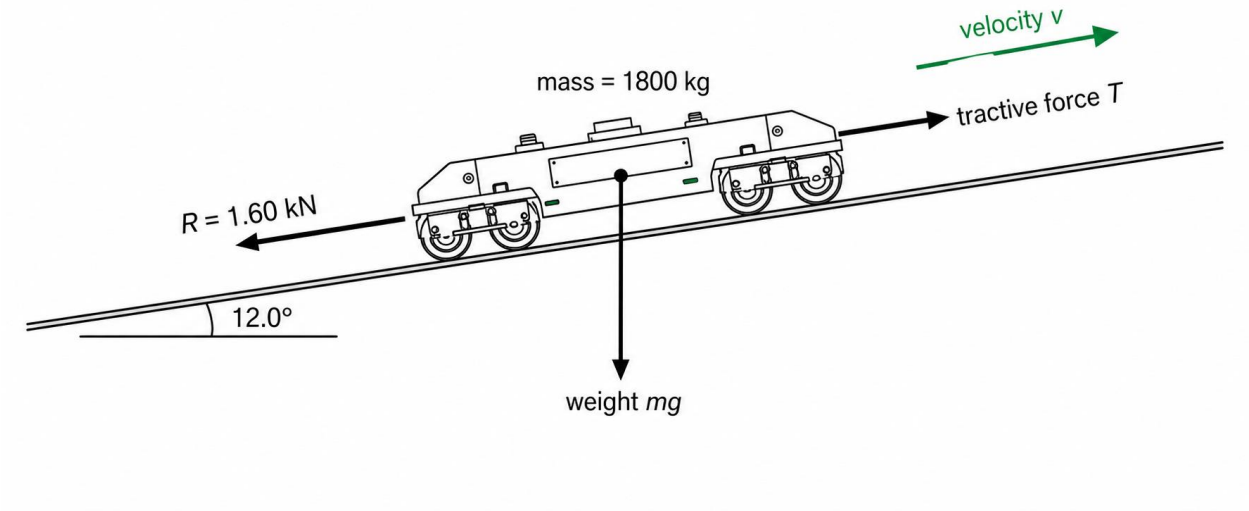
(c) Test B input is 4.20 kW. Calculate efficiency and assess the claim that it is at least 80%. [2 marks]

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## 3. Constant-speed climb [5 marks]

*The Kepler Ridge instrument carrier transports telescope equipment up a 12.0° service rail at a constant speed of 3.20 m $s^{-1}$. Its mass is 1800 kg and the total resistance is 1.60 kN. Use g = 9.81 N $kg^{-1}$. The schematic omits the normal contact force; it is not a complete free-body diagram.*

**Kepler Ridge instrument carrier** not to scale




(a) Calculate the component of the carrier's weight acting down the slope. [1 mark]

(b) Calculate the tractive force provided by the motor. [1 mark]

(c) Calculate the useful mechanical output power of the motor. [1 mark]

(d) The resultant force on the carrier is zero. Explain why the motor's useful output power is not zero. [2 marks]

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## 4. Which force belongs in P = Fv? [4 marks]

*The carrier continues up the slope at the constant speed described in Question 3. For each transfer rate, identify the force that should be used in P = Fv.*

(a) The useful mechanical output power of the motor. [1 mark]

(b) The rate at which the carrier's gravitational energy store increases. [1 mark]

(c) The rate at which energy is transferred to thermal stores by resistance. [1 mark]

(d) The rate of change of the carrier's kinetic energy. [1 mark]

## 5. Accelerating uphill [4 marks]

*The 1800 kg carrier is now travelling uphill at 2.40 m $s^{-1}$ and accelerating at 0.300 m $s^{-2}$. The resistance is 1.90 kN. The slope angle remains 12.0°. Use g = 9.81 N $kg^{-1}$.*

(a) Calculate the resultant force on the carrier. [1 mark]

(b) Calculate the tractive force provided by the motor. [1 mark]

(c) Calculate the useful mechanical output power of the motor at this instant. [1 mark]

(d) Calculate the rate at which the carrier's kinetic energy is increasing at this instant. [1 mark]

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## 6. Hoisting a calibration package [4 marks]

*A winch raises a 620 kg calibration package vertically through 18.0 m in 34.0 s. The package begins and ends at rest. Its electrical input power is 4.20 kW. The only useful transfer is the package's gravitational energy increase; all remaining input energy is dissipated to thermal stores. Use g = 9.81 N kg$^{-1}$.*

(a) Calculate the useful energy transferred to the package's gravitational energy store. [1 mark]

(b) Calculate the electrical energy supplied to the winch. [1 mark]

(c) Calculate the efficiency of the winch. [1 mark]

(d) Calculate the energy dissipated during the lift. [1 mark]

## 7. Choosing an operating mode [5 marks]

*The hoist must complete 240 kJ of useful work. In Quiet mode it takes 60.0 s with an input power of 5.00 kW. In Fast mode it takes 40.0 s and receives 320 kJ of input energy.*

(a) Calculate the efficiency in each mode. [2 marks]

(b) Calculate the useful output power in each mode. [2 marks]

(c) A technician says, 'Fast mode is better because it is more powerful.' Evaluate this statement. [1 mark]

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## 8. Constant-power upper section [5 marks]

*On a level upper section, the 1800 kg carrier's motor has a constant mechanical output power of 24.0 kW. Resistance does not decrease as speed increases. The values below describe this operating range.*

(a) At 4.00 m $s^{-1}$, calculate the tractive force provided by the motor. [1 mark]

(b) The resistance is 2.40 kN at this speed. Calculate the resultant force and the acceleration. [2 marks]

(c) At 8.00 m $s^{-1}$, calculate the tractive force. The resistance is now 3.00 kN. [1 mark]

(d) Explain why the carrier has reached its maximum constant speed at 8.00 m $s^{-1}$. [1 mark]

## Review and improve

☐ I can derive P = Fv from work done and speed.
☐ I can choose the force linked to the energy transfer being calculated.
☐ I can distinguish useful output power from efficiency.

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