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WORKSHEETS
ATTEMPT | CHECK | CORRECT | IMPROVE

OCR A A Level Physics | Power and efficiency worksheet

35-40 minutes independent practice + 15-20 minutes review | 34 marks

Specification points covered

- 3.3.3(a) Define power, the unit watt, and use P = W / t.
- 3.3.3(b) Use and derive P = Fv from first principles.
- 3.3.3(c) Calculate the efficiency of a mechanical system.

How to use this worksheet
Attempt every question independently. Show numerical working in the blank spaces and use the ruled lines for precise written explanations. In P = Fv, always identify the force linked to the energy transfer being calculated.

1. From work done to power [4 marks]

Begin with the definitions that connect energy transfer, force and motion.

(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 the motion. **[2 marks]**

2. Power and efficiency check [3 marks]

An engineering team checks three values in the specification for an electric actuator.

(a) The actuator transfers 72.0 kJ of energy in 45.0 s. Calculate its power. **[1 mark]**

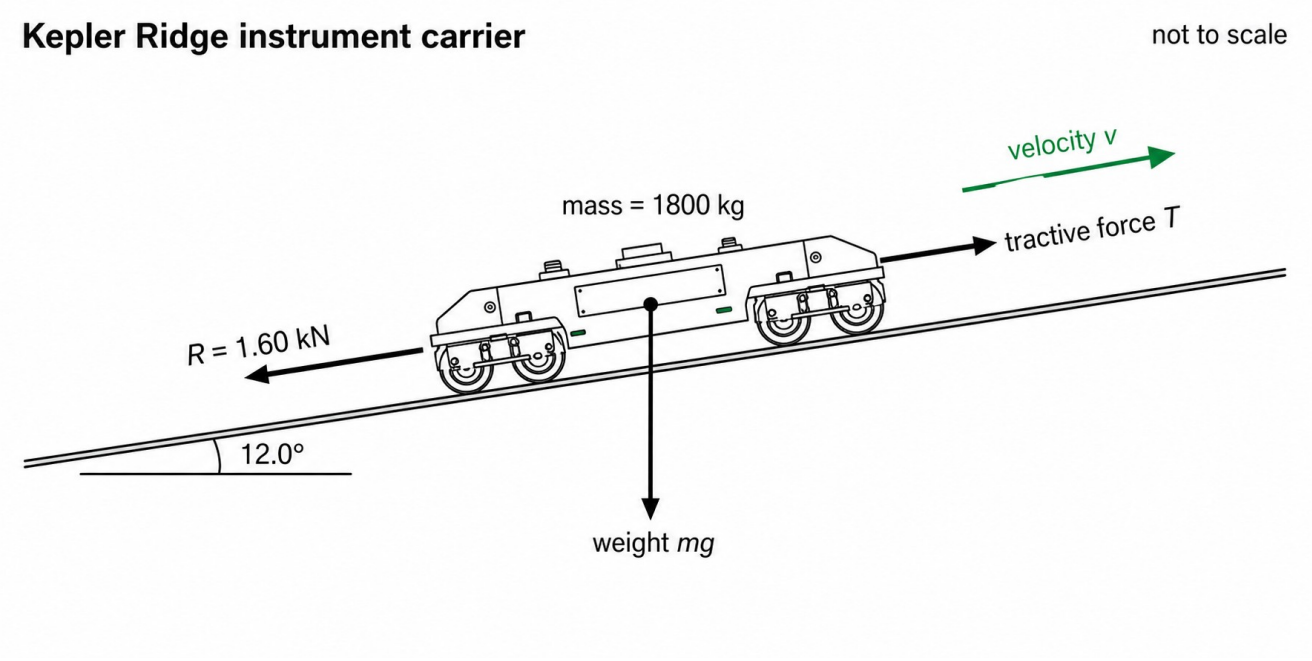
(b) It provides a tractive force of 850 N while moving at 3.60 m s^{-1}. Calculate its useful mechanical output power. **[1 mark]**

(c) Its electrical input power is 4.20 kW. Calculate its efficiency at this operating point. **[1 mark]**

Scenario: the Kepler Ridge instrument carrier
An electric rail carrier transports telescope instruments between an observatory workshop and a high-altitude test platform. Treat the carrier as a particle when resolving forces along the rail.

3. Constant-speed climb [6 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. The carrier has mass 1800 kg and the total resistance to motion is 1.60 kN. Use g = 9.81 N kg⁻¹.



(a) Calculate the component of the carrier's weight acting down the slope. **[2 marks]**

(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]**

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]**

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 electrical input power to the winch is 4.20 kW. 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 [4 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. **[1 mark]**

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

8. Constant-power upper section [5 marks]

On a level upper section, the carrier's motor has a constant mechanical output power of 24.0 kW. The carrier still has mass 1800 kg.

(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.