

## Energy and work done

AQA GCSE Physics 8463 and Combined Science Trilogy 8464 | Foundation and Higher

Worked solutions and teaching prompts | 29 parts | 46 marks

### Specification points covered

8463 4.1.1.1-4.1.1.2 / 8464 6.1.1.1-6.1.1.2: kinetic and gravitational potential energy  
8463 4.5.2 / 8464 6.5.2: work done by a force; distance along the line of action  
8463 4.1.2.1 / 8464 6.1.2.1: conservation of energy and dissipation to the surroundings

A theatre team moves props on trolleys, lifts scenery with a hoist and tests a prop sled on a ramp. The team must account for energy transfers and choose safe settings. Each test is independent; masses include the trolley or sled and its load where relevant.

Both tiers complete all questions. Use the stated  $g = 10 \text{ N kg}^{-1}$ , not a remembered value. Allow equivalent methods and meaningful follow-through; a correct answer with a required unit earns a single calculation mark. This is an original PhysicsUK resource, not an official AQA mark scheme.

### 1 The team checks its language

**1(a)** A trolley gains speed while staying at the same height. Name the energy store that increases. **[1 mark]**

**Answer / mark points:** The kinetic energy store. [1]

**1(b)** A hoist raises a stationary load to a higher position, where it is again stationary. Name the energy store that increases. **[1 mark]**

**Answer / mark points:** The gravitational potential energy store. [1] Accept the gravitational potential energy of the load-Earth system.

**Teacher prompt:** Potential energy alone does not identify the required store.

### 2 Choosing trolley settings

Use the total moving mass in  $E_k = 0.5mv^2$ . Tests (a)-(d) use different settings.

**2(a)** A trolley and its load have a total mass of 20 kg. Calculate their kinetic energy at  $0.50 \text{ m s}^{-1}$ . **[1 mark]**

**Answer / mark points:**  $E_k = 0.5 \times 20 \times 0.50^2 = 2.5 \text{ J}$ . [1]

**Teacher prompt:** Square the speed, not the mass. Retain the factor 0.5.

**2(b)** The same 20 kg trolley and load move at  $1.0 \text{ m s}^{-1}$ . Calculate their kinetic energy. **[1 mark]**

**Answer / mark points:**  $E_k = 0.5 \times 20 \times 1.0^2 = 10 \text{ J}$ . [1]



## 2 Choosing trolley settings continued

**2(c)** Another trolley and load have a total mass of 40 kg and move at  $1.0 \text{ m s}^{-1}$ . Calculate their kinetic energy. **[1 mark]**

**Answer / mark points:**  $E_k = 0.5 \times 40 \times 1.0^2 = 20 \text{ J}$ . [1]

**2(d)** A 30 kg trolley and load move at  $0.80 \text{ m s}^{-1}$ . Calculate their kinetic energy. **[1 mark]**

**Answer / mark points:**  $E_k = 0.5 \times 30 \times 0.80^2 = 9.6 \text{ J}$ . [1]

**2(e)** Use (a)-(c) to compare the effect of doubling speed at fixed mass with doubling mass at fixed speed. **[2 marks]**

**Answer / mark points:** Doubling speed from (a) to (b) quadruples  $E_k$ : 2.5 J to 10 J, because speed is squared. [1]

Doubling mass from (b) to (c) doubles  $E_k$ : 10 J to 20 J. [1]

**2(f)** A different trolley and load have kinetic energy 9.0 J at  $0.60 \text{ m s}^{-1}$ . Calculate their total mass. **[2 marks]**

**Answer / mark points:**  $m = 2E_k / v^2$ . [1]

$m = (2 \times 9.0) / 0.60^2 = 50 \text{ kg}$ . [1]

**2(g)** A 48 kg trolley and load have kinetic energy 24 J. Calculate their speed. **[2 marks]**

**Answer / mark points:**  $v^2 = 2E_k / m = (2 \times 24) / 48 = 1.0 \text{ m}^2 \text{ s}^{-2}$ . [1]

$v = \sqrt{1.0} = 1.0 \text{ m s}^{-1}$ . [1]

**Teacher prompt:** The rearrangement gives speed squared. Take its positive square root.

**2(h)** A small 800 g prop moves at  $2.0 \text{ m s}^{-1}$ . Calculate its kinetic energy. **[2 marks]**

**Answer / mark points:**  $800 \text{ g} = 0.800 \text{ kg}$ . [1]

$E_k = 0.5 \times 0.800 \times 2.0^2 = 1.6 \text{ J}$ . [1]

**2(i)** A stop can absorb at most 12 J and must absorb all the trolley kinetic energy. Decide whether each setting in (b) and (c) is suitable. Justify both decisions. **[2 marks]**

**Answer / mark points:** Setting (b) is suitable: 10 J is no more than 12 J. [1]

Setting (c) is not suitable: 20 J exceeds 12 J. [1]



### 3 Lifting scenery

Figure 1 shows a vertical rise of 2.5 m. Part (b) is a separate lift; parts (c)-(d) give other lift data. Use the height specified in each question.

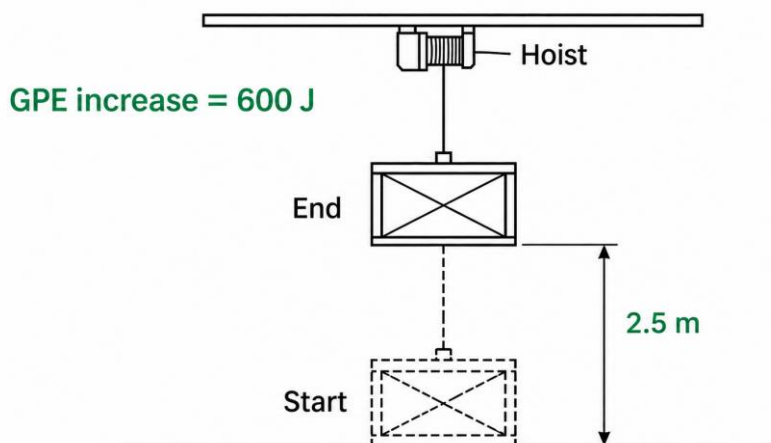


Figure 1

**3(a)** The scenery load has mass 24 kg. Calculate its gravitational potential energy increase for the lift in Figure 1. **[1 mark]**

**Answer / mark points:** Change in  $E_p = mgh = 24 \times 10 \times 2.5 = 600 \text{ J}$ . [1]

**3(b)** In a separate lift a 12 kg load rises vertically by 5.0 m. Calculate its gravitational potential energy increase. **[1 mark]**

**Answer / mark points:** Change in  $E_p = 12 \times 10 \times 5.0 = 600 \text{ J}$ . [1]

**3(c)** A 24 kg load gains 360 J of gravitational potential energy. Calculate its vertical rise. **[2 marks]**

**Answer / mark points:**  $h = \text{change in } E_p / (mg)$ . [1]  
 $h = 360 / (24 \times 10) = 1.5 \text{ m}$ . [1]

**3(d)** A load gains 750 J of gravitational potential energy when lifted vertically by 2.5 m. Calculate its mass. **[2 marks]**

**Answer / mark points:**  $m = \text{change in } E_p / (gh)$ . [1]  
 $m = 750 / (10 \times 2.5) = 30 \text{ kg}$ . [1]



### 3 Lifting scenery continued

3(e) A trainee uses the 8.0 m full cable length instead of 2.5 m in part (a). Explain why this is wrong. [1 mark]

**Answer / mark points:** h is the change in vertical height of the load, not the length of the cable. [1]

3(f) The 24 kg load is raised through 2.5 m in 3.0 s in one test and 6.0 s in another. Compare its gravitational potential energy gains and explain your answer. [2 marks]

**Answer / mark points:** The gains are equal: 600 J in each test. [1] Mass, g and vertical rise are unchanged; the time taken is not a factor in mgh. [1]

### 4 Accounting for work done

Use the force named in each question. These are separate tests unless the question refers back to the hoist.

4(a) A worker pushes horizontally with a constant force of 30 N while the trolley moves 5.0 m horizontally. Calculate the work done by this force. [1 mark]

**Answer / mark points:**  $W = Fs = 30 \times 5.0 = 150 \text{ J}$ . [1]

4(b) A brake exerts a constant 50 N force opposite the trolley motion over 0.40 m. Calculate the amount of energy transferred by the brake. [1 mark]

**Answer / mark points:** Energy transferred = force  $\times$  distance =  $50 \times 0.40 = 20 \text{ J}$ . [1] This is the magnitude of the braking work, not a positive gain of kinetic energy.

4(c) A constant 24 N force does 96 J of work while acting parallel to the trolley motion. Calculate the distance moved. [2 marks]

**Answer / mark points:**  $s = W / F$ . [1]

$s = 96 / 24 = 4.0 \text{ m}$ . [1]

4(d) A force parallel to the motion transfers 5.0 J over a distance of 25 cm. Calculate the force. [2 marks]

**Answer / mark points:** 25 cm = 0.25 m. [1]

$F = W / s = 5.0 / 0.25 = 20 \text{ N}$ . [1]



## 4 Accounting for work done continued

**4(e)** For the 24 kg load in Question 3(a), the upward cable force is 240 N through 2.5 m. Calculate the work done by the cable force. Compare it with the gravitational potential energy gain. **[2 marks]**

**Answer / mark points:** Work done by cable force =  $240 \times 2.5 = 600 \text{ J}$ . [1] It equals the 600 J gravitational potential energy gain in 3(a). [1]

**Teacher prompt:** Use the cable force, not the resultant force. The work by the cable transfers energy to the gravitational potential store.

**4(f)** A trolley of weight 240 N moves 5.0 m horizontally at the same height. A trainee says its weight does 1200 J of work. Explain why gravity does no work in this movement. **[2 marks]**

**Answer / mark points:** The weight acts vertically while the displacement is horizontal, so there is no movement along the force. [1] The distance along the weight is zero, so work done by gravity is zero. [1]

**Teacher prompt:** Do not multiply every force by the total path length. No trigonometric calculation is needed.

**4(g)** In one lift the motor receives 750 J electrically. The load starts and finishes at rest and gains 600 J of gravitational potential energy. All other transferred energy heats the hoist and surroundings. Calculate this energy and correct the statement: the missing energy was destroyed. **[2 marks]**

**Answer / mark points:** Energy transferred to thermal stores =  $750 - 600 = 150 \text{ J}$ . [1] Energy is conserved: the 150 J is dissipated to the thermal stores of the hoist and surroundings, not destroyed. [1]

## 5 A prop sled for a stage effect

In Figure 2 a 2.0 kg sled is released from rest at A and slides to B. Its centre falls vertically by 0.80 m while it travels 2.0 m along the ramp. The sled does not rotate. Its only changing energy stores are gravitational potential, kinetic and thermal.

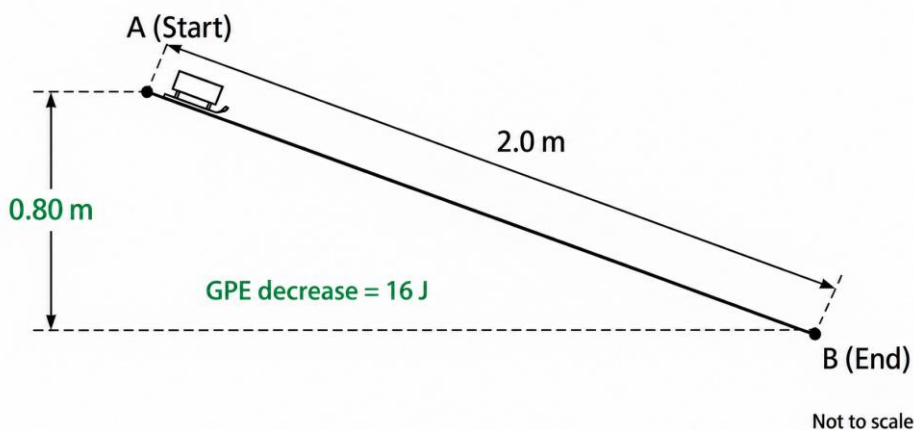


Figure 2

**5(a)** Which distance in Figure 2 should be used to calculate the gravitational potential energy decrease? Explain your choice. **[1 mark]**

**Answer / mark points:** 0.80 m, because  $mgh$  uses the vertical height change, not the 2.0 m distance along the ramp. [1 for choice and reason]

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## 5 A prop sled for a stage effect continued

Continue the Figure 2 test: mass 2.0 kg, vertical drop 0.80 m, released from rest at A; use  $g = 10 \text{ N kg}^{-1}$ .

**5(b)** Calculate the gravitational potential energy decrease from A to B. **[1 mark]**

**Answer / mark points:** Decrease in  $E_p = 2.0 \times 10 \times 0.80 = 16 \text{ J}$ . [1]

**5(c)** First assume there is no friction or air resistance. Calculate the sled speed at B. **[2 marks]**

**Answer / mark points:** All 16 J is transferred to the kinetic energy store:  $0.5 \times 2.0 \times v^2 = 16$ . [1]  
 $v^2 = 16$ , so  $v = 4.0 \text{ m s}^{-1}$ . [1]

**Teacher prompt:** The sled starts at rest. Use the full GPE decrease, then take the square root to obtain speed.

**5(d)** In a real test 7.0 J is transferred to thermal stores before B. Calculate the kinetic energy at B and the speed at B. **[3 marks]**

**Answer / mark points:**  $E_k \text{ at B} = 16 - 7.0 = 9.0 \text{ J}$ . [1]  
 $v^2 = 2E_k / m = (2 \times 9.0) / 2.0 = 9.0$ . [1]  
 $v = 3.0 \text{ m s}^{-1}$ . [1]

**Teacher prompt:** Only part of the initial gravitational potential energy becomes kinetic energy. Do not use all 16 J.

**5(e)** A trainee says friction used up 7.0 J, so energy was not conserved. Explain the error and why the real speed is lower than in (c). **[2 marks]**

**Answer / mark points:** Energy is conserved: 7.0 J is transferred to thermal stores of the sled, ramp and surroundings; it is not destroyed. [1] Less energy reaches the kinetic store (9.0 J rather than 16 J), so the same-mass sled has a lower speed (3.0 rather than 4.0  $\text{m s}^{-1}$ ). [1]

## Review and improve

Model full store names: kinetic, gravitational potential and thermal. Energy is transferred or dissipated, not destroyed. Distinguish vertical height from path length and work done by a particular force from a calculation using the resultant force.

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