



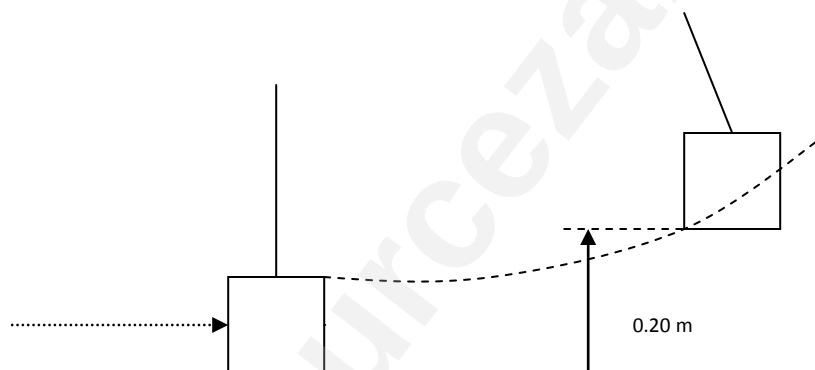
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MOMENTUM, WORK, ENERGY AND POWER

Learner Note: Please ensure that you understand that when there is friction, that mechanical energy is not conserved. Also, remember that $W = F \cdot \Delta x \cdot \cos\theta$ where θ is the angle between F and Δx and not the inclination of the plane if the object is on an inclined plane.

LESSON OVERVIEW

1. Typical exam questions – 30 minutes
2. Review/solutions/memo – 30 minutes

SECTION A: TYPICAL EXAM QUESTIONS**Question 1: 20 minutes**

An arrow of mass 0.10kg is shot by a crossbow into a wooden block suspended by a cord from the ceiling in a room. The arrow penetrates the block, becoming stuck in it. The block then swings upward, reaching a vertical height of 0.20m above the level where it was struck.

- 1.1 If the mass of the wooden block is 3.9kg, calculate the potential energy of the block plus arrow after swinging to a vertical height of 0,20m. (4)
- 1.2 Calculate the velocity of the block immediately after being struck by the arrow. (6)
- 1.3 State the law of Conservation of Momentum. (3)
- 1.4 Use the Law of Conservation of Momentum to calculate the velocity of the arrow just before striking the block. (5)
- 1.5 In another test, it was found that an identical arrow shot with the same velocity would penetrate 100mm into a block of wood clamped into a vice. Calculate the average force the arrow exerts on the block. (6)

[21 marks]

Question 2: 10 minutes

Two matric physical sciences pupils, Thabang and James, have the same mass of 80kg each. They want to investigate their physical power.

Their hypothesis is: People of the **same mass** will have the **same power**.

They have the following apparatus at their disposal:

A flight of stairs
A stop watch
A measuring tape
And a bathroom scale

- 2.1 Give a method they should follow to test this hypothesis. (3)
- 2.2 Identify the control, independent and dependent variables. (3)
- 2.3 Show what formula needs to be used and how you would use them. (3)
- 2.4 Give the base S.I. units for the unit of power. (1)

[10 marks]

SECTION B: SOLUTIONS AND HINTS
Question 1:

- 1.1 $E_p = mgh$ ✓
 $= 4 \times 9,8 \times 0,2$ ✓
 $= 7,84 \text{ J}$ ✓ (4)
- 1.2 By conservation of Mechanical E
 Mechanical E top = Mechanical E bottom
 $[mgh + \frac{1}{2}mv^2]_{\text{top}} = [mgh + \frac{1}{2}mv^2]_{\text{bottom}}$ ✓
 $4 \times 9,8 \times 0,2 + \frac{1}{2} \times 4 \times 0^2 = \frac{1}{2} \times 4 \times v^2 + 4 \times 9,8 \times 0$ ✓
 $7,84 = 2v^2$
 $v = 1,97 \text{ ms}^{-1}$ to the right ✓ (6)
- 1.3 The total linear momentum of an isolated system ✓ remains constant ✓ in both magnitude and direction. ✓ (3)

1.4

$$\begin{aligned}
 p_{\text{before}} &= p_{\text{after}} \quad \checkmark \\
 m_1 v_{i1} + m_2 v_{i2} &= (m_1 + m_2) v_f \\
 (0,1)(v_{i1}) \checkmark + (3,9)(0) \checkmark &= (0,1 + 3,9)(1,97) \checkmark \\
 0,1 v_{i1} &= 7,88 \\
 v_f &= 78,8 \text{ m} \cdot \text{s}^{-1} \text{ to the right} \quad \checkmark \quad (5)
 \end{aligned}$$

1.5

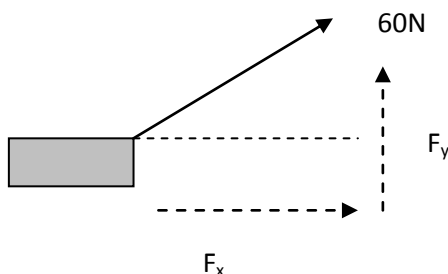
$$\begin{aligned}
 E_k &= F \cdot x \cos \theta \quad \checkmark \\
 \frac{1}{2} m v^2 \checkmark &= F \times 0,1 \checkmark \cos 0^\circ \checkmark \\
 \frac{1}{2} (0,1) (78,8)^2 \checkmark &= F \times (0,1) \\
 F &= 3104,72 \text{ N in direction of arrow} \quad \checkmark \quad (6)
 \end{aligned}$$

Question 2:

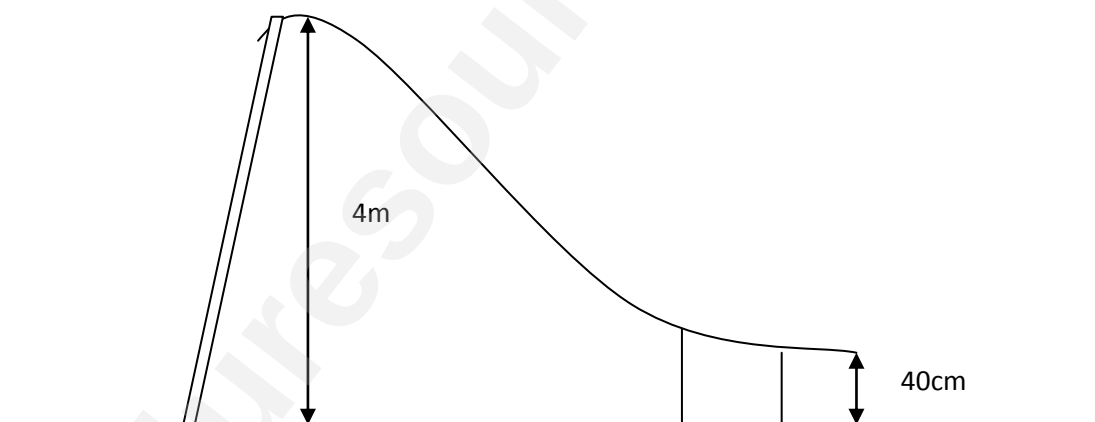
- 2.1 :
- Use the measuring tape to measure **perpendicular height** of stairs
 - Run as fast as possible up the stairs
 - Use stop watch to time run
 - Calculate the work done for each which should be the same
 - Calculate the power of each
 - Draw conclusion
 - ✓✓✓ - All necessary steps present – One missing at most
 - ✓✓ - 2 – 3 steps missing
 - ✓ - 4 – 5 steps missing
- (3)
- 2.2 Control variable - Same steps, weight, mass, height, timer, work done ✓
- Dependent - Power ✓ or **time**
- Independent - Time ✓ or **which boy**
- (3)
- 2.3 To work out the weight $F_g = mg$ ✓
- To work out the Work done use : $W = F \cdot \Delta x \cdot \cos \theta = mgh$ ✓
- To work out the Power use : $P = W/t$ ✓
- (3)
- 2.4 $\text{kg} \cdot \text{m}^2 \cdot \text{s}^{-3}$ ✓
- (1)
- [10 marks]**

SECTION D: HOMEWORK**Question 1: 3 minutes**

Themba pushes a box with a force of 100N across the floor for 10m. Calculate the amount of work that Themba has performed on the box. (3)

Question 2: 6 minutes

Linda pulls a 10 kg log a distance of 20 m. He pulls with a force of 60N on the rope. The rope is at an angle of 20° with the horizontal. Calculate the amount of work he has done. (6)

Question 3: 11 minutes

Susie, mass 40 kg, slides down the slide that is 4m high at its highest point and 40cm at its end. What will be her velocity at the end of the slide? (8)

SECTION E: SOLUTIONS TO SESSION 16 HOMEWORK

Question 1

1.1 $8\text{m}\cdot\text{s}^{-1}$ ✓ ✓ (2)

1.2 Direction up is positive

$$v_f^2 = v_i^2 + 2a\Delta y$$

$$(0)^2 = (8)^2 + 2(-9,8)\Delta y$$

$$0 = 64 - 19,6\Delta y$$

$$\Delta y = 3,27\text{m}$$

✓ ✓ ✓ (4)

1.3.1 When the ball lands in the gutter, the gutter exerts an upward force on the ball. The system is not isolated ✓ any more. Work is done by the upward force and some of the mechanical energy of the ball is converted ✓ into heat and sound. (2)

1.3.2 Energy is converted into other forms (like heat and sound) ✓ (1)

1.4 $E_{\text{mech at start}} = mgh + \frac{1}{2}mv^2$ ✓

$$= (0,01)(9,8)(0) + \frac{1}{2}(0,01)(8)^2$$

$$= 0,32\text{J}$$

$$E_{\text{mech at start}} = mgh + \frac{1}{2}mv^2$$

$$= (0,01)(9,8)(0) + \frac{1}{2}(0,01)(7)^2$$

$$= 0,245\text{J}$$

$$W_{\text{gutter}} = \Delta E_{\text{mech}} = E_{\text{end}} - E_{\text{start}}$$

$$= 0,245 - 0,32$$

$$= -0,075\text{J}$$

✓ ✓

OR

$$E_{\text{mech at max height}} = mgh + \frac{1}{2}mv^2$$

$$= (0,01)(9,8)(3,27) + \frac{1}{2}(0,01)(0)^2$$

$$= 0,32\text{J}$$

$$E_{\text{mech in gutter}} = mgh + \frac{1}{2}mv^2$$

$$= (0,01)(9,8)(2,5) + \frac{1}{2}(0,01)(0)^2$$

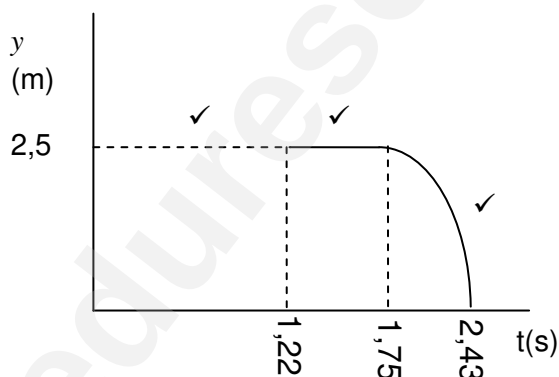
$$= 0,245\text{J}$$

$$W_{\text{gutter}} = \Delta E_{\text{mech}} = E_{\text{gutter}} - E_{\text{max height}}$$

$$= 0,245 - 0,32 = -0,075\text{J}$$

✓ ✓

1.5



- Both Axes correctly labelled ✓
- Intercepts on axes correct ✓
- No graph up to 1,22s
- Constant line between 1,22s and 1,75s
- Curve with negative gradient from 1,75s to 2,43s

(5)

(4)

Question 2:

2.1 $W_{\text{net}} = \Delta K$ ✓

$$W_f + W_N + W_{Fg} = \Delta K$$

$$f\Delta x \cos\theta + 0 + 0 = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$$

$$(30)(2)(\cos 180^\circ) = \frac{1}{2}(3)v_f^2 - \frac{1}{2}(3)(7)^2$$

$$-60 = \frac{1}{2}(3)v_f^2 - 73,5$$

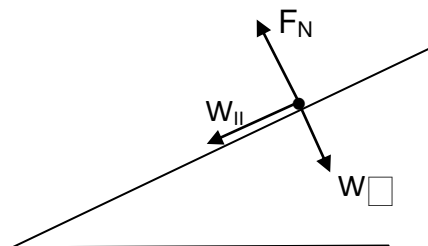
$$v_f = 3\text{ m}\cdot\text{s}^{-1}$$

✓

(5)



2.2

 F_N = normal force $W_{||}$ = parallel component of weight $W_{\perp}$ = perpendicular component of weight

✓ for all 3 forces correctly drawn

✓ for all 3 forces correctly labelled (2)

2.3 $W_{\text{net}} = \Delta K$

$$W_{||} + W_N + W_{\perp} = \Delta K$$

$$W_{||} \Delta x \cos \theta + 0 + 0 = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 \quad \checkmark$$

$$mg \sin 20^\circ \Delta x \cos 180^\circ \checkmark = 0 - \frac{1}{2}(3)(3)^2 \quad \checkmark$$

$$(3)(9,8) \sin 20^\circ d (-1) \checkmark = 0 - \frac{1}{2}(3)(3)^2$$

$$d = 1,34 \text{ m} \quad \checkmark$$

(5)