SUPER PHYSICS

Chapter 7 Notes

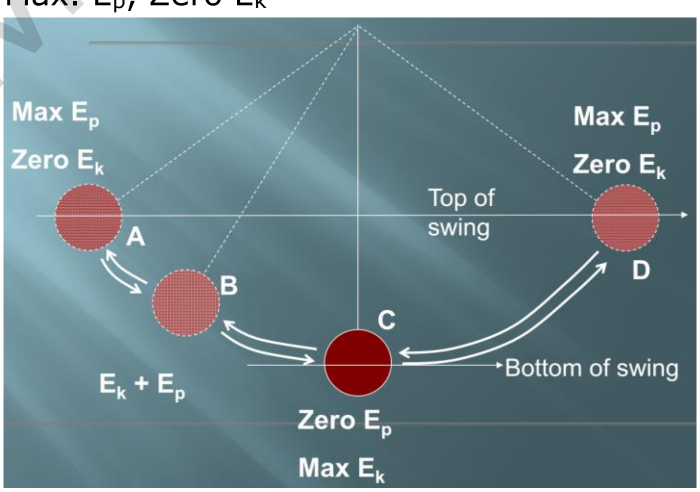
Work, Energy & Power

Energy

- Definition: The capacity to do work.
- Different types of energy
  - Kinetic Energy
  - Gravitational Potential Energy
  - Elastic Potential Energy
  - Sound, Thermal, Electrical, Light Energy

Conservation of Energy

- Definition: Energy cannot be created or destroyed, but it can be converted from one form into another or transferred from one body to another
- The total energy of **a closed system** remains constant
- Energy gained = Energy lost (eg. loss in E_p = gain in E_k)
- Swinging Object
  - Start: Max. E_p, Zero E_k
  - Midpoint: Zero E_p, Max. E_k
  - End: Max. E_p, Zero E_k



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Kinetic Energy

- Energy related to movement of mass

$$E_k = \frac{1}{2}mv^2$$

- Where E_k = kinetic energy (j), m = mass (kg), v = velocity (v)

Gravitational Potential Energy

- Energy related to position of mass is gravitational potential energy

$$E_p = mgh$$

- E = gravitational energy (j), m = mass (kg), h = height (m), g = gravitational constant

Electrical Energy

- Fluorescent Bulb: Electrical energy → More light than thermal energy
- Incandescent Bulb: Electrical energy → More thermal than light energy
- Saving water conserves energy because less electrical energy of the pump is needed to be converted into kinetic energy of water
- Air Conditioner: Electrical energy → Net thermal energy

Mechanical Energy

- Sum of kinetic and potential energy in an object used to do work
- Mechanical energy of an object is constant if its weight is only force acting on it
- **Initial ME = Final ME** (e.g. Final E_k = Initial E_p + E_k)

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Law of Conservation of Energy

- By the law of conservation of energy,
  Gain in E_k = Loss in E_p / Max. E_k = Max. E_p

Example 1:

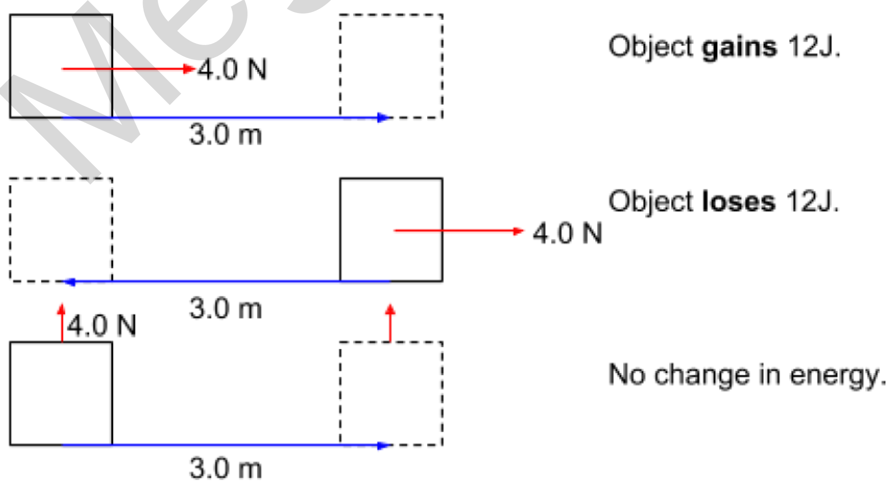
Account for the failure of the ball to reach the original height.

- Some of the energy has been converted to thermal and sound energy when the ball contacted with the floor, so the KE after the ball rebounds is smaller than before it hits the ground
- Since the ball's KE is smaller, its final GPE will also be smaller

<u>Work Done</u>

$$Work\ Done = F \times s$$

- Where F = force (N) , s = displacement (m), Work Done units: joules
- Calculating energy in joules: Power in watts (W) and **time** in <u>**seconds**</u> (s)



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Example 1:

An electric kettle has 2.5kW. How much energy is transferred in 3min?

Energy = (2.5 x 1000) (3 x <u>60</u>) = 450,000J

Example 2:

What is the distance moved by a 6kg box gliding at 2m s^{-1} when friction is 3N?

- Initial KE = ½ x 4 x 6 = 12J; Final KE = 0J
- ½mv^2 = F x s
- Distance = 12/3 = 4m

Example 3:

A man exerts a force, F, to push a 2kg box 5m up an 8m long slope at a constant speed. Friction is 3N. Calculate force F.

- Final E = Initial E + Net work done
- mgh = F(8) - (3)(8)J
- 2x10x5 = F(8)-24J
- 8F = 124J
- F = 15.5J

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Power

- Definition: The rate of doing work

$$\boldsymbol{Power = \frac{Work}{Time} \ or \ \frac{Force \times Distance}{Time}}$$

$$Average\ Power = \frac{Total\ work\ done\ by\ force}{Total\ time}$$

- Unit: Watt (**W**) / Joules per second (J s^{-1})

Example 1:

A man is doing push-ups. He applies a force of 300N as he pushes up 0.5m. He does 10 push-ups in 30s. What is his average power output in 30s?

- Power = W/t = (F x s) /t = (300 x 0.5 x 10) / 30 = 50W

Example 2:

What information is not required to find useful work done of man going up stairs?

- Horizontal distance NOT needed! [finds work done against friction]
- <u>Vertical</u> height is needed as it is same direction as the weight (e.g. work done by person weighing 600N, upstairs with 3m vertical height = 600 x 3 = 1800J)

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Example 3:

A man of 80kg jumps 39km above earth's surface and parachute opens 3km above. During freefall, gravitational field strength increased from 9.7N kg^{-1} to 9.8N kg^{-1}. Estimate the loss in E_p during freefall.

- Initial E_p 36km above
  = mgh = (80)(9.7)(36)

  = 27,936**k**J
- Final E_p 3km above
  = mgh = (80)(9.8)(3)

  = 2352**k**J
- Loss in E_p
  = 27,936 - 2352 = 25,584**k**J

Example 4:

State energy change that occurs during fall and explain why man's speed does not depend on his mass (air resistance negligible).

- Loss in E_p, which is converted to E_k
- Object with greater mass has more GPE, but requires more conversion to KE to move at same speed as object with smaller mass
- Hence, man's speed depends on gravitational field strength, not mass

Efficiency

- Efficiency = **(Useful output energy/Total input energy) x 100%**
- Efficiency = **(Useful mechanical work done/Total input energy) x 100%**
- Efficiency = **(Useful output power/Total input power) x 100%**