Energy & Power Equations

08/11/25 Physics

Context

- For the most part energy and power equations at Higher are the same as at Nat 5.
- Some questions will revolve around the law of conservation of energy, including new types of questions in unit 2.

Definitions

- Power – the energy consumed per unit time
- Conservation of Energy – energy can be neither created nor destroyed, just transferred from one form to another

Equations

- Power – $P = E/t$
- Gravitational Potential Energy – $E_p = mgh$
- Kinetic Energy – $E_k = \frac{1}{2}mv^2$
- Heat Energy – $E_h = cm\Delta T$
- Electrical Energy – $E_e = VIt$
- Work Done – $E_w = Fd$

Technique

- A skiier of mass 60 kg skis frictionless down a slope, starting from an altitude of 26.1m. What velocity does she have when she reaches the bottom of the slope?
- E_p lost = E_k gained
- $mgh = \frac{1}{2}mv^2$
- $60 \times 9.8 \times 26.1 = \frac{1}{2} \times 60 \times v^2$

$\Rightarrow v^2 = 511.56$ $\qquad v = 22.6ms^{-1}$

Thing to Remember

- The line 'E_p lost = E_k gained' is very important (shows knowledge of the conservation of energy)

Momentum and Collisions

08/11/25 Physics

Context

- Momentum is one of the most common ODU questions to come up and appears in different varieties.
- However, all of these variants have the same structure in terms of their calculations.

Definitions

- Momentum – a measure of an object's motion calculated from the product of its mass and velocity
- Law of conservation of momentum – in the absence of net external forces (also acceptable: in an isolated system) momentum is always conserved, e.g. the total momentum before the collision is the same as after the collision.
- Elastic collision – a collision where kinetic energy is conserved (the two objects rebound)
- Inelastic collision – a collision where kinetic energy is lost (the objects collide and remain locked together)
- Explosion – two objects start moving together before splitting and moving in different directions

Equations

- Conservation of momentum – $m_1v_1 + m_2v_2 = m_3v_3 + m_4v_4$

Technique

- Two cable cars of mass 300kg are travelling towards each other – one at $12ms^{-1}$ to the right, one at $4ms^{-1}$ to the left. What is the velocity of the cars after they couple together during the collision?

- $M_1 v_1 + M_2 v_2 = M_3 v_3$
  $\Rightarrow$ ~~[illegible]~~ $300 \times 12 + 300 \times (-4) = (300 + 300) v_3$ (NB: to the right is positive)
  $\Rightarrow 3600 + (-1200) = 600 v_3$
  $v_3 = \frac{2400}{600} = 4 ms^{-1}$ to the right
- Calculate the kinetic energy lost in the collision and hence state the type of collision.
- E_k before $= \frac{1}{2} \times 300 \times 12^2 + \frac{1}{2} \times 300 \times (-4)^2 = 24\,000 J$
  E_k after $= \frac{1}{2} \times 600 \times 4^2 = 4800 J$
  E_k lost $= 24\,000 - 4800 =$ ~~[illegible]~~ $19\,200 J$ $\therefore$ inelastic collision

Thing to Remember

- Apply sign convention to collisions!

08/11/25

Impulse
Physics

Context

- Impulse is the change in momentum of an object and is used as a way of showing the impact of a collision, e.g. a car crash.
- We want to limit the force of an impact by making its time as long as possible for safety, e.g. with air bags in cars.

Definitions

- Impulse - change in momentum, also force times time

Equations

- Impulse - $Ft = \Delta p$

where does this come from?

- $F = ma \Rightarrow F = m\left(\frac{v-u}{t}\right) \Rightarrow F = \frac{mv - mu}{t}$

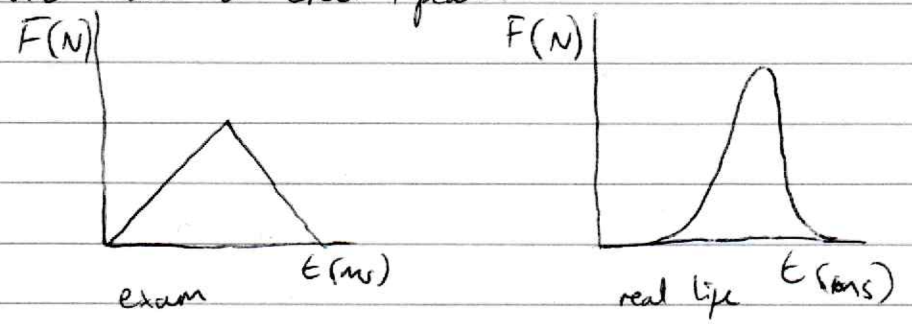
and as $p = mv$

$\therefore F = \frac{p_v - p_u}{t}$

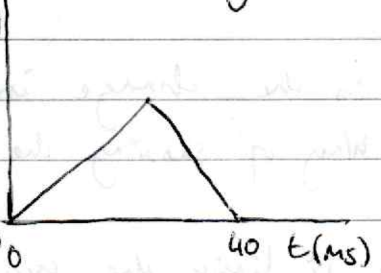
$\Rightarrow Ft = \Delta p$

Technique

- Similar to displacement, impulse is the area under the force-time graph.
- In an exam this will usually be triangular, in reality it is more like a crest / peak:



- ~~Ka~~ The following force-time diagram for a ball already travelling at $5ms^{-1}$. The ball has mass 0.2kg. What is its final velocity?
- Impulse = area under the Ft graph = $\frac{1}{2} \times b \times h$ = 1000Nms



- $Ft = \Delta p \Rightarrow 1000 = 0.2v - 0.2 \times 5$
- ~~1000~~ $1001 = 0.2v \quad v = 5005ms^{-1}$

(over 14 times the speed of sound)

Thing to Remember

- We try and increase the time taken in a collision so that, because the impulse remains the same, the force will be reduced.