Topic 5: Impacts and Collisions

1) Impacts:

a) Formulae:

Coefficient of Restitution:

$$-e = \frac{new\ velocity}{old\ velocity} = \frac{v}{u}$$

Impulse:

$$\vec{I} = m\vec{v} - m\vec{u}$$

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Potential/Kinetic Energy:

$$KE = \frac{1}{2}mv^2 \qquad PE = mgh$$

b) Other rules and results:

Notes:

- 'e' is the coefficient of restitution and can take values between 0 and 1
  - If e = 0 => perfectly inelastic
  - If e = 1 => perfectly elastic
- For impacts off horizontal or vertical surfaces (e.g. snooker cushions):
  - If impact is in $\vec{i}$ direction => $\vec{j}$ velocity unchanged
  - If impact is in $\vec{j}$ direction => $\vec{i}$ velocity unchanged
- The Kinetic Energy Lost in an impact/collision is given by:

$$K.E\ Lost = KE_{before} - KE_{after}$$

- When two objects collide, the impulse imparted to both will have the same magnitude but opposite directions/signs.

2) Direct/Oblique Collisions:

a) Direct Collisions:

Steps:

1) Make out "Before, Mass and After" table. (Remember particles moving right => positive $\vec{i}$ component, particles moving left => negative $\vec{i}$ component)

2) Use Law of Restitution to form an equation:

$$-e = \frac{v_1 - v_2}{u_1 - u_2}$$

3) Use Law of Conservation of Momentum to form an equation:

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

4) Solve the two equations from steps 2 and 3 together.

b) Oblique Collisions:

Notes:

- Steps are the same as with Direct Collisions.
- Two types of problem:
  - Angle of particle after impact given:

Before	Mass	After
$u\cos A\,\vec{i} + u\sin A\,\vec{j}$	m	$v\cos B\,\vec{i} + v\sin B\,\vec{j}$
$0\vec{i} + 0\vec{j}$	2m	$p\vec{i} + 0\vec{j}$

  - Particle deflects through a certain angle:

Before	Mass	After
$u\cos A\,\vec{i} + u\sin A\,\vec{j}$	m	$p\vec{i} + u\sin A\,\vec{j}$
$0\vec{i} + 0\vec{j}$	2m	$q\vec{i} + 0\vec{j}$

- When forming your two equations using the laws on the left, remember you only need to use the $\vec{i}$ components
- When the angle of deflection is mentioned, you may also need:

$$\text{Tan } \theta = \pm \frac{m_1 - m_2}{1 + m_1m_2}$$

3) General Tips for Exam Question:

- Do lay out the information clearly.
- Do remember that the j-velocities will not change (if the i-axis in the line of centres at impact)
- Do you know your theory of vectors well.
- Don't forget to put the minus in front of 'e' in NEL.
- Don't apply NEL to both directions, just to the direction of impact.
- Don't confuse momentum and kinetic energy.