Q. 2.

Before	(Mass)	After
$2u\cos A\vec{i} + 2u\sin A\vec{j}$	$2M$	$p\vec{i} + 2u\sin A\vec{j}$
$-u\vec{i} + 0\vec{j}$	M	$0\vec{i} + 0\vec{j}$

(i) $2M(2u\cos A) + M(-u) = 2M(p) + M(0)$

$$\Rightarrow p = 2u\cos A - \frac{1}{2}u$$

$$\frac{p-0}{2u\cos A + u} = \frac{-5}{118}$$

$$\Rightarrow 118p = -10u\cos A - 5u$$

But $p = 2u\cos A - \frac{1}{2}u$

$$\therefore 118\left(2u\cos A - \frac{1}{2}u\right)$$

$$= -10u\cos A - 5u$$

$$\Rightarrow 236\cos A - 59 = -10\cos A - 5$$

$$\Rightarrow \cos A = \frac{9}{41}$$

$$\Rightarrow \sin A = \frac{40}{41}$$

(ii) $p = 2u\cos A - \frac{1}{2}u$

$$= 2u\left(\frac{9}{41}\right) - \frac{1}{2}u = \frac{-5u}{82}$$

$$2u\sin A = 2u\left(\frac{40}{41}\right) = \frac{80u}{41} = \frac{160u}{82}$$

$\therefore$ Velocity after impact

$$= \frac{u}{82}(-5\vec{i} + 160\vec{j})$$

$$= \frac{5u}{82}(-\vec{i} + 32\vec{j})\text{ m/s}$$

Q. 3. (i)

Before	(Mass)	After
$4u$	m	p
$2u$	m	q

$m(4u) + m(2u) = m(p) + m(q)$

… divide by m

$\Rightarrow p + q = 6u$ **Equation 1**

$$\frac{p-q}{4u-2u} = -e$$

$\Rightarrow p - q = -2eu$ **Equation 2**

Adding equations **1** and **2** we get

$2p = 2u(3 - e)$

$\Rightarrow p = u(3 - e)$

$q = 6u - p$ from **Equation 1**

$\Rightarrow q = 6u - u(3 - e)$

$\Rightarrow q = 3u + eu$

$\Rightarrow q = u(3 + e)$

$$\text{K.E.}_{\text{before}} = \frac{1}{2}(m)(4u)^2 + \frac{1}{2}(m)(2u)^2$$

$$= 10mu^2$$

$$\text{K.E.}_{\text{after}} = \frac{1}{2}(m)[u(3-e)^2] + \frac{1}{2}(m)[u(3+e)]^2$$

$$= \frac{1}{2}(m)[u^2(9 - 6e + e^2 + 9 + 6e + e^2)]$$

$$= \frac{1}{2}(m)[u^2(18 + 2e^2)]$$

$$= mu^2(9 + e^2)$$

$$\text{Loss} = 10mu^2 - mu^2(9 + e^2)$$

$$= mu^2 - mu^2e^2$$

$$= mu^2(1 - e^2)$$

(ii) Firstly, calculate velocity of first sphere before impact:

$4u\cos 30°\vec{i} + 4u\sin 30°\vec{j}$

$$= 4u\left(\frac{\sqrt{3}}{2}\right)\vec{i} + 4u\left(\frac{1}{2}\right)\vec{j}$$

$= 2u\sqrt{3}i + 2u\vec{j}$

Before	(Mass)	After
$2u\sqrt{3}\vec{i} + 2u\vec{j}$	m	$p\vec{i} + 2u\vec{j}$
$0\vec{i} + 0\vec{j}$	m	$q\vec{i} + 0\vec{j}$

Momentum in the $\vec{i}$–direction is conserved

$\Rightarrow m(2u\sqrt{3}) + m(0) = m(p) + m(q)$

… divide by m

$\Rightarrow p + q = 2u\sqrt{3}$ **Equation 3**

N.E.L.

$$\frac{p-q}{2u\sqrt{3} - 0} = -e$$

$\Rightarrow p - q = -2eu\sqrt{3}$ **Equation 4**

Adding equations **3** and **4** we get

$2p = 2u\sqrt{3}(1 - e)$

$\Rightarrow p = u\sqrt{3}(1 - e)$

$\Rightarrow$ velocity of 1st sphere after impact

$= u\sqrt{3}(1 - e)\vec{i} + 2u\vec{j}$

$q = 2u\sqrt{3} - p$ from **Equation 3**