Q. 3. **Before** **After**

$u \sin A\vec{i} - u \cos A\vec{j}$ $u \sin A\vec{i} + p\vec{j}$

$\frac{\text{NEW}}{\text{OLD}} = -e$

$\Rightarrow \frac{p}{-u \cos A} = \frac{-1}{4}$

$\Rightarrow p = \frac{1}{4}u \cos A$

Initial Speed $= u \sin A\vec{i} + \frac{1}{4}u \cos A\vec{j}$

$s_y = 0$

$\Rightarrow \frac{1}{4}u \cos At - \frac{1}{2}g \cos At^2 = 0$

$\Rightarrow t = 0$ **OR** $t = \frac{u}{2g}$

At $t = \frac{u}{2g}$,

$s_x = u \sin At + \frac{1}{2}g \sin At^2$

$= u \sin A\left(\frac{u}{2g}\right) + \frac{1}{2}g \sin A\left(\frac{u^2}{4g^2}\right)$

$= \frac{5u^2 \sin A}{8g}$

At the first hop $\left(\text{when } t = \frac{u}{2g}\right)$,

$v_x = u \sin A + g \sin At$

$= u \sin A + g \sin A\left(\frac{u}{2g}\right)$

$= \frac{3}{2}u \sin A$

$v_y = \frac{1}{4}u \cos A - g \cos At$

$= \frac{1}{4}u \cos A - g \cos A\left(\frac{u}{2g}\right)$

$= -\frac{1}{4}u \cos A$

After the first hop,

$v_x = \frac{3}{2}u \sin A$ and $v_y = -\frac{1}{4}\left(-\frac{1}{4}u \cos A\right)$

$= \frac{1}{16}u \cos A$

Second hop:

Initial speed $= \frac{3}{2}u \sin A\vec{i} + \frac{1}{16}u \cos A\vec{j}$

$s_y = 0$

$\Rightarrow \frac{1}{16}u \cos At - \frac{1}{2}g \cos At^2 = 0$

$\Rightarrow t = 0$ **OR** $t = \frac{u}{8g}$

At $t = \frac{u}{8g}$

$s_x = \frac{3}{2}u \sin A\, t + \frac{1}{2}g \sin At^2$

$= \frac{3}{2}u \sin A\left(\frac{u}{8g}\right) + \frac{1}{2}g \sin A\left(\frac{u^2}{64g^2}\right)$

$= \frac{25u^2 \sin A}{128g}$

Q. 4. $v_x = 13u\left(\frac{12}{13}\right) - gt \sin 45°$

$= 12u - \frac{gt}{\sqrt{2}}$

$v_y = 13u\left(\frac{5}{13}\right) - gt \cos 45°$

$= 5u - \frac{gt}{\sqrt{2}}$

$s_x = 13ut\left(\frac{12}{13}\right) - \frac{1}{2}gt^2 \sin 45°$

$= 12ut - \frac{gt^2}{2\sqrt{2}}$

$s_y = 13ut\left(\frac{5}{13}\right) - \frac{1}{2}gt^2 \cos 45°$

$= 5ut - \frac{gt^2}{2\sqrt{2}}$

Need to find landing velocity, i.e. need to find v_x and v_y when $s_y = 0$

$5ut - \frac{gt^2}{2\sqrt{2}} = 0$

$\Rightarrow 10ut\sqrt{2} - gt^2 = 0$

$\Rightarrow t(10u\sqrt{2} - gt) = 0$

$\Rightarrow t = 0$ (Point of Projection) $\quad \underbrace{t = \frac{10u\sqrt{2}}{g}}_{\text{Time of Flight}}$

$v_x = 12u - \frac{g}{\sqrt{2}}\left[\frac{10u\sqrt{2}}{g}\right]$

$= 12u - 10u$

$= 2u$

$v_y = 5u - \frac{g}{\sqrt{2}}\left[\frac{10u\sqrt{2}}{g}\right]$

$= 5u - 10u$

$= -5u$

$\Rightarrow$ Velocity at landing $= 2u\vec{i} - 5u\vec{j}$

$\vec{j}$-velocity after impact $= -5(-e)$

$= 5e = 5\left(\frac{2}{5}\right)$

$= 2$