Range for 2nd hop = 2[Range for 1st hop]

$\Rightarrow \frac{eu^2}{g}[3 + e] = 2\left[\frac{2u^2}{g}\right]$ ... multiply by $\frac{g}{u^2}$

$\Rightarrow e(3 + e) = 4$

$\Rightarrow 3e + e^2 = 4$

$\Rightarrow e^2 + 3e - 4 = 0$

$\Rightarrow (e + 4)(e - 1) = 0$

$\Rightarrow$ ~~$e = -4$~~ $e = 1$ ... $0 \leqslant e \leqslant 1$

Q. 6. Fall from height h:

$u = 0, \quad a = g, \quad s = h$

$v = \sqrt{u^2 + 2as} = \sqrt{2gh}$

$\Rightarrow$ Strikes the plane at a speed of $\sqrt{2gh}$

x-component of velocity at impact

$= \sqrt{2gh}\cos 60^\circ = \frac{\sqrt{2gh}}{2} = \frac{\sqrt{gh}}{2}$

y-component of velocity at impact

$= -\sqrt{2gh}\sin 60^\circ = -\sqrt{2gh}\left(\frac{\sqrt{3}}{2}\right) = -\sqrt{\frac{3gh}{2}}$

x-component is unchanged during impact

y-component after impact $= \frac{1}{2}\sqrt{\frac{3gh}{2}}$

Magnitude of velocity after impact

$= \sqrt{\frac{gh}{2} + \frac{3gh}{8}} = \sqrt{\frac{4gh + 3gh}{8}}$

$= \sqrt{\frac{7gh}{8}}$

Let θ be the angle at which the particle leaves the plane

$\tan\theta = \frac{1}{2}\sqrt{\frac{3gh}{2}} \times \sqrt{\frac{2}{gh}}$

$= \frac{\sqrt{3}}{2}$

$\Rightarrow \sin\theta = \frac{\sqrt{3}}{\sqrt{7}}$ and $\cos\theta = \frac{2}{\sqrt{7}}$

Projectile equations are:

$v_x = \left[\sqrt{\frac{7gh}{8}}\right]\left[\frac{2}{\sqrt{7}}\right] + gt\sin 30^\circ$

$= \sqrt{\frac{gh}{2}} + \frac{gt}{2}$

$v_y = \left[\sqrt{\frac{7gh}{8}}\right]\left[\frac{\sqrt{3}}{\sqrt{7}}\right] - gt\cos 30^\circ$

$= \sqrt{\frac{3gh}{8}} - \frac{gt\sqrt{3}}{2}$

$s_x = \left[\sqrt{\frac{7gh}{8}}\right][t]\left[\frac{2}{\sqrt{7}}\right] + \frac{1}{2}gt^2\sin 30^\circ$

$= t\sqrt{\frac{gh}{2}} + \frac{gt^2}{4}$

$s_y = \left[\sqrt{\frac{7gh}{8}}\right][t]\left[\frac{\sqrt{3}}{\sqrt{7}}\right] - \frac{1}{2}gt^2\cos 30^\circ$

$= t\sqrt{\frac{3gh}{8}} - \frac{gt^2\sqrt{3}}{4}$

Range: s_x when $s_y = 0$

$t\sqrt{\frac{3gh}{8}} - \frac{gt^2\sqrt{3}}{4} = 0$ ... multiply by $\frac{4\sqrt{8}}{\sqrt{3}}$

$\Rightarrow 4t\sqrt{gh} - gt^2\sqrt{8} = 0$

$\Rightarrow 4t\sqrt{gh} - 2gt^2\sqrt{2} = 0$

$\Rightarrow 2t\sqrt{gh} - gt^2\sqrt{2} = 0$

$\Rightarrow t\sqrt{2gh} - gt^2 = 0$

$\Rightarrow t\left(\sqrt{2gh} - gt\right) = 0$

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

Range $= \left[\sqrt{\frac{2h}{g}}\right]\sqrt{\frac{gh}{2}} + \frac{g}{4}\left[\frac{2h}{g}\right]$

$\Rightarrow$ Range $= h + \frac{h}{2}$

$= \frac{3h}{2}$