**3. (a)** A particle is projected with a velocity of $u$ m/s at an angle $\beta$ to the horizontal ground.

2000

Show that the particle hits the ground at a distance $\frac{u^2}{g}\sin 2\beta$ from the point of projection.

Find the angle of projection which gives maximum range.

$$\vec{r} = (u\cos\beta.t)\,\vec{i} + (u\sin\beta.t - \tfrac{1}{2}gt^2)\,\vec{j} \qquad 5$$

$$r_j = 0 \quad \Rightarrow \quad t = \frac{2u\sin\beta}{g} \qquad 5$$

$$\text{Range} = u\cos\beta\left(\frac{2u\sin\beta}{g}\right) = \frac{u^2\sin 2\beta}{g} \qquad 5$$

$$\text{For max range} \quad \sin 2\beta = 1 \quad \text{or} \quad \frac{dR}{d\beta} = \frac{u^2\cos 2\beta(2)}{g} = 0$$

$$\Rightarrow \quad \beta = 45^\circ \qquad 5 \qquad \boxed{20}$$