1.) $V_{xi} = 27\cos 10 = 26.59\,ms^{-1}$

$V_{yi} = 27\sin 10 = 4.69\,ms^{-1}$

If we make 2m above ground the x axis, Then we need to see if the ball is higher than 1.5m in y, when it has moved 10m in x.

$$x = x_i + V_{xi}t + \frac{1}{2}a_x t^2$$

$$10 = 26.59t \quad \therefore \quad t = \frac{10}{26.59} = 0.38s$$

$$y = y_i + V_{yi}t + \frac{1}{2}a_y t^2$$

$$y = (4.69 \times 0.38) + \left(\frac{1}{2} \times {}^{-}9.81 \times 0.38^2\right)$$

$$y = 1.07m$$

The defender does intercept the pass as the ball will only be 3.07m above the ground.

2.) a.)

$m_1 = 0.1\ kg$ $\quad$ $m_2 = 0.1\ kg$

$V_{ix} = 5ms^{-1}$ $\quad$ $V_{ix} = {}^{-}2\ ms^{-1}$

$V_{iy} = 0ms^{-1}$ $\quad$ $V_{iy} = 2\ ms^{-1}$

$V_{fx} = 2ms^{-1}$ $\quad$ $V_{fx} = ?$

$V_{fy} = 3ms^{-1}$ $\quad$ $V_{fy} = ?$

momentum is conserved. $\therefore P_f = P_i$

$P_{xi} = 0.1 \times 5 + 0.1 \times {}^{-}2 = 0.3\ kgms^{-1}$

$0.3 = 0.1 \times 2 + V_{fx} \times 0.1$

$\underline{V_{fx} = 1ms^{-1}}$

final velocity vector

$(1\hat{i} - 1\hat{j})$

$P_{yi} = 0.1 \times 2 = 0.2\ kgms^{-1}$

$0.2 = 0.1 \times 3 + V_{fy} \times 0.1$

$\underline{V_{fy} = {}^{-}1ms^{-1}}$

b.) This collision was inelastic

3.) a.)

$F_g = mg = 5 \times 10^{-4} \times 9.81$

$= 4.905 \times 10^{-3}\ N$

Terminal velocity is when the force due to gravity is equal to the drag force. At this point all forces are equal and there is no more acceleration. $\underline{F_g = F_D}$

$F_D = \eta v^2$ where $\eta = 2 \times 10^{-5}\ N$

$\therefore$

$4.905 \times 10^{-3} = 2 \times 10^{-5} \times v^2$

$$\frac{4.905 \times 10^{-3}}{2 \times 10^{-5}} = v^2$$

$$\sqrt{\frac{4.905 \times 10^{-3}}{2 \times 10^{-5}}} = v = 15.66 ms^{-1}$$

b.) $E_{gpe} = mgh = 5 \times 10^{-4} \times 9.81 \times 500$

$= 2.453J$

Energy is conserved $E_{gpe} = E_k$

$E_k = \frac{1}{2} mv^2 \quad v = \sqrt{\frac{2E_k}{m}} \quad v = 99.05 ms^{-1}$

c.) Energy at terminal

$E_k = \frac{1}{2} mv^2 = \frac{1}{2} \times 5 \times 10^{-4} \times 15.66^2 = 0.061J$

The total energy at 500 m was 2.453J. This means that 2.392J were lost due to drag.