A hunter in the plains of Africa is equipped with a bow and arrow. The maximum range of the bow is 100 m. If a Lion charges straight towards him at 30 km/hr and the hunter aims his bow at 30^0 relative to the horizontal find

a) Time of flight of the arrow
b) Arrow velocity
c) How far away should the lion be when the hunter releases the arrow
d) The radius of curvature of the arrow path 1.5 s after launch.

The range of a projectile for a given velocity will be maximum when it is projected at and angle of 45^0 and thus the maximum range is given by

$$R_{\max} = \frac{u^2 \sin(2*45^0)}{g} = \frac{u^2}{g}$$

The maximum range is given equal to 100 m hence the initial velocity of projection u is

$$u = \sqrt{R_{\max} * g} = \sqrt{100*9.8} = 31.3 \text{ m/s}$$

(a) The time of flight is given by

$$T = \frac{2u\sin\theta}{g} = \frac{2*31.3*\sin 30^0}{9.8} = 3.19 \text{ s.}$$

(b) The initial velocity of arrow is already calculated and is 31.3 m/s.

(c) 30 km/h = 30*1000/3600 = 8.33 m/s.

If the arrow hits the lion the distance covered by the lion during the time of flight is

x_1 = 8.33*3.19 = 26.6 m.

And the horizontal distance covered by the arrow (range)

$$x_2 = \frac{u^2 \sin(2\theta)}{g} = \frac{980*\sin 60^0}{9.8} = 86.6 \text{ m}$$

Hence the initial distance of lion from the hunter must be

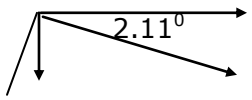
$x_1 + x_2$ = 26.6 + 86.6 = 113.2 m

(d) The velocity of arrow in horizontal direction is constant and is

$u_x = u*\cos\theta = 31.3*\cos 30^0$ = 27.1 m/s

The initial vertical velocity is

$u_y = u*\sin\theta = 31.3*\sin 30^0$ = 15.7 m/s



hence vertical velocity after time 1.5 s is given by

[v = u + a*t]
v_y = 15.7 + (-9.8)*1.5 = - 1.0 m/s

Hence the arrow is coming down at this time with speed

v = $\sqrt{27.1^2 + (-1)^2} = 27.1$ m/s

With angle $\tan^{-1}(-1/27.1) = 2.11^0$ with horizontal.

Component of its weight in the direction perpendicular to the direction of motion at this time (acting as centripetal force) is mg*cos 2.11^0

Hence writing equation of motion of arrow in the direction perpendicular to its motion

$mv^2/R = mg \cos 2.11^0$

Where R is the radius of curvature of the path at that time

Substituting the values we get

$R = v^2/(g*\cos 2.11^0) = 27.1^2/(9.8*0.998) = 75.0$ m