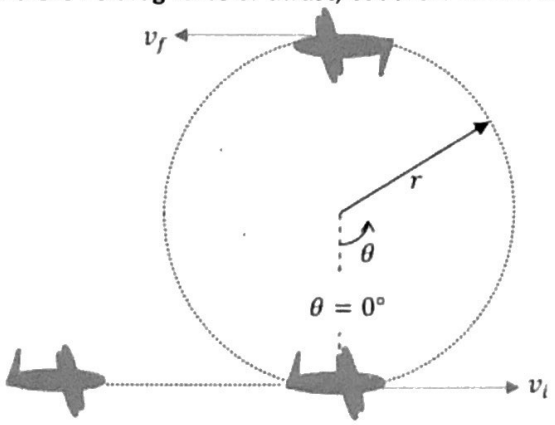
TASK 5

[2 MARKS]

A loop-the-loop flight manoeuvre begins with a plane flying horizontally at an initial speed of v_i . The plane then pulls into an arc to execute the circular motion. For this question, **assume this arc to be perfectly circular** with a radius r as shown in the figure below. **Assume there is no drag force or thrust**, but there is a lift force perpendicular to the plane's motion.



You will need to determine the initial speed vi that is required to complete the manoeuvre

a. **Complete by HAND.** Draw a free body diagram of the plane at an arbitrary position θ in the arc. Note: arbitrary here can be any position $\boldsymbol{\theta}$. For simplicity, we will use $\mathbf{0° < \theta < 90°}$.

b. **Complete by HAND.** Write an equation for the sum of the forces in the radial direction

$$F_c = \frac{mv^2}{r}$$

c. **Complete by HAND.** Write an equation for the sum of the forces in the tangential direction

$$0 = L \cdot \sin\theta - mg$$

8 **Important:** If you are struggling with a task, ensure that you have performed hand-written work (e.g. hand calculations, pseudocode, flow charts) to better understand the processes involved. Do this before asking demonstrators for help and use it to assist with your illustration of the problem.

d. **Complete by HAND.** The necessary condition to maintain circular motion here is that the lift force $\mathcal{L} \geq 0N$ at the top ($\theta = 180°$). Determine the angular speed of the plane at this position required to satisfy this condition

$$\frac{mv^2}{r} = mg$$

$$\therefore v = \sqrt{rg} = \sqrt{9.81r} \qquad w = \sqrt{rg}\, r$$

e. **Complete in MATLAB.** The equation of a circle can be defined by:

$$x_{ord} = r\cos(\theta) + x$$
$$y_{ord} = r\sin(\theta) + y$$

Where r is the radius, x is the x co-ordinate of the centre of the loop and y is the y co-ordinate of the centre of the loop. We want to use this to try and plot the path of the plane as it travels around a loop.

A plane takes off at location $[x = 0m \;\; y = 0m]$ and after travelling a horizontal distance of 500m, the plane is at a height of 200m. At this location, the pilot starts to do a perfect loop with a radius 100m.

Create an **anonymous function (@ function, not a function file)** for both x_{ord} and y_{ord} from the variables θ, x, y **and** r as stated above. Plot the path of the plane as it travels around a loop as **a magenta dashed line**. Plot the centre of the loop as a **black triangle** and **make the axis square**.

2 marks deducted for poor programming practices (missing comments, unnecessary outputs, no axis labels, inefficient coding, etc.)

END OF ASSESSED QUESTIONS

The remainder of this document contains supplementary and exam-type questions for extended learning. Use your allocated lab time wisely!

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