Special Edition

Design Project 2
Predator-Prey Contest

ENGN0040: Dynamics and Vibrations

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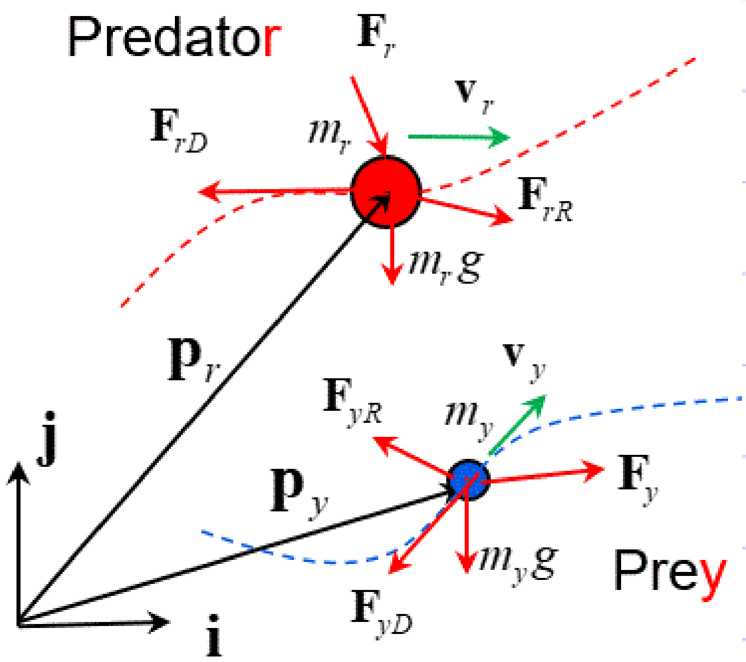
Equations of Motion



$$\mathbf{F}_r^{TOT} = \mathbf{F}_r + \mathbf{F}_{rD} + \mathbf{F}_{rR} - m_r g\mathbf{j}$$

$$\mathbf{F}_y^{TOT} = \mathbf{F}_y + \mathbf{F}_{yD} + \mathbf{F}_{yR} - m_y g\mathbf{j}$$

Unknowns

$\underline{p}_r = (x_r, y_r) \qquad \underline{v}_r = (v_{xr}, v_{yr})$

$\underline{p}_y = (x_y, y_y) \qquad \underline{v}_y = (v_{xy}, v_{yy})$

Total fuel E_r, E_y

Store in MATLAB vector

$$\underline{w} = [\underline{p}_r ; \underline{p}_y ; \underline{v}_r ; \underline{v}_y ; E_r ; E_y]$$

EOM:

$$\frac{d\underline{p}_r}{dt} = \underline{v}_r \qquad \frac{d\underline{p}_y}{dt} = \underline{v}_y$$

$$\frac{d\underline{v}_r}{dt} = \frac{\underline{F}_r^{TOT}}{m_r} \qquad \frac{d\underline{v}_y}{dt} = \frac{\underline{F}_y^{TOT}}{m_y}$$

Energy Consumption

$$\frac{dE_r}{dt} = -0.1\left(|\underline{F}_r|\right)^{3/2} \qquad \frac{dE_y}{dt} = -0.2\left(|\underline{F}_y|\right)^{3/2}$$

Arrange in MATLAB form

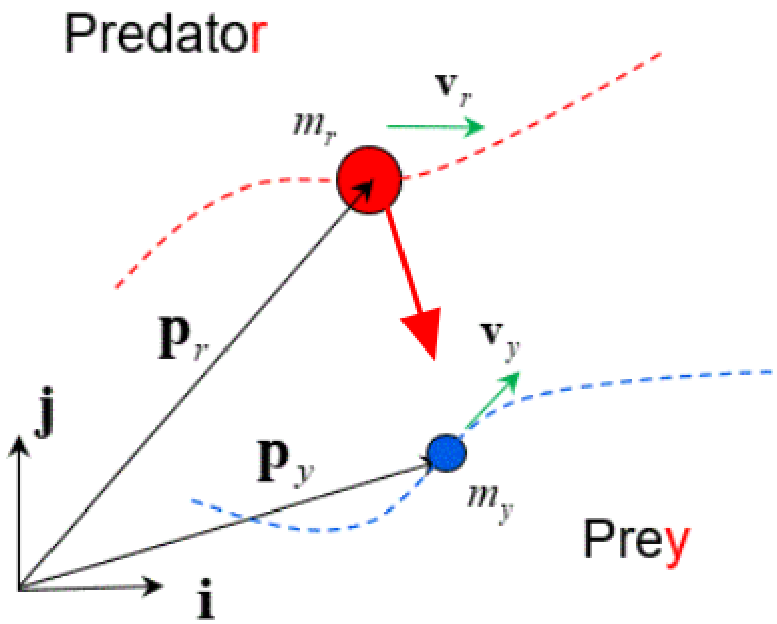
$$\frac{d}{dt}\begin{bmatrix} \underline{p}_r \\ \underline{p}_y \\ \underline{V}_r \\ \underline{V}_y \\ E_r \\ E_y \end{bmatrix} = \begin{bmatrix} \underline{V}_r \\ \underline{V}_y \\ \underline{F}_r^{TOT}/m_r \\ \underline{F}_y^{TOT}/m_y \\ -0.1\left(|\underline{F}_r|\right)^{3/2} \\ -0.2\left(|\underline{F}_y|\right)^{3/2} \end{bmatrix}$$

EOM is already coded in template provided
You will need to add code to find $\underline{F}_y^{TOT}$
(and write your controller code)

Basic Predator Strategy

Apply propulsive force towards prey

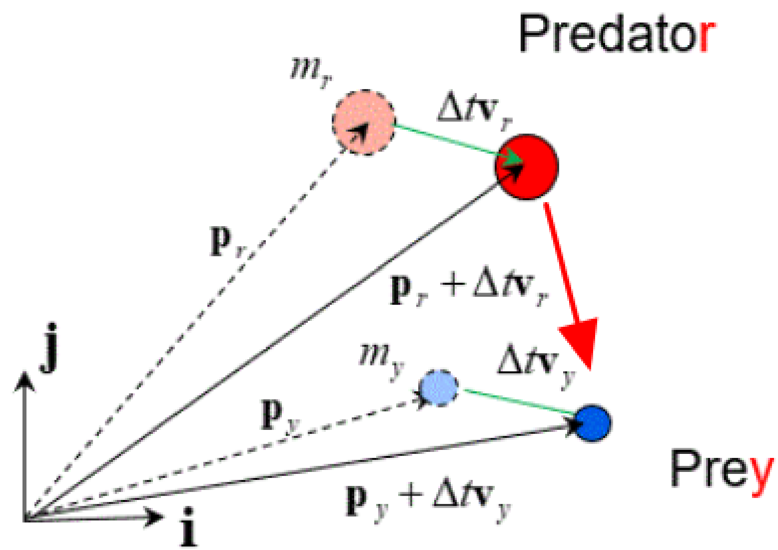
$$F_r = \underbrace{F_r^{max}}_{\text{Magnitude}} \underbrace{\left\{ \frac{p_y - p_r}{|p_y - p_r|} \right\}}_{\text{Direction (unit vector)}}$$



More advanced predator strategy

(1) Predict positions of prey & predator some time Δt later

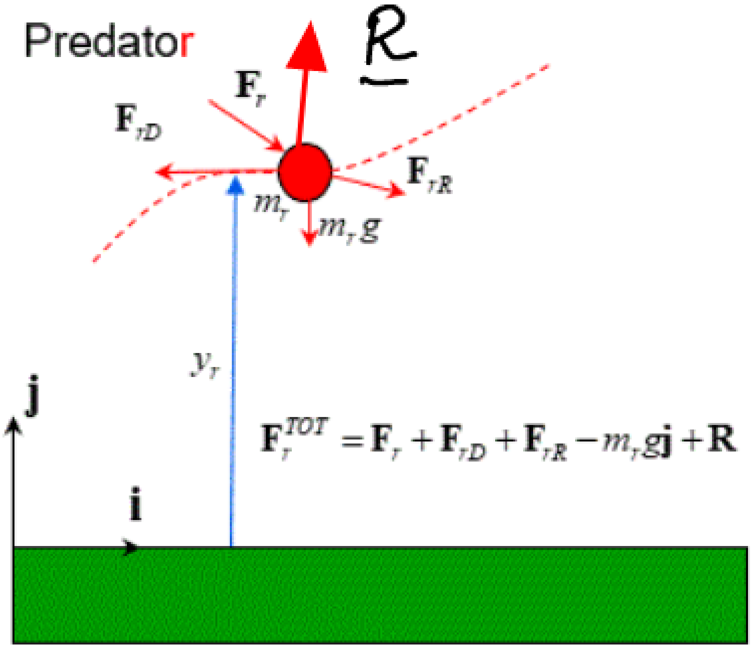
(2) Apply force based on predicted positions



$$F_r = F_r^{max} \left\{ \frac{p_y + \Delta t \underline{V}_y - (p_r + \Delta t \underline{V}_r)}{|p_y + \Delta t \underline{V}_y - (p_r + \Delta t \underline{V}_r)|} \right\}$$

You need to choose a value for Δt

Avoiding ground



Basic strategy (many others!)

Apply increasing vertical force as vehicle approaches ground

Let $\underline{F}_r^0$ be force with no ground correction

$$\underline{R} = \frac{C}{y_r}\,\underline{j} \quad : \text{ground correction}$$

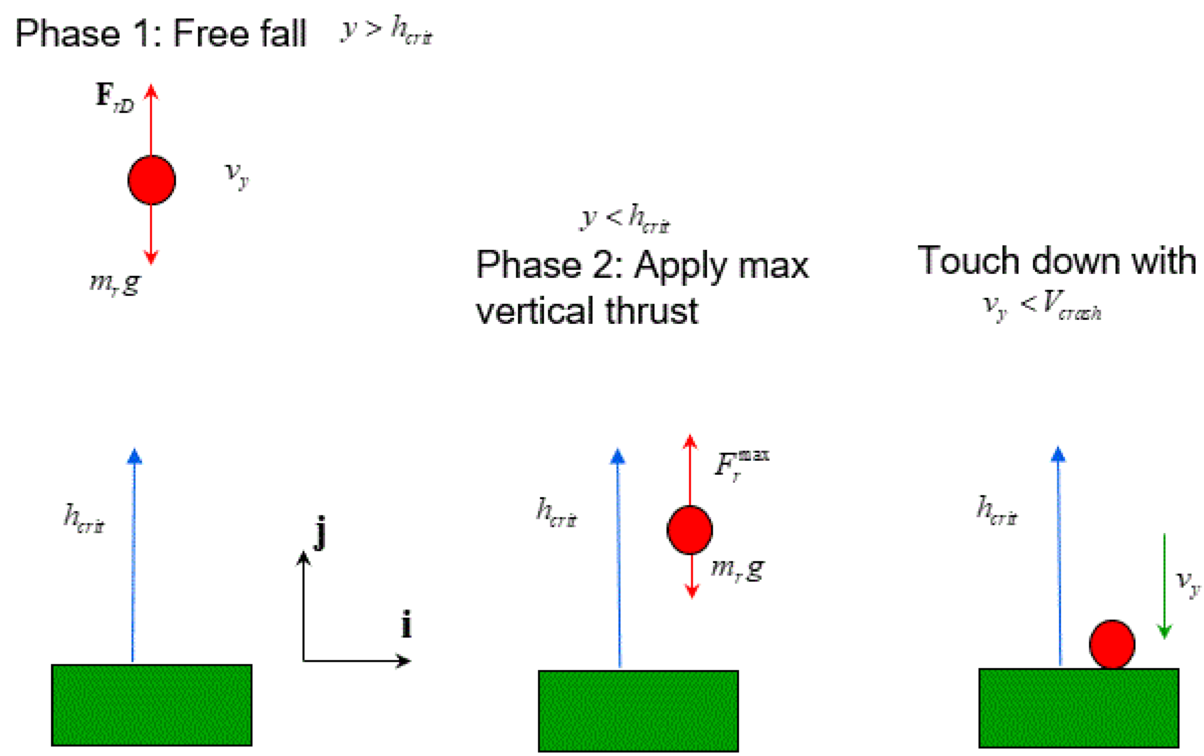
$$\underline{F}_r = F_r^{max}\,(\underline{F}_r^0 + \underline{R}) / (\,|\underline{F}_r^0 + \underline{R}|\,)$$

You will need to choose C

How to land (refueling)

(1) Free fall
($\underline{F}_r = \underline{0}$)

(2) Apply max vertical force when
$y_r < h_{crit}$
to slow down



You can use straight line motion calculus to find h_{crit}

Implement in code with conditional statements