Theoretical Mechanics

Homework 3. Innopolis University, Fall 2020

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Task 1

Solution
The system could be viewed as four bar linkage O_1OAO_2 with a rigid body attached to the OA that is half circle and particle M is moving on the border of the circle.

We can easily find O and A and we can find M by the intersection of the circle that is centered in the center of the Circle with the radius of the circle and the line of OM. Or we can find O and A easily using the cosine and sine of the angle then find M using relative position with O and the angle between OM and OC such that C is the center of the circular rigid body.

$x_o = OO_1 cos\phi$

$y_o = OO_1 sin\phi$

$O_1O_2 = 2 * R$ $x_a = O_2Acos\phi + O_1O_2$

$y_a = O_2Asin\phi + O_1O_2$

$x_M = x_o + cos(\theta)OM$

$y_M = y_o + sin(\theta)OM$

such that $\theta = arcos(OM/2R)$ using cosine rule from triangle OMC

T is the reference frame that is attached to O (non-inertial) and G is the reference frame that attached to O_1 (inertial)

$v^{(T)}_{M/o_{(x)}} = -sin\theta\dot{\theta}OM$

$v^{(T)}_{M/o_{(y)}} = cos\theta\dot{\theta}OM$

$v_{M/o} = \sqrt{(v^{(T)}_{M_{(x)}})^2 + (v^{(T)}_{M_{(y)}})^2}$

$\dot{\theta} = \dot{OM}/(-2Rsin\theta)$

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$v_m = v_M^T + v_o^G$

Relative:

$v_M^T = v_{M/o} + \omega OM$

$\omega = \dot{\phi} = 2 - 0.6t$

Transport:

$v_o^G = v_o + wOO_1$

$v_o = 0$

For acceleration:

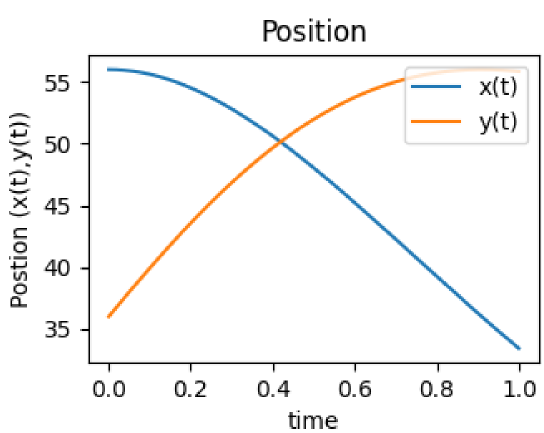
$a_M^G = a_M^T + \alpha^G OO_1 + 2\omega v_M^T + \omega^2 OO_1$

$\alpha = \dot{\omega} = -0.6$

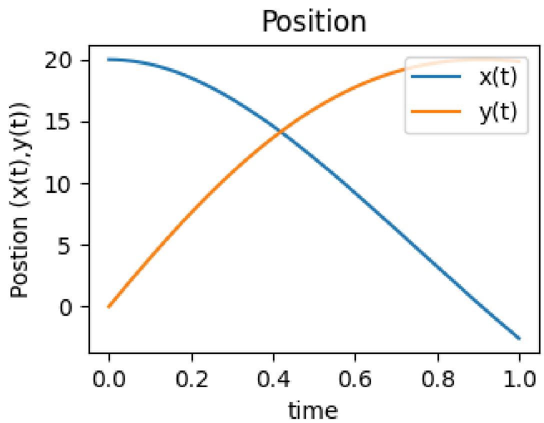
$a_M^T = 0$

And when M reach A, when OM = 2R and solving the equation of OM we can get the time $t = \sqrt{(}R/\pi)$

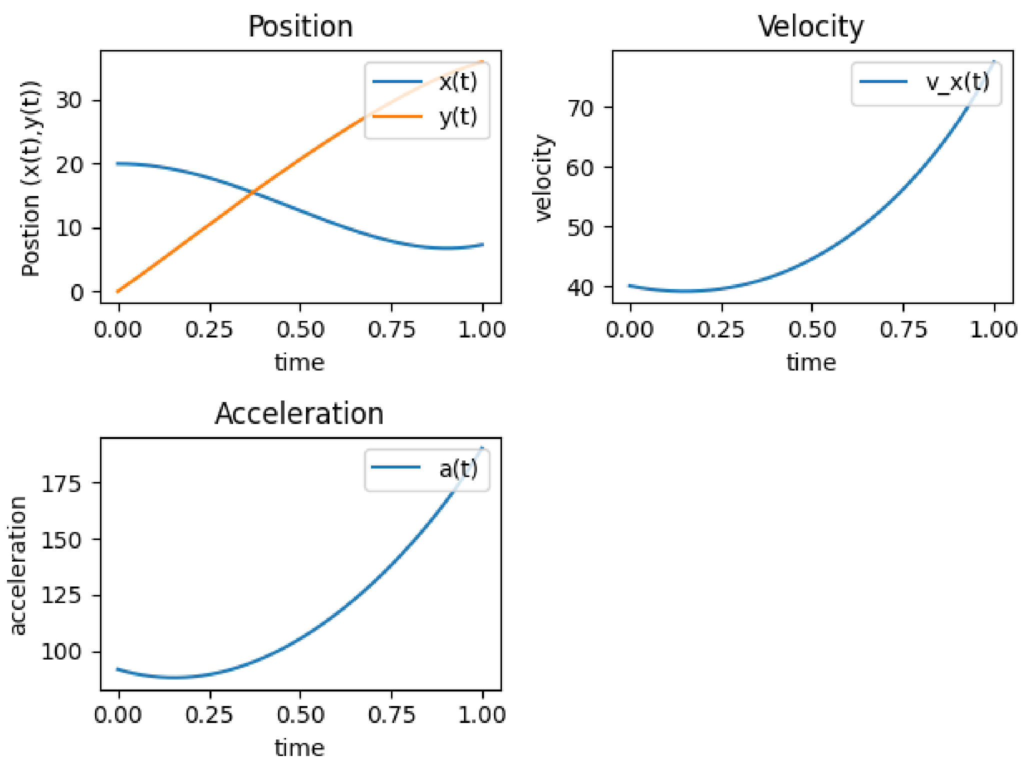
Plots



- **For A**



- **For O**



- **For M**

Task 2

Solution

Position of O can be represented by polar coordinates, thus, M can be found using relative position of O.

$x_o = Rcos\phi$

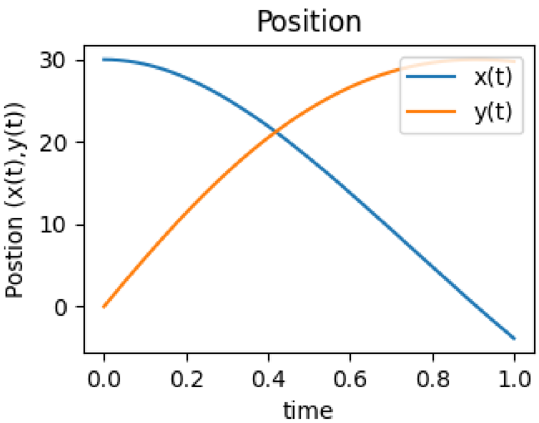
$y_o = Rsin\phi$

$x_M = x_o + cos(\theta)OM$

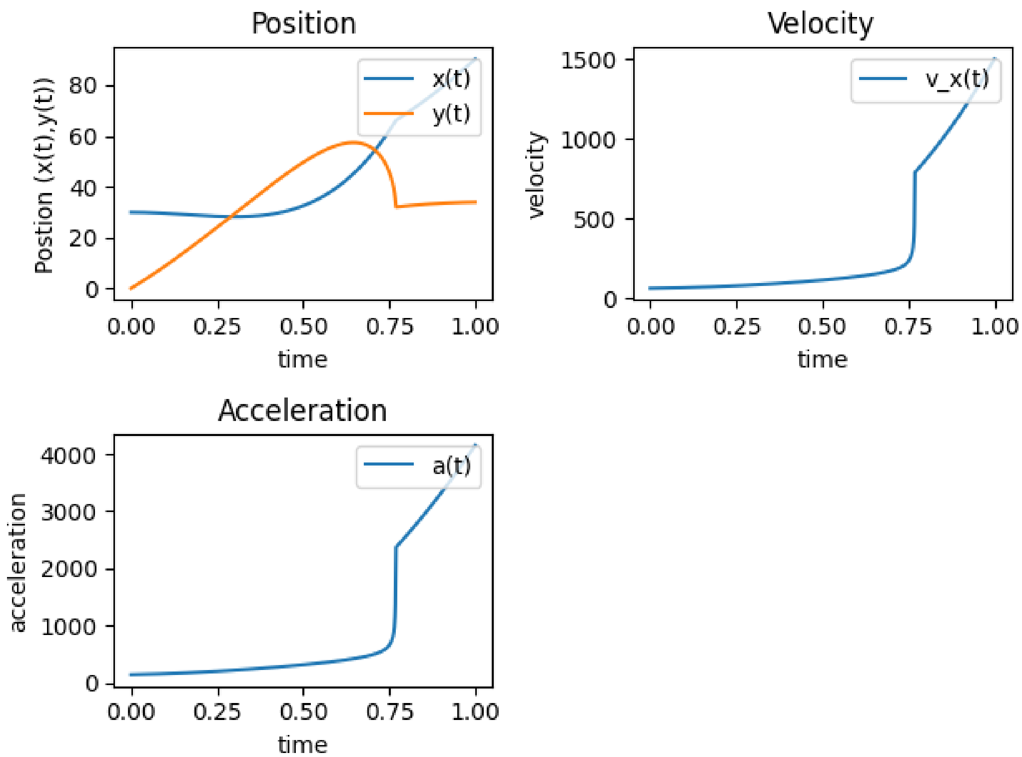
$y_M = y_o + sin(\theta)OM$

such that $\theta = arcos(OM/2R)$ using cosine rule from triangle OMC, such that C is the geometric center of the circle. and the same steps as task1

Plots



- **For O**


Position
x(t)
y(t)
Postion (x(t),y(t))
time
Velocity
v_x(t)
velocity
time
Acceleration
a(t)
acceleration
time

- **For M**