Merry-go-round

The equation of motion in of a ball a stationary x,y plane is defined by:

Out[1]//TraditionalForm=

$$\begin{pmatrix} x(t) = t\, v_x - \frac{R}{2} \\ y(t) = t\, v_y \end{pmatrix}$$

In[2]:=
```
(* Naming the rotational coordinate system x'، y' and is obtained by
 multiplying the stationary coordinate system by the rotation matrix λ*)
```

Out[3]//TraditionalForm=

$$\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} \cos(t\,\omega) & -\sin(t\,\omega) \\ \sin(t\,\omega) & \cos(t\,\omega) \end{pmatrix} . \begin{pmatrix} x(t) \\ y(t) \end{pmatrix}$$

In[4]:=
```
(* subsituting x,y by their equations and compute the matrix multiplication yields*)
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In[5]:=
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x[t_] := Vx * t - R / 2
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In[6]:=
```
y[t_] := Vy * t
```

Out[7]//TraditionalForm=

$$\begin{pmatrix} \left(t\,\mathrm{Vx} - \frac{R}{2}\right)\cos(t\,\omega) - t\,\mathrm{Vy}\sin(t\,\omega) \\ \left(t\,\mathrm{Vx} - \frac{R}{2}\right)\sin(t\,\omega) + t\,\mathrm{Vy}\cos(t\,\omega) \end{pmatrix}$$

The trajectory of this equation of motion in a stationary coordinate system is shown below:

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(* Taking R=5, ω=5, Vx=6, Vy=4*)
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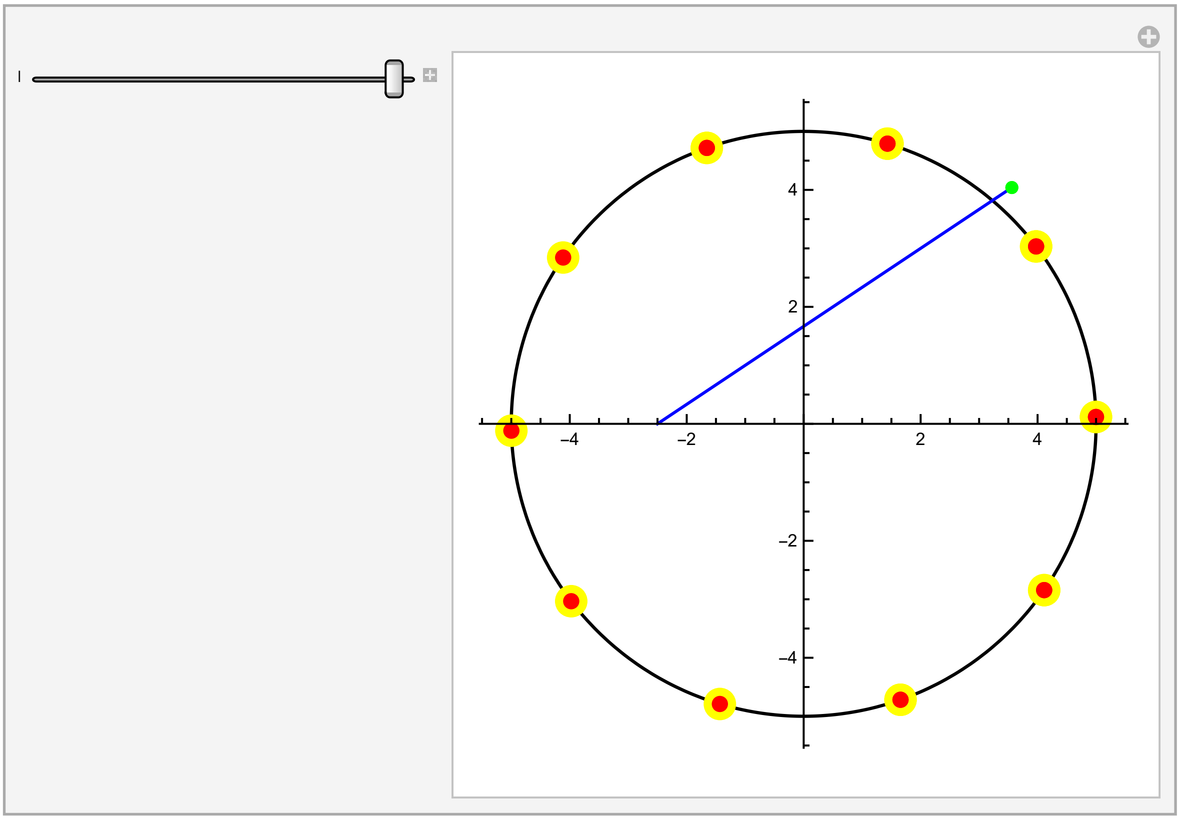
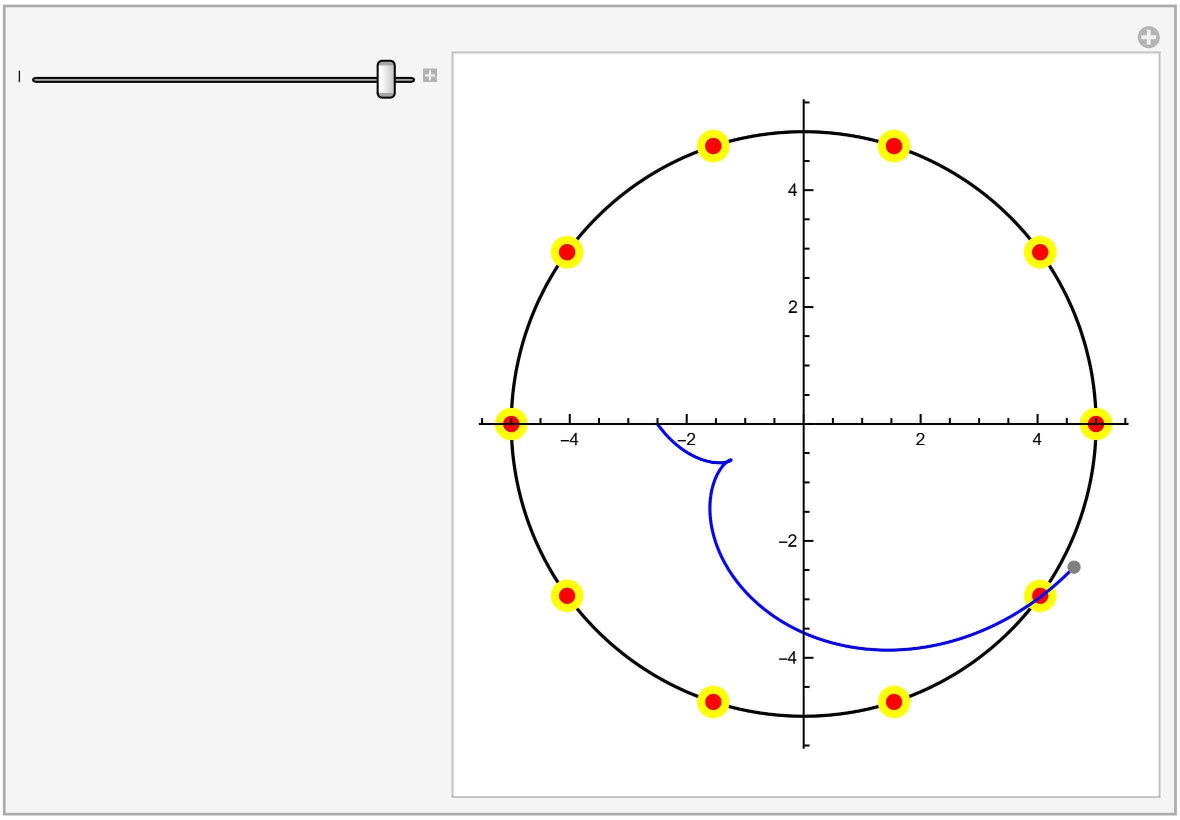
In[9]:=
```
R = 5; ω = 5; Vx = 6; Vy = 4;
```

Out[10]=



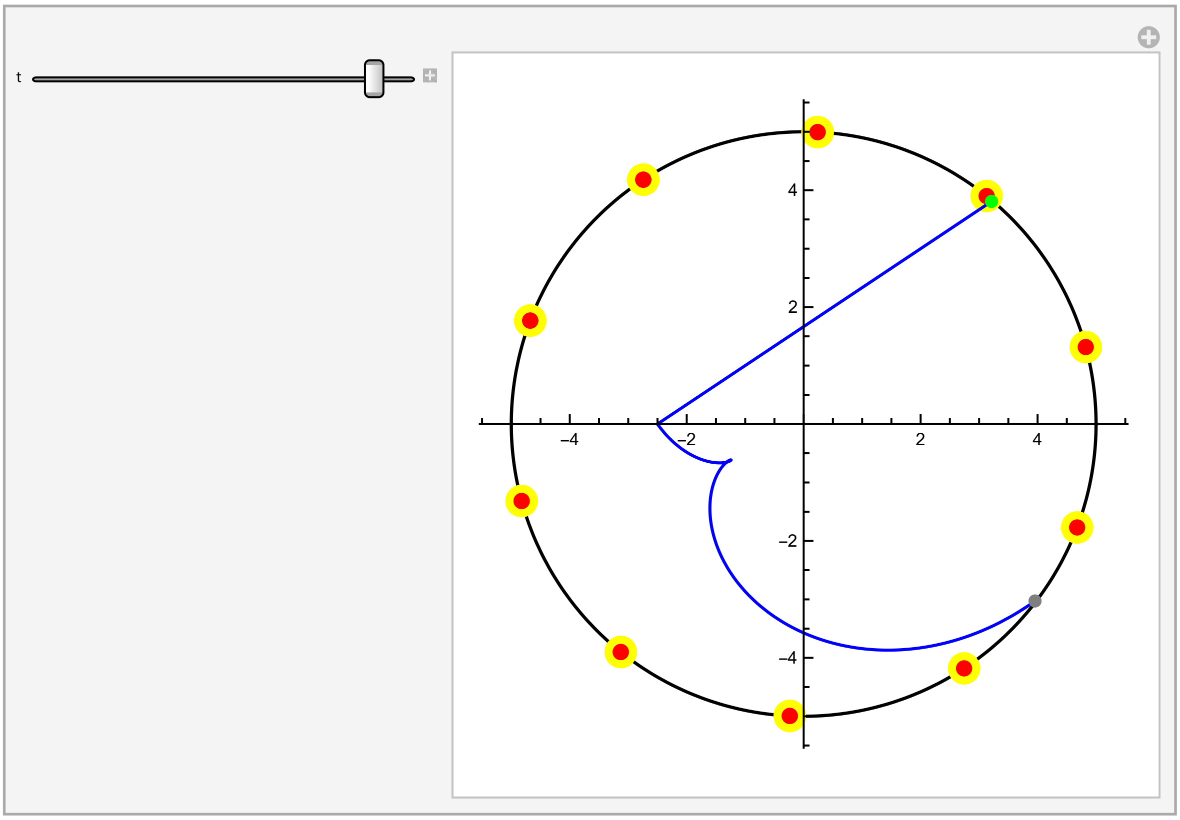
The trajectory of ball when we observe it in a rotating non-inertial frame:

Out[11]=



It is important to show this observation, both of the trajectories will exit the merry-go-round at the same time, which gives us an intuition that the ball have physically exited the merry-go-round no matter what frame you are observing it from:

Out[12]=



Another interesting observation is when we set $\omega = 0$, the trajectories will follow the same path - as expected:

Out[13]=