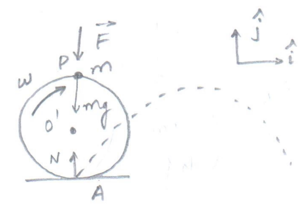
17.3.2 A uniform disk of radius r rolls at a constant rate without slip. A small ball of mass m is attached to the outside edge of the disk. What is the force required to hold the disk in place when the mass is above the center of the disk?

2

16.3.2



$\vec{a}_A = -\omega^2 r \hat{j}$

$\vec{F} = m\vec{a}$

$\vec{a}_{P/O} = \vec{a}_{A/O} + \vec{a}_{P/A}$

$= \omega^2 r \hat{j} - 2\omega^2 r \hat{j}$

$= -\omega^2 r \hat{j}$

Force required to hold the disk

$m\vec{g} + \vec{N} + \vec{F} = m\vec{a}$

$\vec{N}$ can only be positive

$\vec{F} + \vec{N} = -m\omega^2 r \hat{j} + mg\hat{j}$

so, if $g > \omega^2 r$

$\vec{N} = (mg - m\omega^2 r)\hat{j}$ and $F_{required} = 0$

if $g < \omega^2 r$

then,

$\vec{F}_{min} = -(m\omega^2 r - mg)\hat{j}$

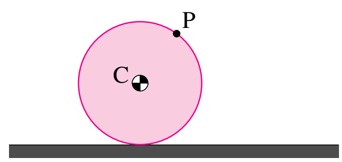
Disclaimer: *We have lost track of the many people who wrote these solutions. They are not official and have not been reviewed by the authors for correctness.*

17.3.3 Rolling at constant rate. A round disk rolls on the ground at constant rate. It rolls $1\frac{1}{4}$ revolutions over the time of interest.

a) **Particle paths.** Accurately plot the paths of three points: the center of the disk C, a point on the outer edge that is initially on the ground, and a point that is initially half way between the former two points. [Hint: Write a parametric equation for the position of the points. First find a relation between ω and v_C. Then note that the position of a point is the position of the center plus the position of the point relative to the center.] Draw the paths on the computer, make sure x and y scales are the same.

b) **Velocity of points.** Find the velocity of the points at a few instants in the motion: after $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$, and 1 revolution. Draw the velocity vector (by hand) on your plot. Draw the direction accurately and draw the lengths of the vectors in proportion to their magnitude. You can find the velocity by differentiating the position vector or by using relative motion formulas appropriately. Draw the disk at its position after one quarter revolution. Note that the velocity of the points is perpendicular to the line connecting the points to the ground contact.

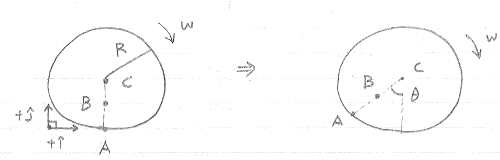
c) **Acceleration of points.** Do the same as above but for acceleration. Note that the acceleration of the points is parallel to the line connecting the points to the center of the disk.



Problem 17.3

For this problem, I looked at the sample derivation done on page 767 in textbook.

14.31



a) point C : $\vec{r}_C = \boxed{R\theta\,\hat{\imath} + R\hat{\jmath}}$

point A : $\vec{r}_A = \vec{r}_C + \vec{r}_{A/C}$

$= \vec{r}_C + (-R\sin\theta\,\hat{\imath} - R\cos\theta\,\hat{\jmath})$

$= R\theta\,\hat{\imath} + R\hat{\jmath} - R\sin\theta\,\hat{\imath} - R\cos\theta\,\hat{\jmath}$

$= \boxed{R(\theta - \sin\theta)\,\hat{\imath} + R(1-\cos\theta)\,\hat{\jmath}}$

point B : $\vec{r}_B = \vec{r}_C + \vec{r}_{B/C}$

$= \vec{r}_C + (-\tfrac{1}{2}R\sin\theta\,\hat{\imath} - \tfrac{1}{2}R\cos\theta\,\hat{\jmath})$

$= R\theta\,\hat{\imath} + R\hat{\jmath} - \tfrac{1}{2}R\sin\theta\,\hat{\imath} - \tfrac{1}{2}R\cos\theta\,\hat{\jmath}$

$= \boxed{R(\theta - \tfrac{1}{2}\sin\theta)\,\hat{\imath} + R(1 - \tfrac{1}{2}\cos\theta)\,\hat{\jmath}}$

plot of path on separate sheets.

b) point C: $\vec{v}_C = \dot{\vec{r}}_C = R\dot{\theta}\hat{\imath}$

$\frac{1}{4}$ rev. $(\theta = \frac{\pi}{2}) \Rightarrow \vec{v}_C = \boxed{R\dot{\theta}\hat{\imath}}$

$\frac{1}{2}$ rev. $(\theta = \pi) \Rightarrow \vec{v}_C = \boxed{R\dot{\theta}\hat{\imath}}$

$\frac{3}{4}$ rev. $(\theta = \frac{3\pi}{2}) \Rightarrow \vec{v}_C = \boxed{R\dot{\theta}\hat{\imath}}$

1 rev. $(\theta = 2\pi) \Rightarrow \vec{v}_C = \boxed{R\dot{\theta}\hat{\imath}}$

point A: $\vec{v}_A = \vec{v}_C + \vec{\omega} \times \vec{r}_{A/C}$

$\frac{1}{4}$ rev. $\Rightarrow \vec{v}_A = R\dot{\theta}\hat{\imath} + \dot{\theta}(-\hat{k}) \times R(-\hat{\imath})$

$= R\dot{\theta}\hat{\imath} + R\dot{\theta}\hat{\jmath} = \boxed{R\dot{\theta}(\hat{\imath}+\hat{\jmath})}$

$\frac{1}{2}$ rev. $\Rightarrow \vec{v}_A = R\dot{\theta}\hat{\imath} + \dot{\theta}(-\hat{k}) \times R(+\hat{\jmath})$

$= R\dot{\theta}\hat{\imath} + R\dot{\theta}\hat{\imath} = \boxed{2R\dot{\theta}\hat{\imath}}$

$\frac{3}{4}$ rev. $\Rightarrow \vec{v}_A = R\dot{\theta}\hat{\imath} + \dot{\theta}(-\hat{k}) \times R(+\hat{\imath})$

$= R\dot{\theta}\hat{\imath} - R\dot{\theta}\hat{\jmath} = \boxed{R\dot{\theta}(\hat{\imath}-\hat{\jmath})}$

1 rev. $\Rightarrow \vec{v}_A = R\dot{\theta}\hat{\imath} + \dot{\theta}(-\hat{k}) \times R(-\hat{\jmath})$

$= R\dot{\theta}\hat{\imath} - R\dot{\theta}\hat{\imath} = \boxed{\vec{0}}$

✓

point B: $\vec{v}_B = \vec{v}_C + \vec{\omega} \times \vec{r}_{B/C}$

$\frac{1}{4}$ rev. $\Rightarrow$ $\vec{v}_B = R\dot{\theta}\hat{\imath} + \dot{\theta}(-\hat{k}) \times \frac{1}{2}R(-\hat{\imath})$

$= \boxed{R\dot{\theta}\left(\hat{\imath} + \frac{1}{2}\hat{\jmath}\right)}$

$\frac{1}{2}$ rev. $\Rightarrow$ $\vec{v}_B = R\dot{\theta}\hat{\imath} + \dot{\theta}(-\hat{k}) \times \frac{1}{2}R(+\hat{\jmath})$

$= \boxed{\frac{3}{2}R\dot{\theta}\hat{\imath}}$

$\frac{3}{4}$ rev. $\Rightarrow$ $\vec{v}_B = R\dot{\theta}\hat{\imath} + \dot{\theta}(-\hat{k}) \times \frac{1}{2}R(+\hat{\imath})$

$= \boxed{R\dot{\theta}\left(\hat{\imath} - \frac{1}{2}\hat{\jmath}\right)}$

1 rev. $\Rightarrow$ $\vec{v}_B = R\dot{\theta}\hat{\imath} + \dot{\theta}(-\hat{k}) \times \frac{1}{2}R(-\hat{\jmath})$

$= \boxed{\frac{1}{2}R\dot{\theta}\hat{\imath}}$

velocity vectors shown on separate sheets. $\longrightarrow$

c) point C: $\vec{a}_C = \dot{\vec{v}}_C = R\ddot{\theta}\hat{\imath} = \boxed{\vec{0}}$ $(\ddot{\theta} = 0)$

point A: $\vec{a}_A = \vec{a}_C + \vec{a}_{A/C}$

$= \vec{a}_C + \cancel{\dot{\vec{\omega}} \times \vec{r}_{A/C}}^{\,0} - \omega^2 \vec{r}_{A/C}$

$\frac{1}{4}$ rev. $\Rightarrow$ $\vec{a}_A = \vec{0} - \dot{\theta}^2 R(-\hat{\imath}) = \boxed{R\dot{\theta}^2\hat{\imath}}$

$\frac{1}{2}$ rev. $\Rightarrow$ $\vec{a}_A = \vec{0} - \dot{\theta}^2 R(+\hat{\jmath}) = \boxed{-R\dot{\theta}^2\hat{\jmath}}$

$\frac{3}{4}$ rev. $\Rightarrow$ $\vec{a}_A = \vec{0} - \dot{\theta}^2 R(+\hat{\imath}) = \boxed{-R\dot{\theta}^2\hat{\imath}}$

1 rev. $\Rightarrow$ $\vec{a}_A = \vec{0} - \dot{\theta}^2 R(-\hat{\jmath}) = \boxed{R\dot{\theta}^2\hat{\jmath}}$

point B: $\vec{a}_B = \vec{a}_C + \vec{a}_{B/C}$

$= \vec{a}_C + \cancel{\dot{\vec{\omega}} \times \vec{r}_{B/C}}^{\,0} - \omega^2 \vec{r}_{B/C}$

$\frac{1}{4}$ rev. $\Rightarrow$ $\vec{a}_A = \boxed{\frac{1}{2}R\dot{\theta}^2\hat{\imath}}$

$\frac{1}{2}$ rev. $\Rightarrow$ $\vec{a}_A = \boxed{-\frac{1}{2}R\dot{\theta}^2\hat{\jmath}}$

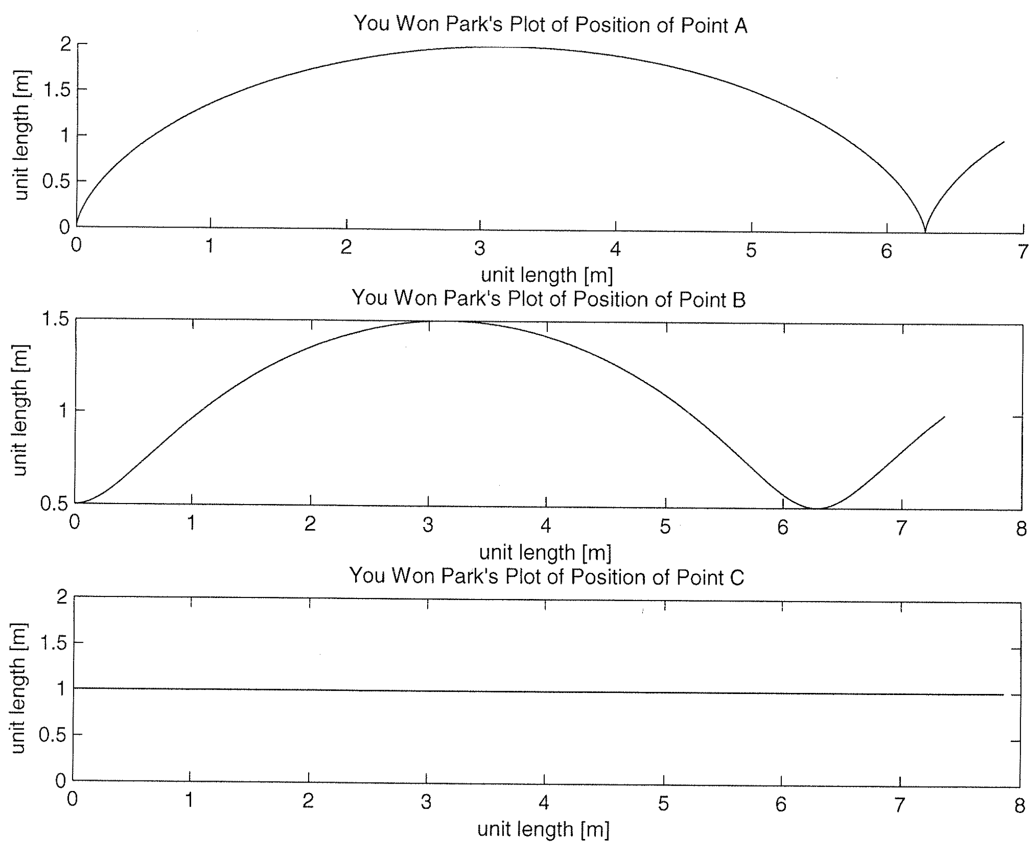
$\frac{3}{4}$ rev. $\Rightarrow$ $\vec{a}_A = \boxed{-\frac{1}{2}R\dot{\theta}^2\hat{\imath}}$

1 rev. $\Rightarrow$ $\vec{a}_A = \boxed{\frac{1}{2}R\dot{\theta}^2\hat{\jmath}}$

acceleration vectors shown on separate sheets.

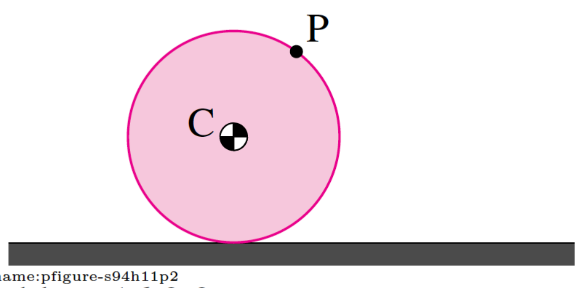
✓

```
function prob1431
% You Won Park's solution to problem 14.31 in HW 17
% Due Mar. 26, 2009

% Constants, initial conditions
R = 1;      % Radius of disk [m]

% Angle interval
angspan = linspace(0,5*pi/2,1001);

% Point C coordinates (center of disk)
rc_x = R*angspan;   % x coord. of C
rc_y = R;           % y coord. of C

% Point A coordinates (ground contact)
ra_x = R*(angspan-sin(angspan));    % x coord. of A
ra_y = R*(1-cos(angspan));          % y coord. of A

% Point B coordinates (halfway)
rb_x = R*(angspan-.5*sin(angspan));     % x coord. of B
rb_y = R*(1-.5*cos(angspan));           % y coord. of B

% Plot positions of A,B,C
figure(1)
subplot(3,1,1)
hold on
plot(ra_x,ra_y,'k')     % Position of A
title('You Won Park''s Plot of Position of Point A')
xlabel('unit length [m]')
ylabel('unit length [m]')

subplot(3,1,2)
plot(rb_x,rb_y,'k')     % Position of B
title('You Won Park''s Plot of Position of Point B')
xlabel('unit length [m]')
ylabel('unit length [m]')

subplot(3,1,3)
plot(rc_x,rc_y,'k')     % Position of C
title('You Won Park''s Plot of Position of Point C')
xlabel('unit length [m]')
ylabel('unit length [m]')

end
```


You Won Park's Plot of Position of Point A
unit length [m]
unit length [m]
You Won Park's Plot of Position of Point B
unit length [m]
unit length [m]
You Won Park's Plot of Position of Point C
unit length [m]
unit length [m]

16.3.3

Saturday, April 20, 2019 12:48 PM



Problem 16.3.3

Rolling at constant rate

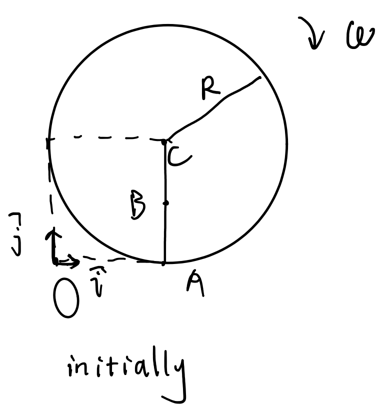
ω is const.

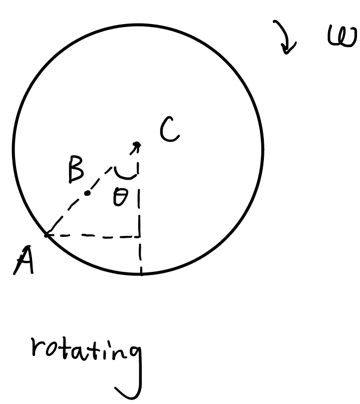
rolls $1\frac{1}{4}$ revolutions in total

a) Particle paths

Accurately plot the path of three points

1. center of the disk C
2. point A on the outer edge that is initially on the ground
3. point B that is initially half way between C and A

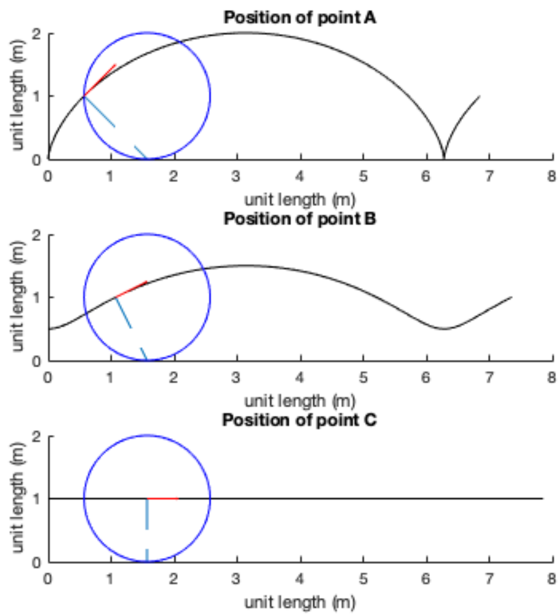


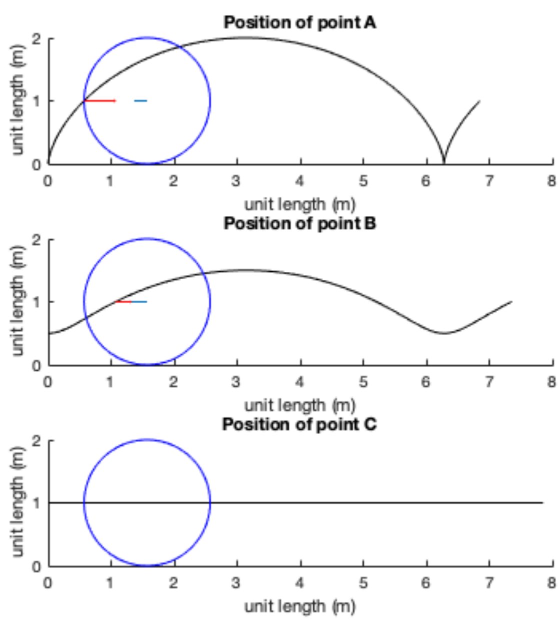


```
clc;
close all;
clear;
dbstop if error
% Initial conditions
R = 1;    % Radius of disk [m]
omega = 1;    % Angular velocity [rad/s]

% Angle interval
npoints = 1001;
angspan = linspace(0,5*pi/2,npoints);    % 5/4 revolution in total

% Point C path coordinates (center of disk)
rc_x = R*angspan;
rc_y = R*ones(1,npoints);

% Point A path coordinates (ground contact)
ra_x = R*(angspan-sin(angspan));
ra_y = R*(1-cos(angspan));

% point B path coordinates (halfway of A and C)
rb_x = 0.5*(ra_x+rc_x);
rb_y = 0.5*(ra_y+rc_y);

% Positions of A,B,C at 1/4 revolution
theta = pi/2;
ra = R*[theta-sin(theta) 1-cos(theta)]';
rc = R*[theta 1]';
rb = 0.5*(ra+rc);

% Velocities of A,B,C at 1/4 revolution
va = R*omega*[1 1]';
vc = R*omega*[1 0]';
vb = 0.5*(va+vc);

% Accelerations of A,B,C at 1/4 revolution
aa = R*omega^2*[1 0]';
ac = [0 0]';
ab = 0.5*(aa+ac);

% Plot paths of A,B,C
% Draw position of the circle and vectors of velocites at 1/4
 revolution
figure
subplot(3,1,1)
axis equal
axis([0 8 0 2])
hold on
plot(ra_x,ra_y,'k');              % path of A
title('Position of point A');
xlabel('unit length (m)');
ylabel('unit length (m)');
```

```
% line w.r.t the contact point with the groud, perpendicular to
 velocity
plot([ra(1) rc(1)],[ra(2) 0],'--')
% position of the circle and vectors of velocites
drawCircleAndVector(rc,R,ra,va);

subplot(3,1,2)
axis equal
axis([0 8 0 2])
hold on
plot(rb_x,rb_y,'k');
title('Position of point B');
xlabel('unit length (m)');
ylabel('unit length (m)');
% line w.r.t the contact point with the groud, perpendicular to
 velocity
plot([rb(1) rc(1)],[rb(2) 0],'--')
% position of the circle and vectors of velocites
drawCircleAndVector(rc,R,rb,vb);

subplot(3,1,3)
axis equal
axis([0 8 0 2])
hold on
plot(rc_x,rc_y,'k');
title('Position of point C');
xlabel('unit length (m)');
ylabel('unit length (m)');
% line w.r.t the contact point with the groud, perpendicular to
 velocity
plot([rc(1) rc(1)],[rc(2) 0],'--')
% position of the circle and vectors of velocites
drawCircleAndVector(rc,R,rc,vc);

% Plot paths of A,B,C
% Draw position of the circle and vectors of accelerations at 1/4
 revolution
figure
subplot(3,1,1)
axis equal
axis([0 8 0 2])
hold on
plot(ra_x,ra_y,'k');
title('Position of point A');
xlabel('unit length (m)');
ylabel('unit length (m)');
% line w.r.t the center of the circle, parallel to the corresponding
 acc
plot([ra(1) rc(1)],[ra(2) rc(2)],'--')
drawCircleAndVector(rc,R,ra,aa);

subplot(3,1,2)
axis equal
axis([0 8 0 2])
```

```
hold on
plot(rb_x,rb_y,'k');
title('Position of point B');
xlabel('unit length (m)');
ylabel('unit length (m)');
% line w.r.t the center of the circle, parallel to the corresponding
 acc
plot([rb(1) rc(1)],[rb(2) rc(2)],'--')
drawCircleAndVector(rc,R,rb,ab);

subplot(3,1,3)
axis equal
axis([0 8 0 2])
hold on
plot(rc_x,rc_y,'k');
title('Position of point C');
xlabel('unit length (m)');
ylabel('unit length (m)');
% line w.r.t the center of the circle, parallel to the corresponding
 acc
plot([rc(1) rc(1)],[rc(2) rc(2)],'--')
drawCircleAndVector(rc,R,rc,ac);

function drawCircleAndVector(rc,R,r,comp)
% Draw a circle with center rc and radius R
% Also draws the vector with acting point r and components comp
    angle = 0:pi/50:2*pi;
    circle_x = rc(1) + R*cos(angle);
    circle_y = rc(2) + R*sin(angle);
    plot(circle_x,circle_y,'b');
    hold on
    scale = 0.5;
    quiver(r(1),r(2),comp(1),comp(2),scale,'r');
end
```





Disclaimer: *We have lost track of the many people who wrote these solutions. They are not official and have not been reviewed by the authors for correctness.*

point C: $\vec{r_C} = R\theta\hat{i} + R\hat{j}$

point A: $\vec{r_A} = \vec{r_C} + \vec{r_{A/C}}$

$= \vec{r_C} + (-R\sin\theta\,\hat{i} + R\cos\theta\,\hat{j})$

$= R(\theta - \sin\theta)\hat{i} + R(1-\cos\theta)\hat{j}$

point B: $\vec{r_B} = \vec{r_C} + \vec{r_{B/C}}$

$= \vec{r_C} + (-\frac{1}{2}R\sin\theta\,\hat{i} + \frac{1}{2}R\cos\theta\,\hat{j})$

$= R(\theta - \frac{1}{2}\sin\theta)\hat{i} + R(1-\frac{1}{2}\cos\theta)\hat{j}$

plot see attached

b) Find velocities of the three points after $\frac{1}{4}, \frac{1}{2}, \frac{3}{4}, 1$ revolution

Draw velocity vector (direction, length)

Draw the position of the disk after $\frac{1}{4}$ revolution

point C: $\vec{V_C} = \dot{\vec{r_C}} = R\dot{\theta}\hat{i}$

$$\left.\begin{array}{ll} \frac{1}{4}\text{ rev.} & (\theta = \frac{\pi}{2}) \\ \frac{1}{2}\text{ rev.} & (\theta = \pi) \\ \frac{3}{4}\text{ rev.} & (\theta = \frac{3\pi}{2}) \\ 1\text{ rev.} & (\theta = 2\pi) \end{array}\right\} \Rightarrow \boxed{\vec{V_C} = R\dot{\theta}\hat{i}}$$

point A: $\vec{V_A} = \vec{V_C} + \vec{\omega} \times \vec{r_{A/C}}$

$\frac{1}{4}$ rev $\Rightarrow$ $\vec{V_A} = R\dot{\theta}\hat{i} + \dot{\theta}(-\hat{k}) \times R(-\hat{i})$

$= R\dot{\theta}(\hat{i} + \hat{j})$

$\frac{1}{2}$ rev $\Rightarrow$ $\vec{V_A} = R\dot{\theta}\hat{i} + \dot{\theta}(-\hat{k}) \times R(+\hat{j})$

$= R\dot{\theta}\hat{i} + R\dot{\theta}\hat{i} = 2R\dot{\theta}\hat{i}$

$\frac{3}{4}$ rev $\Rightarrow$ $\vec{V_A} = R\dot{\theta}\hat{i} + \dot{\theta}(-\hat{k}) \times R(+\hat{i})$

$= R\dot{\theta}\hat{i} - R\dot{\theta}\hat{j} = R\dot{\theta}(\hat{i} - \hat{j})$

1 rev $\Rightarrow$ $\vec{V_A} = R\dot{\theta}\hat{i} + \dot{\theta}(-\hat{k}) \times R(-\hat{j})$

$= R\dot{\theta}\hat{i} - R\dot{\theta}\hat{j} = \vec{0}$

point B: $\vec{V_B} = \vec{V_C} + \vec{\omega} \times \vec{r_{B/C}}$ OR $= \underbrace{\frac{1}{2}(\vec{V_A} + V_C)}$

$\frac{1}{4}$ rev: $\Rightarrow$ $\vec{V_B} = R\dot{\theta}\hat{i} + \dot{\theta}(-\hat{k}) \times \frac{1}{2}R(-\hat{i})$

$= R\dot{\theta}(\hat{i} + \frac{1}{2}\hat{j})$

$\frac{1}{2}$ rev: $\Rightarrow$ $\vec{V_B} = R\dot{\theta}\hat{i} + \dot{\theta}(-\hat{k}) \times \frac{1}{2}R(+\hat{j})$

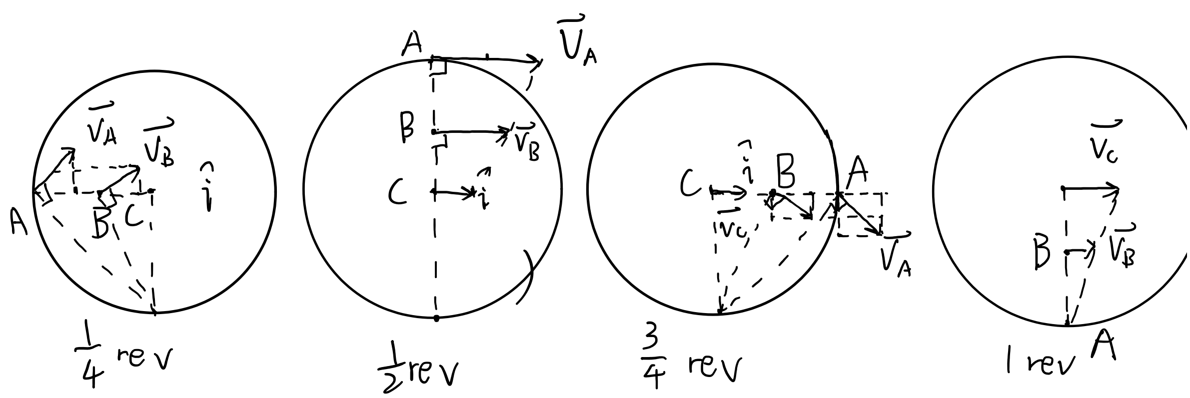
$= \frac{3}{2}R\dot{\theta}\hat{i}$

$\frac{3}{4}$ rev: $\Rightarrow$ $\vec{V_B} = R\dot{\theta}\hat{i} + \dot{\theta}(-\hat{k}) \times \frac{1}{2}R(+\hat{i})$

$= R\dot{\theta}(\hat{i} - \frac{1}{2}\hat{j})$

1 rev: $\Rightarrow$ $\vec{V_B} = R\dot{\theta}\hat{i} + \dot{\theta}(-\hat{k}) \times \frac{1}{2}R(-\hat{j})$

$= \frac{1}{2}R\dot{\theta}\hat{i}$



c) Do the same but for the acceleration of three points

point C: $\vec{a_C} = \dot{\vec{V_C}} = R\ddot{\theta}\hat{i} = \vec{0}$ $(\ddot{\theta} = 0)$

point A: $\vec{a_A} = \vec{a_C} + \vec{a_{A/C}}$

$$= \vec{a}_c + \dot{\vec{\omega}} \times \cancel{\vec{r}_{A/c}}^{\,0} - \omega^2 \vec{r}_{A/c}$$

$\frac{1}{4}$ rev $\Rightarrow$ $\vec{a}_A = \vec{0} - \dot{\theta}^2 R(-\hat{i}) = R\dot{\theta}^2\hat{i}$

$\frac{1}{2}$ rev $\Rightarrow$ $\vec{a}_A = \vec{0} - \dot{\theta}^2 R(+\hat{j}) = -R\dot{\theta}^2\hat{j}$

$\frac{3}{4}$ rev $\Rightarrow$ $\vec{a}_A = \vec{0} - \dot{\theta}^2 R(\hat{i}) = -R\dot{\theta}^2\hat{i}$

1 rev $\Rightarrow$ $\vec{a}_A = \vec{0} - \dot{\theta}^2 R(-\hat{j}) = R\dot{\theta}^2\hat{j}$

point B: $\vec{a}_B = \vec{a}_c + \vec{a}_{B/c}$

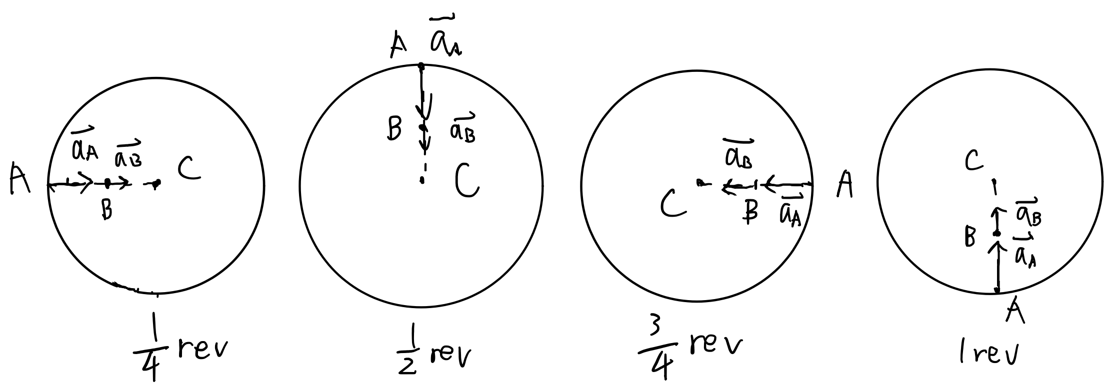
$$= \vec{a}_c + \dot{\vec{\omega}} \times \cancel{\vec{r}_{B/c}}^{\,0} - \omega^2 \vec{r}_{B/c} \overset{\text{OR}}{=} \underbrace{\frac{1}{2}(\vec{a}_A + \vec{a}_c)}$$

$\frac{1}{4}$ rev $\Rightarrow$ $\vec{a}_B = \frac{1}{2}R\dot{\theta}^2\hat{i}$

$\frac{1}{2}$ rev $\Rightarrow$ $\vec{a}_B = -\frac{1}{2}R\dot{\theta}^2\hat{j}$

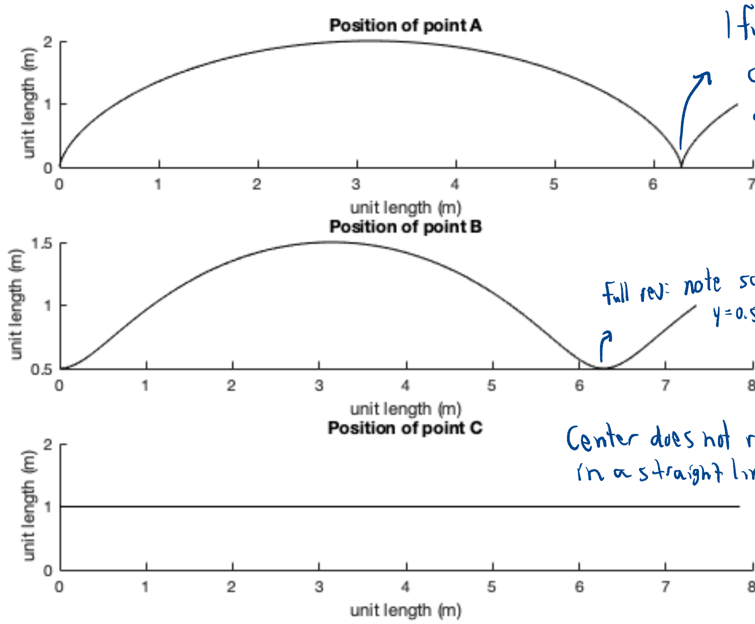
$\frac{3}{4}$ rev $\Rightarrow$ $\vec{a}_B = -\frac{1}{2}R\dot{\theta}^2\hat{i}$

1 rev $\Rightarrow$ $\vec{a}_B = \frac{1}{2}R\dot{\theta}^2\hat{j}$



Disclaimer: *We have lost track of the many people who wrote these solutions. They are not official and have not been reviewed by the authors for correctness.*

```
% Initial conditions
R = 1;   % Radius of disk [m]

% Angle interval
npoints = 1001;
angspan = linspace(0,5*pi/2,npoints);    % 5/4 revolution in total

% Point C coordinates (center of disk)
rc_x = R*angspan;
rc_y = R*ones(npoints);

% Point A coordinates (ground contact)
ra_x = R*(angspan-sin(angspan));
ra_y = R*(1-cos(angspan));

% point B coordinates (halfway of A and C)
rb_x = R*(angspan-0.5*sin(angspan));
rb_y = R*(1-0.5*cos(angspan));

% Plot positions of A,B,C
figure(1)
subplot(3,1,1)
hold on
plot(ra_x,ra_y,'k');
title('Position of point A');
xlabel('unit length (m)');
ylabel('unit length (m)');

subplot(3,1,2)
hold on
plot(rb_x,rb_y,'k');
title('Position of point B');
xlabel('unit length (m)');
ylabel('unit length (m)');

subplot(3,1,3)
hold on
plot(rc_x,rc_y,'k');
title('Position of point C');
xlabel('unit length (m)');
ylabel('unit length (m)');
```



1 full rev.: A in contact w/ ground again

Full rev: note scale, B is initially at y = 0.5, not

Center does not rotate and only travels in a straight line

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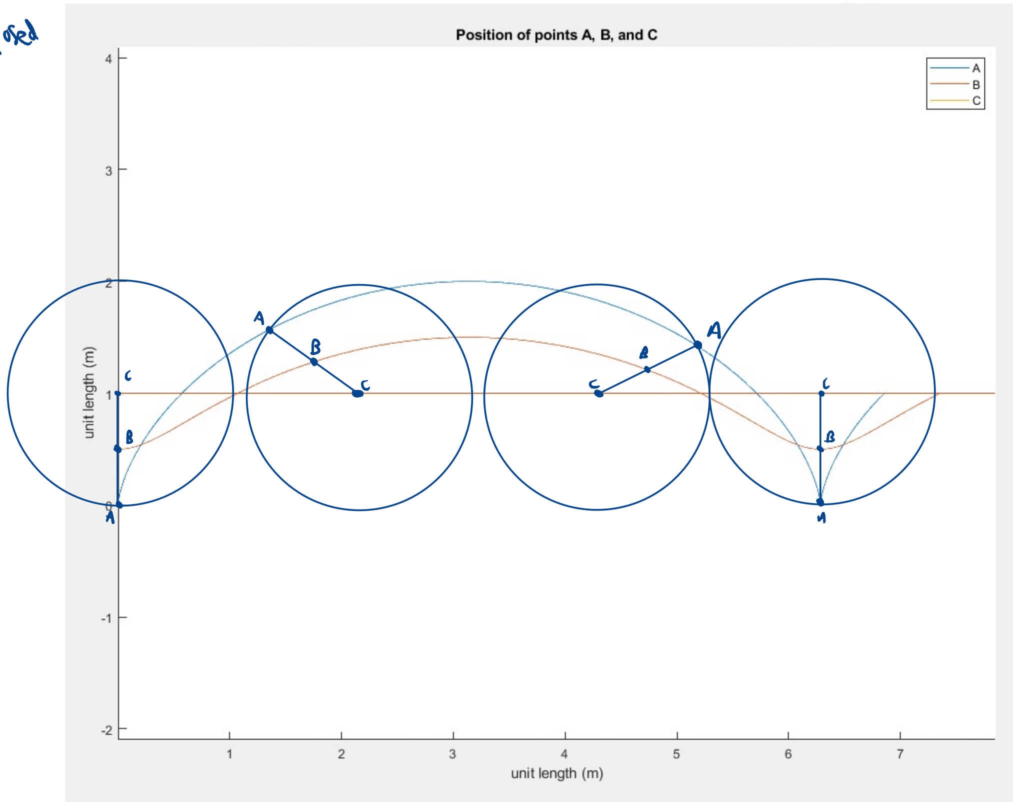
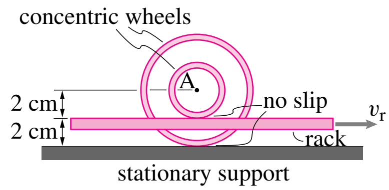
Superimposed plot



Disclaimer: *We have lost track of the many people who wrote these solutions. They are not official and have not been reviewed by the authors for correctness.*

17.3.4 The concentric wheels are welded to each other and roll without slip on the rack and stationary support. The rack moves to the right at $v_r = 1\,\text{m/s}$. What is the velocity of point A in the middle of the wheels shown?



Problem 17.4

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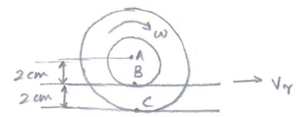
16.3.4



$V_r = 1\,m/sec$

$\vec{V}_{B/A} = -\omega r \hat{i}$

$\vec{V}_{C/A} = -2\omega r \hat{i}$

$\vec{V}_{A/G} = 2\omega r \hat{i}$

$\vec{V}_{B/G} = \vec{V}_{B/A} + \vec{V}_{A/G} = -\omega r \hat{i} + 2\omega r \hat{i} = 20\hat{i}$

$\omega = \frac{20}{r} = -\frac{20}{2} \times 100$

$\omega = -1000\ rad/sec^2$

Disclaimer: *We have lost track of the many people who wrote these solutions. They are not official and have not been reviewed by the authors for correctness.*