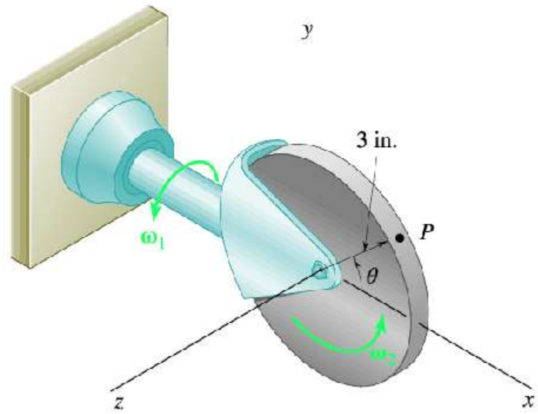
Problem 15.195



PROBLEM STATEMENT

A 3-in.-radius disk spins at the constant rate ω_2 4 rad/s about an axis held by a housing attached to a horizontal rod that rotates at the constant rate $\omega_1 = 5$ rad/s. For the position shown, determine (*a*) the angular acceleration of the disk, (*b*) the acceleration of Point *P* on the rim of the disk if $\theta = 0$, (*c*) the acceleration of Point *P* on the rim of the disk if θ 90°.

Helper Variables

Initialize any helper variables here. As a start, create three variables **i**, **j**, and **k** that represent the three unit vectors commonly used in our work.

As a reminder:

$$\boldsymbol{i} = \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix} \quad \boldsymbol{j} = \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix} \quad \boldsymbol{k} = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$$

Add the code in the code block below

```
% A row vector is written as [x, y, z] (note the commas)
% A column vector is written as [x; y; z] (note the semicolons)

% Remember to add a semicolon at the end of each line to suppress output
% Example: x = [1 2 3];

i = [1; 0; 0];
j = [0; 1; 0];
k = [0; 0; 1];
```

Part A

Start by calculating angular velocity.

Define ω_1, knowing that $\omega_1 = 5\,\boldsymbol{i}$

```
omega1 = 5 * i;
```

Likewise, define ω_2

```
omega2 = 4 * k;
```

Now combine $\omega_1 + \omega_2$

```
omega = omega1 + omega2;
```

Finally, caculate α using the equation $\alpha = \dot{\omega}_{\mathrm{Oxyz}} + \Omega \times \omega$

```
% the cross product A x B is performed using the "cross" function
% C = cross(A,B)

% Don't suppress the output to this line so that the answer is displayed
% (Don't end the line with a semicolon)
```

```
alpha = 0 + cross(omega1, omega)
```

```
alpha = 3×1
     0
   -20
     0
```

Part B

Assume $\theta = 0$ and find the acceleration of point P

First, calculate $\boldsymbol{r}_P$ in terms of the **i**, **j**, and **k** unit vectors;

```
% use feet as the units
rp = 0.25 * i;
```

Next, calculate $\boldsymbol{v}_P$

```
vp = cross(omega,rp);
```

Finally, caculate $\boldsymbol{a}_P$ (Hint: $\boldsymbol{a}_P = \alpha \times \boldsymbol{r}_P + \omega \times \boldsymbol{v}_P$)

```
% Don't suppress the output of this line
ap = cross(alpha,rp) + cross(omega, vp)
```

```
ap = 3×1
    -4
     0
    10
```

Part C

Using the process of Part B, calculate $\boldsymbol{a}_P$ with $\theta = 90\,\text{deg}$

```
% remember not to suppress the line that calculates acceleration
rp = 0.25 * j;
vp = cross(omega,rp);
ap = cross(alpha,rp) + cross(omega, vp)
```

```
ap = 3×1
         0
  -10.2500
         0
```

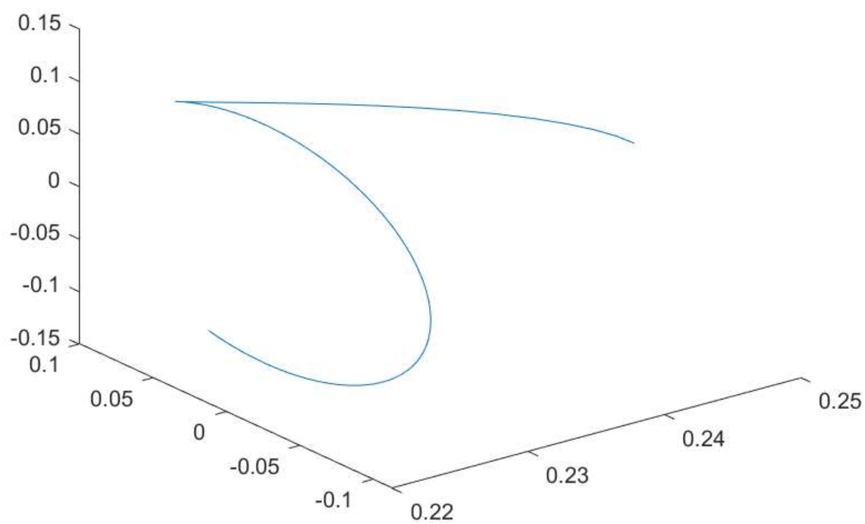
Additional Assignment

Referencing the examples posted on brightspace, create a simulation of the first second of motion of point P with a time step of 0.01 seconds.

Plot the 3D curve that point P travels in space (use the plot3 command)

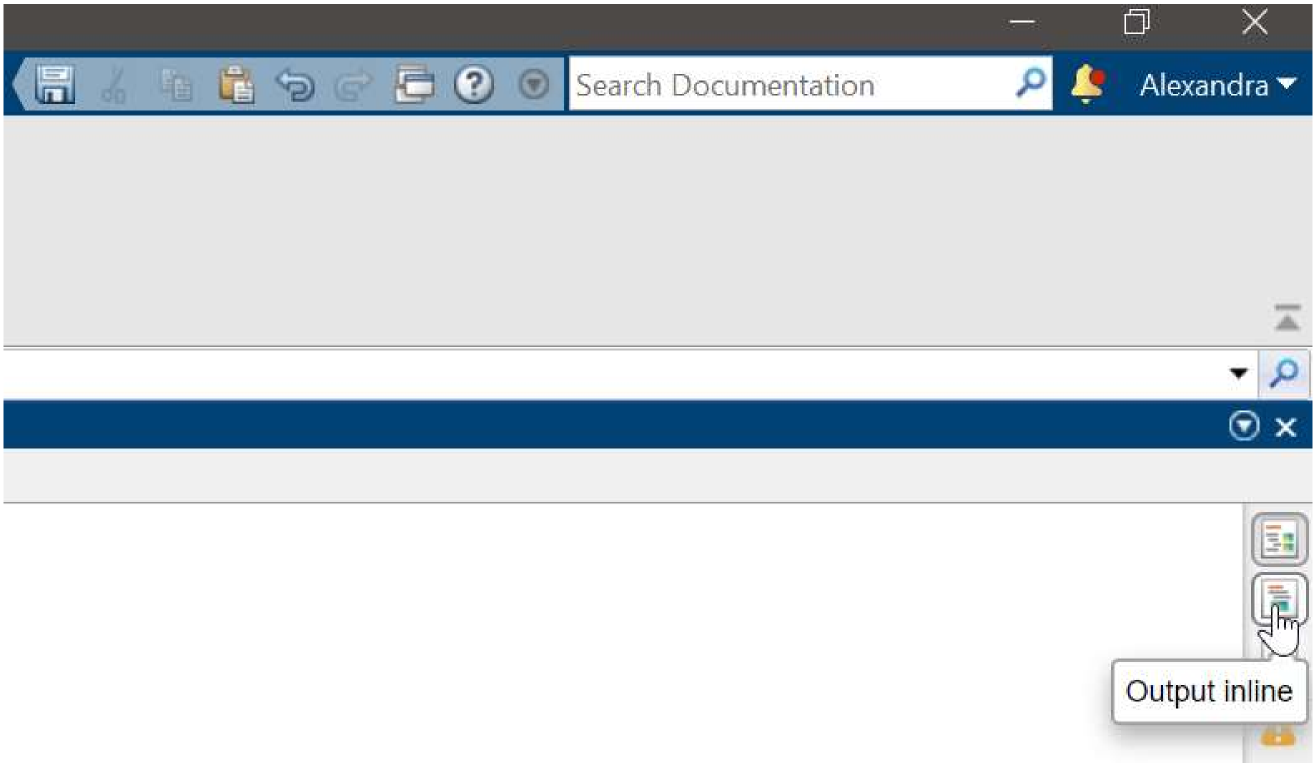
```
% define a time step dt
dt = 0.01;

% define a time vector t using the notation x:dt:y
% to create a vector that goes from x to y in
% increments of dt
% example: x = 1:1:3 produces the vector [1 2 3 4 5]
t = 0:dt:1;

% create a matrix of zeros with 3 rows and length(t) columns
% for rp.
% For context: the three rows represents the
% i, j, and k values and the columns are those three values
% at a specific point in time.
% Hint: zeros(3,y) creates a 3 by y matrix of zeros
```

```
rp = zeros(3, length(t));

% assign an initial value for rp(:,1)
% (Hint: Assume theta = 0 for t = 0, so rp(:,1) is the
% same value we found in part B)
% Remember that you can assign a column vector v to a
% specific column of a matrix m using the notation:
% m(:,i) = v.   ":" means "all rows" in this context
rp(:,1) = 0.25 * i;

% use a for-loop to step through the time vector
% and update the value of rp(:,index) for each index.
% Use the equation r = r0 + v*dt + 0.5*a*dt^2 where
% r0, v, and a are calculated using the previous
% index, index-1
% Note that the axis of rotation for omega2 changes with
% each time step, but stays in the j-k plane
% (remember to start at index=2 since we already have an
% initial value for index=1)
for index=2:1:length(t)
    %denote total rotation due to omega1 as phi
    phi = omega1(1) * t(index);
    omega2 = omega2(3) * (-sin(phi) * j + cos(phi) * k);
    omega = omega1 + omega2;
    alpha = cross(omega1, omega);
    vp = cross(omega,rp(:,index-1));
    ap = cross(alpha,rp(:,index-1)) + cross(omega, vp);
    rp(:,index) = rp(:,index-1) + vp*dt + 0.5*ap*dt^2;
end

% plot the curve of rp
plot3(rp(1,:), rp(2,:), rp(3,:))
```



Submitting Results

On the right-hand side of the Live Editor (this screen) click the "Output inline" button and play this script. Print the results and attach it to to your written homework.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