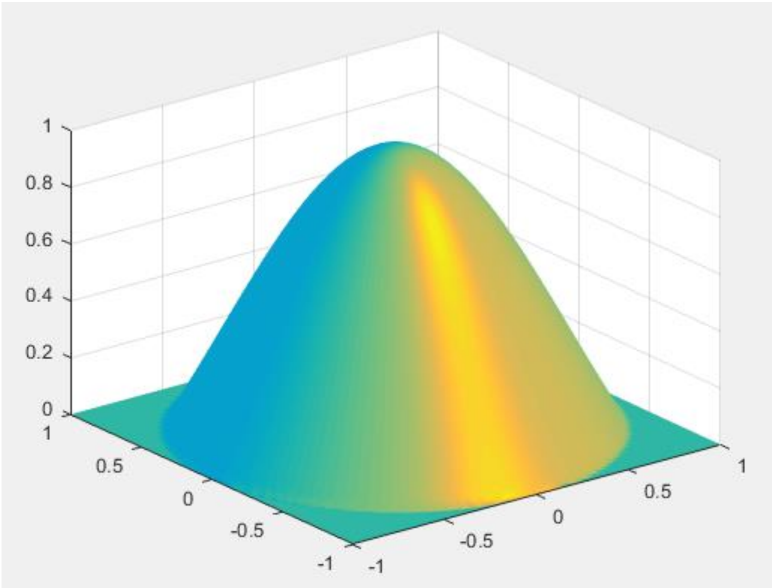
The displacement of the circular membrane corresponds to the fundamental axisymmetric modal shape:

$$u_{01}(r) = CJ_0\left(\frac{\alpha_{01}}{a}r\right)$$

where C is a real constant and defines the magnitude of displacement from the state of equilibrium.



The fundamental axisymmetric modal shape of the circular membrane at $a = 1$ and $C = 1$.

The surface of the deformed membrane (the surface of the revolution) reads:

$$S(C,a) = 2\pi \int_0^a z \sqrt{1 + \left(C \frac{dJ_0\left(\frac{\alpha_{01}}{a} z\right)}{dz}\right)^2}\, dz$$

Note that $\frac{dJ_0\left(\frac{\alpha_{01}}{a}z\right)}{dz} = -\frac{\alpha_{01}}{a} J_1\left(\frac{\alpha_{01}}{a} z\right)$. Therefore,

$$S(C,a) = 2\pi a^2 \int_0^1 z \sqrt{1 + \left(\frac{C\alpha_{01}}{a}\right)^2 J_1^2(\alpha_{01} z)}\, dz$$

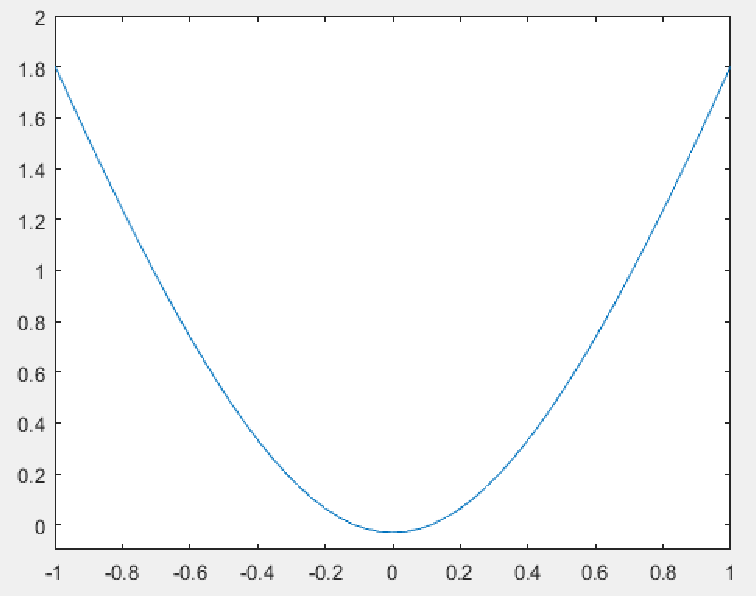
The area of the membrane in the state of equilibrium equals to the diameter of the cross-section of the tube:

$$S(0,a) = \pi a^2$$

The area of the open slits.

The area of the open slits of the flat circular spring reads:

$$\delta(C,a) = S(C,a) - S(0,a)$$



The relationship between the area of open slits $\delta(C, a)$ and C at $a = 1$.

The model is based on several assumptions:

1. If the area of open slits $\delta(C, a)$ is fixed, the drag force is assumed to be proportional to the square of the velocity (due to the high viscosity of the fluid).

2. The velocity determines the shape of the flat circular spring with slits. The higher is the velocity, the larger is the area of open slits (the larger is the parameter C).

3. The higher is the area of open slits, the smaller is the drag force.

Note that $S(C, a)$ is an even function in respect of C. Therefore, according to assumption #2:

$$C = \theta \dot{x}$$

where θ is the coefficient of proportionality between C and $\dot{x}$.

According to assumption #3, the drag force is inverse proportional to the area of open slits. Combining all three assumptions results into the following expression of the drag force D:

$$D(\dot{x}) = h \cdot sign(\dot{x}) \cdot (\dot{x})^2 \cdot \frac{1}{\delta(\theta \dot{x}, a)}$$

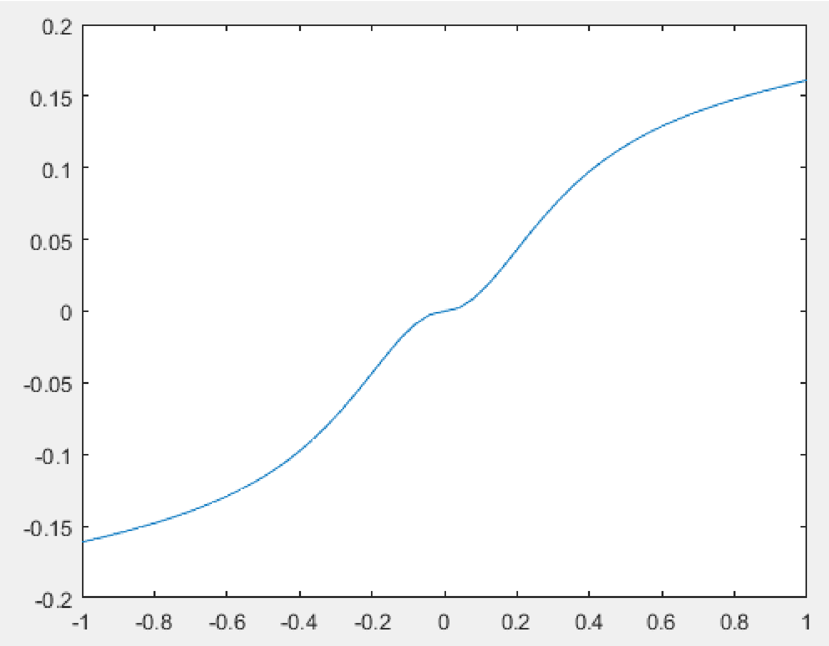
This structure of the drag force has a singularity point at $\dot{x} = 0$. Therefore, we add the fourth assumption:

4. The drag force is not infinite when all slits are closed (when the flat circular spring is in the state of equilibrium).

Combining the fourth assumption yields the final phenomenological model of the drag force:

$$D(\dot{x}) = h \cdot sign(\dot{x}) \cdot (\dot{x})^2 \cdot \frac{1}{\delta(\theta\dot{x}, a) + \varepsilon}$$

where ε is a small positive number determining the drag force when all slits are closed.



The relationship between the drag force and $\dot{x}$ at $h = 0.1$, $\theta = 0.5$, $\varepsilon = 0.1$, and $a = 1$.

Finally, the governing equations of motion read:

$$m\ddot{x} + D(\dot{x}) + kx = f(t)$$

$$D(\dot{x}) = h \cdot sign(\dot{x}) \cdot (\dot{x})^2 \cdot \frac{1}{\delta(\theta\dot{x}, a) + \varepsilon}$$

حل این معادله غیرخطی هایلایت شده

من خودم $\delta(\theta\dot{x}, a)$ و $sign(\dot{x})$ را نمیدونم چیه و هیچ اطلاعات دیگری ندارم. گفته شده که همه اطلاعات داخل این فایل است. لذا توانایی پاسخگویی اطلاعات بیشتر را ندارم.

خواهشمندم اگر توانایی انجام این مساله را دارید بفرمایید.

با استفاده از نرم افزار متلب:

$f(t)$تابعی برحسب زمان درنظر بگیرید.

لطفا یکبار k و m را بصورت دو عدد دلخواه مختلف و یک بار بصورت پارامتر k/m که احتمالا با curve fitting متلب بشه برای رسم نمودارهاش.

موارد خواسته شده:

رسم نمودار نیرو- جابجایی (F-x)

رسم نمودار نیرو- سرعت(F-$\dot{x}$)

بدست اوردن x , $\dot{x}$

باتشکر