## Contents



```
% Joel Lubinitsky - 02/11/15
% MAE 321 - HW 4.4

clear all
close all
clc
```

## Problem 4:

Consider designing a helical spring such that when attached to a 10-kg mass, the result-ing spring–mass system has a natural frequency of 10 rad/s (about 1.6 Hz). (a) Design a similar steel spring, with the same restrictions on mass, wire size, and coil diameter. This spring should result in a system oscillation frequency of 7.5 rad/s. (b) Now design a similar spring made of aluminum instead. Keep the mass, size, and system oscillation frequency restrictions as in the first part of this problem. (c) Place a dashpot parallel to the original steel spring (from part (a) here, not the original example in the book) and choose its viscous-damping value so that the resulting damped natural frequency is reduced to 6 rad/s.

## Known

```
mass                    = 10;             % kg
modulusShearSt          = 8 * 10 ^ 10;    % N/m^2
modulusShearAl          = 2.67 * 10 ^ 10; % N/m^2
frequencyNatural        = 7.5;            % rad/s
frequencyNaturalDamped  = 6;              % rad/s
nCoils                  = 13;
radiusCoil              = 0.1;            % m
```

## Part A

$$\omega_n = \sqrt{\frac{k}{m}}$$

$$k = \frac{Gd^4}{64nR^3}$$

$$\frac{64m\omega_n^2nR^3}{G} = d^4$$

```
diameterWireSt = nthroot((64 * mass * frequencyNatural ^ 2 * nCoils * radiusCoil ^ 3) / modulusShea
rSt, 4)
```

```
diameterWireSt =

    0.0087
```

## Part B

```
diameterWireAl = nthroot((64 * mass * frequencyNatural ^ 2 * nCoils * radiusCoil ^ 3) / modulusShea
rAl, 4)
```

```
diameterWireAl =

    0.0115
```

## Part C

$\omega_d = \omega_n \sqrt{1 - \zeta^2}$

$\zeta = \frac{c}{c_{cr}}$

$c_{cr} = \sqrt{4km}$

$c = \sqrt{4km[1 - (\frac{\omega_d}{\omega_n})^2]}$

```
stiffnessSt = (modulusShearSt * diameterWireSt ^ 4) / (64 * nCoils * radiusCoil ^ 3);
coefficientDampingSt = sqrt(4 * stiffnessSt * mass * (1 - (frequencyNaturalDamped / frequencyNatura
l) ^ 2))
```

```
coefficientDampingSt =

   90.0000
```

## Results

For Part (a), a helical steel spring with the given restrictions can be designed with a wire diameter $d = 0.0087\ m$.

For Part (b), a similar aluminum spring can be designed with a wire diameter $d = 0.0115\ m$.

For Part (c), the given system can be designed with a damper with coefficient $c = 90\ kg/s$.

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