I. Mechanical Systems with Free Oscillation with spring constant and frictional coefficient:

1. $k = 4\ \text{g/s}^2$, $m = 1\ \text{g}$ where the object is initially pulled down 2 cm and with a downward initial velocity of $2\ \text{m/s}$

2. $k = 5\ \text{g/s}^2$, $m = 1\ \text{g}$, $c = 4\ \text{g/s}$ where the object is initially pulled down 2 cm and with a downward initial velocity of $2\ \text{m/s}$

II. Mechanical Systems with Forced Oscillations:

1. $k = 25\ \text{g/s}^2$, $m = 1\ \text{g}$, $c = 0\ \text{g/s}$ where the object is initially pulled down 0 cm and with a downward initial velocity of $10\ \text{m/s}$. Consider an external force of $10\sin 4t$

2. Consider a system in which our mathematical model is:

   i) $y(t) = t\sin t + C_1\cos\omega t + C_2\sin\omega t$

   ii) $y(t) = e^{-at}\left(C_1\cos bt + C_2\sin bt\right) + A\cos\left(\omega t - \phi\right)$

III. RLC Circuits:

1. $R = 20\ \Omega, L = 1$ henry, $C = 0.005$ farads. The voltage is shorted our at $t = 0$ and there is initially a charge of 10 coulombs on the capacitor and no current. How many seconds will it take for the amplitude to be reduced by 99%?

2. $R = 1\Omega, L = \frac{1}{2}$ henry, $C = \frac{2}{3}$ farads. The voltage is given by $E(t) = \cos t$.

IV. Examples of Higher Order Differential Equations with Non-Constant Coefficients:

1. $x^2\frac{d^2y}{dx^2} + \frac{7}{2}x\frac{dy}{dx} - \frac{3}{2}y = 0$ with $x > 0$

2. $x^2\frac{d^2y}{dx^2} + \frac{5}{3}x\frac{dy}{dx} + \frac{5}{9}y = 0$ with $x > 0$

3. $x^2\frac{d^2y}{dx^2} + 2x\frac{dy}{dx} = x^{-1}$ with $x > 0$

4. $x^2 \frac{d^2y}{dx^2} - x\frac{dy}{dx} + y = x^3 \ln x$ with $x > 0$