

The FE reference book may be used during this exam. 4:10-5:50, 152 B.

1. Water (of volume 425 ml) in a glass measuring cup was allowed to cool after being heated to 207F. The ambient air temperature was 70F. The measured water temperature at various times is given by the following table. Obtain a functional description of the relative water temperature ( $\Delta T = T - 70$ ) versus time.

Time (m)	0	5	10	15	20	25	30	35	40	45	50
temp (C)	207	182	167	155	143	135	128	123	118	114	109

2. Determine the equation of motion and the natural frequency of the system shown in the figure below. The equilibrium position corresponds to  $x=0$ .

Figure p4.25 page 239

3. In the schematic below, the first shaft turns  $N$  times faster than the second shaft. Develop a model of the system including the elasticity of the second shaft. Assume the first shaft is rigid and neglect the gear and shaft masses (not inertias). The input is the applied torque  $T_1$ .

Figure p4.44 page 243

4. For the equations (or set of equations) below, assuming all greek characters are known constants, list the numbers of the equations that are:

(a) linear

(b) time invariant (autonomous)

$$\begin{aligned}\dot{x} &= \sigma x + \beta y \\ \dot{y} &= \gamma y + \alpha xy\end{aligned}\tag{1}$$

$$\begin{aligned}\dot{x} &= \sigma x + \beta y \\ \dot{y} &= \gamma y + \alpha x\end{aligned}\tag{2}$$

$$\begin{aligned}\dot{x} &= \sigma x + t\beta y \\ \dot{y} &= \sin(\gamma)y + \alpha x\end{aligned}\tag{3}$$

$$\begin{aligned}\dot{x} &= \sigma x + \beta y \\ \dot{y} &= \sin(t)y + \alpha \sin(x)\end{aligned}\tag{4}$$