1. (20%) Find the linearized transfer function, $G(s)=V(s)/I(s)$, for the electrical network shown in Fig. 1. The network contains a nonlinear resistor whose voltage-current relationship is defined by $i_r = e^{v_r}$.

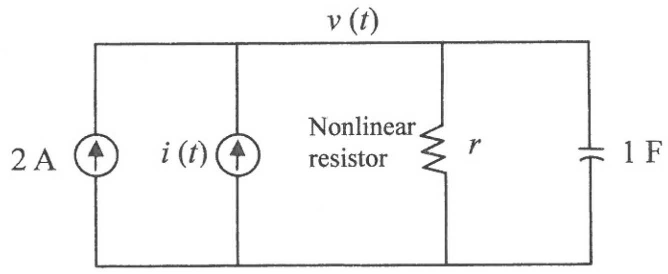

Fig. 1

2. (30%) For a unity feedback system that has the forward transfer function

$$G(s)=\frac{K}{(s+5)(s+20)(s+50)}$$

(a) Draw the Bode plots.
(b) Find the range of K for stability from your Bode plots.
(c) Evaluate gain margin and phase margin from your Bode plots for K=10000.

3. (20%) For a unity feedback system that has the forward transfer function

$$G(s)=\frac{K(s+1)}{s(s+2)(s+20)}$$

(a) Sketch the root locus.
(b) Design a PI controller for K=40 such that
 (i) The steady-state error is less than 5% of the slope for a ramp input.
 (ii) Gain-crossover frequency is 1 rad/sec.

4. (30%) Consider the following state-space equation of a system

$$\frac{dx(t)}{dt}=Ax(t)+Bu(t),$$

$$A=\begin{bmatrix}0 & 1\\ -6 & -5\end{bmatrix},\quad B=\begin{bmatrix}0\\ 1\end{bmatrix}.$$

(a) Find the state-transition matrix $\phi(t)$.
(b) Transform the state equations into the observability canonical form (OCF).
(c) Design a state feedback controller so that:
 (i) The maximum overshoot is 4.33%.
 (ii) Peak time of the unit-step response is 3 sec.