1. A system with zero in the right half-plane is called nonminimum phase. For example, a system $G(s)$ with the transfer function $G(s)=\frac{-s+2}{s^2+3s+2}$ is nonminimum phase. Please find the unit step response of $G(s)$, approximately plot the step response and describe the dynamic feature of a nonminimum phase system. (20%)

2. Consider a vehicle stabilization system as described in **Fig. 1**

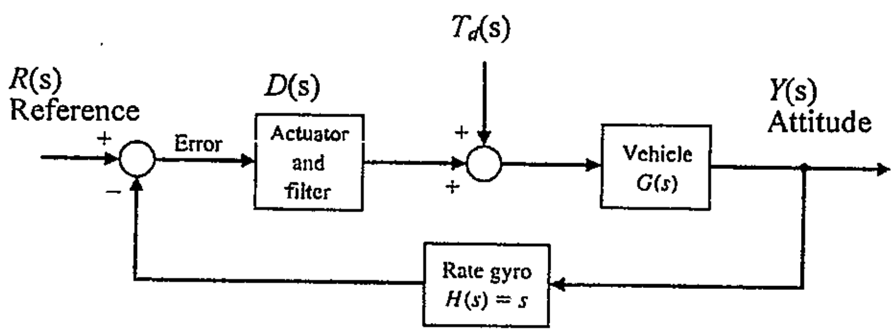


Fig. 1. A vertical takeoff aircraft stabilization system

In the Fig. 1, the vehicle is represented by the transfer function $G(s)=\frac{1}{(s^2+10)}$, the actuator and filter are represented by the transfer function $D(s)=\frac{K(s+b)}{(s+a)}$. The rate gyro sensor is represented by the transfer function: $H(s)=s$.

(a) Determine the transfer function from R(s) to Y(s) (5%)

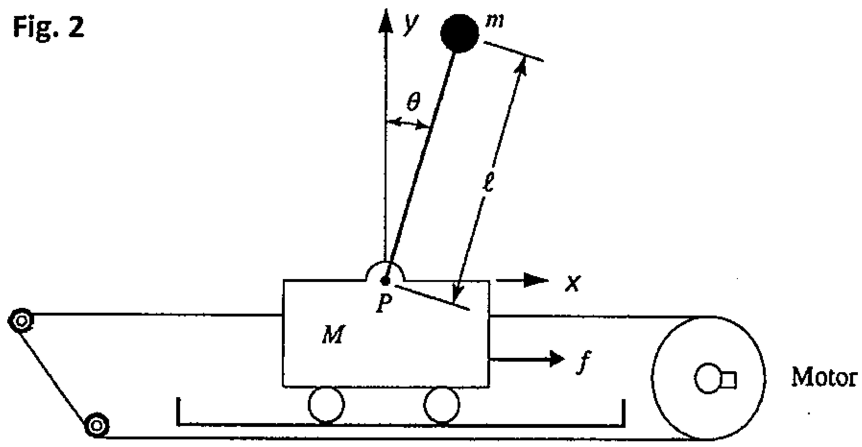
(b) If the desired specifications for a unit step reference are: rising time < 1 sec, overshoot < 10%, please design the desired poles of the system, and find the corresponding D(s) to achieve this goal. (15%)

(c) Determine the transfer function from T_d(s) to Y(s) (5%)

(d) Determine the steady-state error of a wind disturbance of $T_d(s) = 1/s$. (5%)

3. **Fig. 2** shows an inverted pendulum on a cart. If the mass of the cart is represented by M and the force f is applied to hold the bar at the desired position. Let the frictions in the system can be ignored. Assuming M = 2 kg, m = 0.5 kg, and $\ell = 1$ m. (1) Draw the free-body diagram.(2%) (2) Write the dynamic equation of the motion.(6%) (3) Assume that the angle θ is small such that linear approximation can be achieved. Find the linearized state-space model of the system if the state variables and the output variables are defined as $x_1=\theta$, $x_2=\dot{\theta}$, $x_3=x$, $x_4=\dot{x}$, $y_1=x_1=\theta$, and $y_2=x_3=x$.(8%) (4) Determine the controllability for the system.(4%)

Fig. 2



4. The forward-path transfer function of a unity-feedback control system is given by

$$G(s)=\frac{K}{s(s+4)(s^2+4s+20)}$$

Construct the root loci for $K \geq 0$ and indicate the breakaway points and the intersection points with the imaginary axis in the root loci. (15%)

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5. The loop transfer function of a single-loop feedback control system is given as

$$G(s)H(s)=\frac{K(s+5)}{s(s+2)(1+Ts)}$$

The parameters K and T may be represented in a plane with K as the horizontal axis and T as the vertical axis. Determine the regions in the T-versus-K parameter plane where the closed-loop system is asymptotically stable and where it is unstable. Indicate the boundary on which the system is marginally stable. (15%)

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