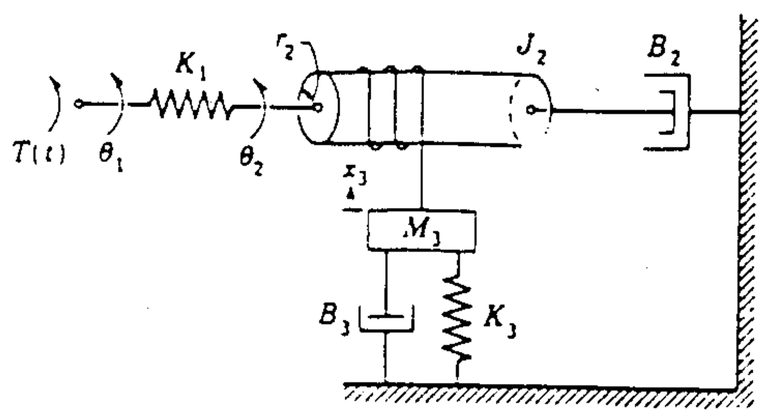
國立臺灣科技大學
九十學年度碩士班招生考試試題

系所組別： 纖維及高分子工程系丙組
科　目： 控制系統

1. In the mechanical system shown, J_2 is the inertia of the drum with a radius r_2. Obtain a differential equation expressing the relationship of the output x_3 in terms of the input θ_1 and the corresponding transfer function. (17%)



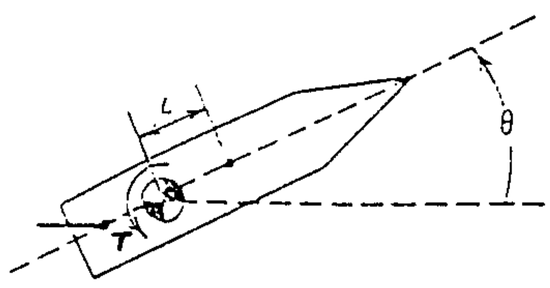
2. The attitude of a vehicle moving through a fluid represents an inherently unstable plant, because the fluid forces do not act through the vehicle's center of mass, but through a point called the center of pressure. They thus create a net torque that acts to rotate the vehicle. The attitude can be controlled by control surfaces, such as elevators and ailerons on missiles and aircraft, by thrusters on rockets, and by diving planes and fins on submarines and other underwater vehicles.

An example of such a system is shown below. A linearized model of the missile's dynamics is

$$I\ddot{\theta} = T + C_n L\theta$$

where θ is the missile's attitude angle, I is the missile's inertia about the indicated axis of rotation, C_n is the normal-force coefficient, L is the distance between the center of mass and the center of pressure, and T is the applied control torque.

The plant is unstable, and the primary control objective is to stabilize the missile's attitude so that $\theta \cong 0$. Develop a control law for this purpose. (17%)



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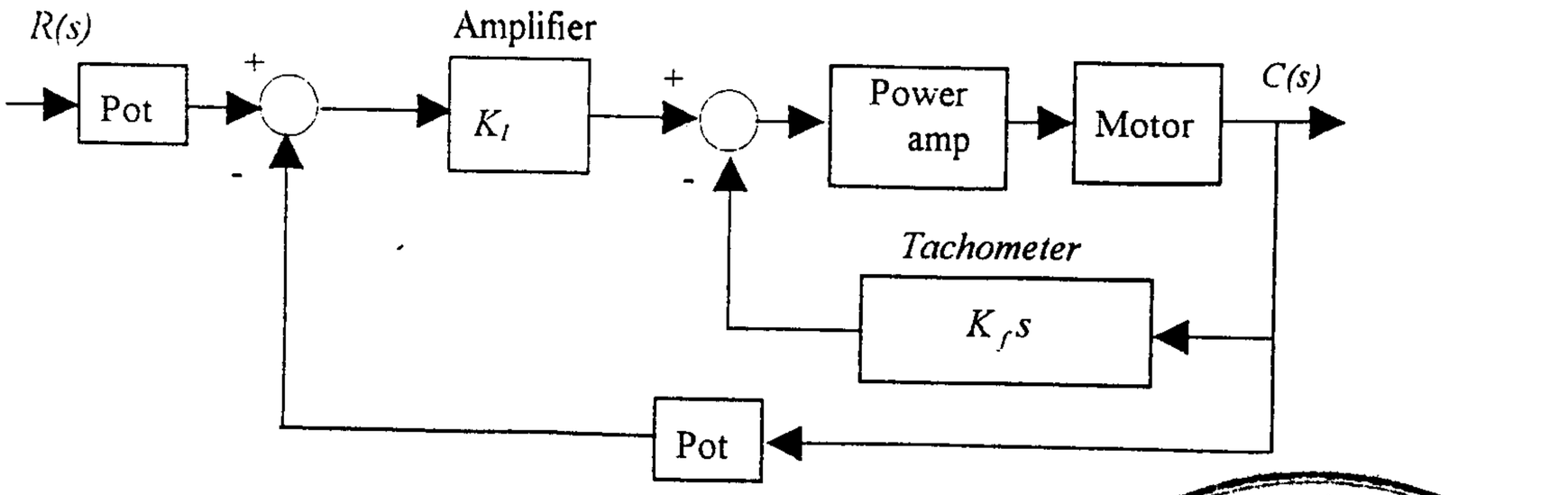
3. A position control is to be designed with a 20% overshoot and a settling time of 2 seconds. You have on hand an amplifier and power amplifier whose cascaded transfer function is $K_1/(s+20)$ with which to drive the motor. Two 10-turn pots are available to convert shaft position into voltage. A voltage of $\pm 5\pi$ volts is placed across the pots. A dc motor whose transfer function is of the form

$$\frac{\theta_o(s)}{E_a(s)} = \frac{K}{s(s+a)}$$

is also available. The transfer function of the motor is found experimentally as follows: The motor and geared load are driven open-loop by applying a large, short, rectangular pulse to the armature. An oscillogram of the response shows that the motor reached 63% of its final output value at 1/2 second after the application of the pulse. Further, with a constant 10 volts dc applied to the armature, the constant output speed was 100 rad/s.

a. Draw a complete block diagram of the system, specifying the transfer function of each component when the system is operating with 20% overshoot. (8%)
b. What will the steady-state error be for a unit ramp input ? (8%)
c. Determine the transient response characteristics. (8%)
d. If tachometer feedback is used around the motor, as shown in following Figure, find the tachometer and the amplifier gain to meet the original specifications. (9%)



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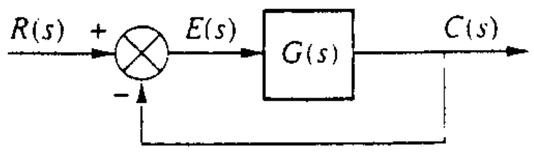
4. For the unity feedback system with

$$G(s) = \frac{K}{s(s^2 + 7s + 17)}$$

find the range of K so that the system response includes no term having a time constant greater than 0.5 second. (13%)

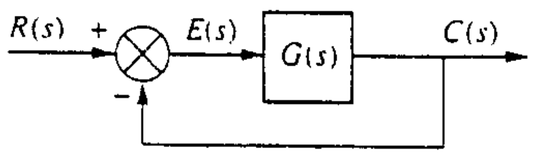


5. For the unity feedback system with

$$G(s) = \frac{K}{s(s+1)(s+4)} \qquad K > 0$$ (20%)

(a) Draw a root locus. Identify all asymptotes, points of breakaway from the real axis, and intersection of the root locus and the imaginary axis.

(b) Find the value of K that yields a damping ratio of 0.5 for the system's closed-loop dominant poles.



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