Problem 1 (30%), (6% for each sub-problem)

Consider a unity feedback system with a PI controller to control a first-order plant:

(a) Write down the transfer function of controller and appropriate model of plant with static and dynamic characteristic parameters.

(b) Draw a block diagram to express the control system and indicate input, output, error, and disturbance on the block diagram.

(c) Find open-loop and closed-loop transfer function.

(d) Derive stability condition by using Routh-Hurwitz method.

(e) Give your mathematical analysis and reasoning to determine if the control system is utilized more appropriate as a regulator or tracker.

Problem 2 (20%)

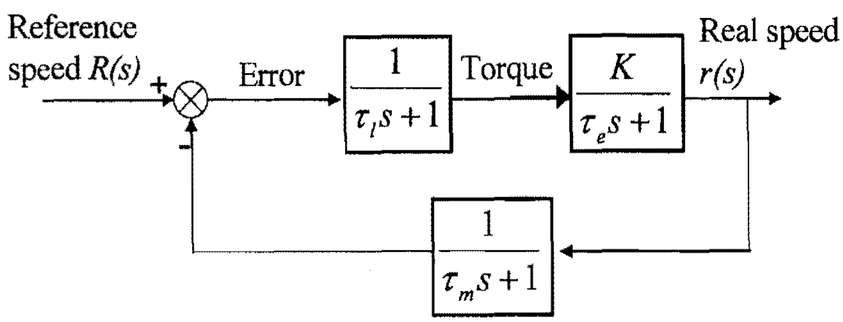
For the statement described in problem 1, give an appropriate physical control system and explain all the necessary information to be considered in operating the control system.

Problem 3 (25%)

A speed control for a gasoline engine is shown below. Because of the restriction at the carburetor intake and the capacitance of the manifold, a lag occurs and the lag time constant τ_l is 1 second. The engine time constant τ_e is 3 seconds. The speed measurement time constant τ_m is 0.4 second.

(a) (15%) Determine the necessary gain K if the steady-state speed error is required to be less than 10% of the speed reference setting.

(b) (10%) With the gain determine from part (a), utilize the Nyquist criterion to investigate the stability of the system.



(背面仍有題目,請繼續作答)

Problem 4 (25%)

It is important to ensure the passenger comfort on ships by stabilizing the ship's oscillations due to waves. Most ship stabilization systems use fins to generate a stabilization torque on the ship, see figure below. The output signal is the angle *y(t)* and the control signal *u(t)* is the torque generated by the fins. The block diagram is given below.

The transfer function for a given ship is $G(s) = \dfrac{9}{s^2 + 1.2s + 9}$

(a) (10%) Suppose that the oscillations are to be controlled using a P-controller $u(t) = K(r(t) - y(t))$ where $r(t)$ is the desired angle. How do the poles of the closed loop system depend on K > 0? Draw a root locus! Describe qualitatively how the step response for the closed-loop system depends on K > 0 (stability? speed? oscillations?).

(b) (10%) Suppose that the reference signal $r(t) = 0$, that is, the desired angle for the ship is zero. What is the transfer function from the wave effect $v(t)$ to the angle $y(t)$? Suppose that the wave disturbance can be described as a step disturbance with amplitude a. What is the angle y in stationarity?

(c) (5%) State a control structure so that the angle y will be zero in stationarity even if there is a step disturbance.