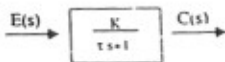


Marks

- (3) 1.a) For the first order system shown below, sketch the form of output dynamic response if the system, as initially at rest, is subjected to a step input of magnitude B. Locate τ on your sketch.



- (5) b) One of the methods of finding τ when the system is subjected to a step input involves measuring the initial slope of the output signal. Derive the equation for determining τ from the slope for the system in part a). Hint: you need to use the time response from part a).

- (5) 2.a) What is the significance of each of the gains K_P , K_I , and K_D in a PID controller in a closed loop system?
- (4) b) What is the basic algorithm for implementing integral and derivative control for a digital type controller?

- (12) 3. Consider the converging-diverging nozzle used in laboratory T2. The upstream plenum chamber conditions are 800 kPa (abs) and 300 K. The specific gas constant for air is 286.9 J/kg/K. Determine the range of back pressures P_b over which each of the following conditions will exist for: a) fully subsonic flow throughout and b) a normal shock wave in the diverging portion of the nozzle.

- (3) 4.a) How is it possible to determine whether cutter compensation is to the right or left of a machine profile? Make a sketch.



- (3) b) What is the difference between an incremental and absolute value programmed for a CNC machine?

- (4) c) If a CNC machine did not correct the offset shown in the offset library of the controller, what would be the reason for this?

- don't turn offsets on

- (4) d) How and why are OFFSET switches used on CNC machines?

- (3) e) Why can't we program a constant cutting speed for a drill in a CNC program?

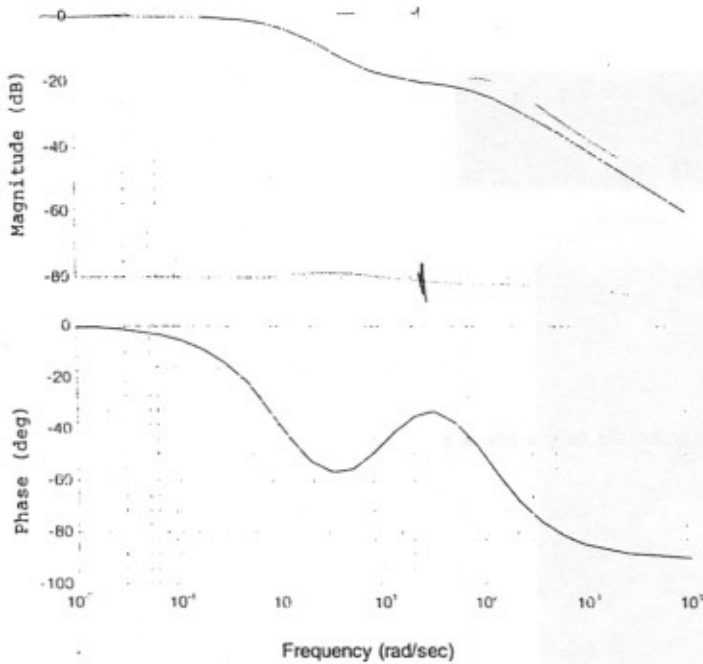
- (3) 5.a) A compact tension specimen is tested in fatigue using loads from 10 kN to 100 kN in tension. The crack initially propagates in the "correct" mode i.e. perpendicular to the loading axis but later the crack path deviates and the crack eventually describes a curve – final fracture occurring at an angle of 45 degrees to the tensile axis. Suggest a possible reason for this behavior.

- (5) b) Describe briefly 5 changes that may be made in order to increase the fatigue life of a machine component.

- (4) c) Why does iron corrode more rapidly when in contact with copper than when isolated?

6. Consider the following Bode gain and phase diagrams.

Bode Diagrams



- (4) a) If a transfer function is derived from the above Bode diagrams, it will have one zero. Explain the features of the gain and phase diagrams that indicate the presence of this zero.
- (3) b) What is the order of the denominator polynomial of the transfer function derived from the Bode diagrams?
- (6) c) Derive the transfer function.

- (8) 7. Sound pressure measurements were taken at points which define a sphere (radius is 2m) about a source as shown in Figure V1. The measurements were taken at a center frequency known to dominate the sound power spectrum for the machine. Given the following values for the sound pressure level determine the mean sound pressure level, the sound power level, and plot the directivity index in the x-y and x-z planes for this center frequency.

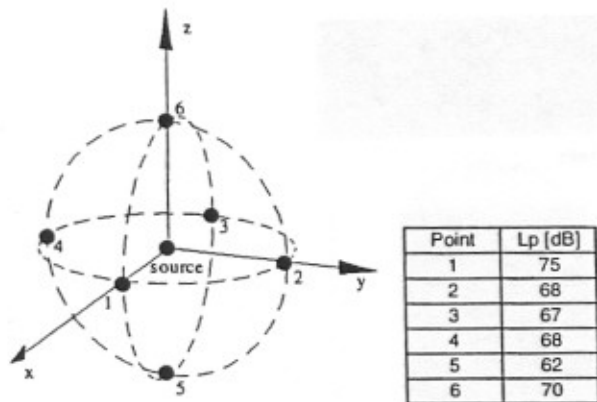
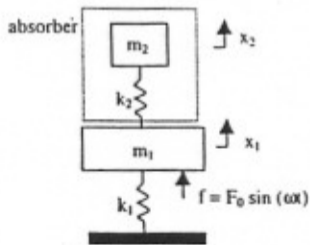


Figure V1 Locations of Sound Pressure Level measurements.

- (9) 8. To cancel the vibration in a mechanical system being operated at its natural frequency, an absorber can be added which has the same natural frequency. This situation is shown schematically in Figure V2. If the only spring available for the absorber is 10% stiffer than that calculated to be ideal, what will the resulting amplitude of vibration be when the exciting force has an amplitude of 100 N?



$$\begin{aligned}m_1 &= 5 \text{ kg} \\m_2 &= 0.05 \text{ kg} \\k_1 &= 12\,500 \text{ N/m} \\k_2 &= 125 \text{ N/m} \\\omega &= \omega_1 = \omega_2 = 50 \text{ rad/s}\end{aligned}$$

Figure V2 Mechanical system with an absorber.

- (6) 9. In conducting a Krouse fatigue test a bending moment of 80 in. lb. was applied to a standard test specimen 0.2500 inches in diameter. The individual measuring the specimen recorded the size, in error, as 0.2600 in., and the group predicted the fatigue life based on this wrong diameter.

What was the actual reversed bending stress applied to the specimen?

What per-cent error would the 0.2600 size produce in the reversed fatigue stress?

Without calculation, state whether the students' specimen would fail earlier or later than they predicted.

- (6) 10. In a ROCLE test of a CH, 0W-40 lubricant an elliptical wear scar was produced with major and minor axes 2.00 mm x 1.00 mm in length. A mass of 4.0 kg was applied through a system of levers with a mechanical advantage of 20:1, to the roller. Calculate the stress supported by the oil film in MPa. For what applications would this lubricant be specified?