90. The transfer function relating a step input to the output of a control system is:

$$\frac{16}{s^3 + 0.8s^2 + 16s}$$

The natural frequency ω_n of the system and the damping ratio ς are most nearly:

- ○ A. $\omega_n = 2$ rad/s; $\varsigma = 0.1$
- ○ B. $\omega_n = 2$ rad/s; $\varsigma = 0.2$
- ○ C. $\omega_n = 4$ rad/s; $\varsigma = 0.1$
- ○ D. $\omega_n = 4$ rad/s; $\varsigma = 0.2$

Refer to the Second-Order Control System Models section in the Instrumentation, Measurement, and Controls chapter of the *FE Reference Handbook*.

see page 228 of FE Handbook

The equation of the system can be written as $\dfrac{16}{s(s^2+0.8s+16)}$ which is in the form

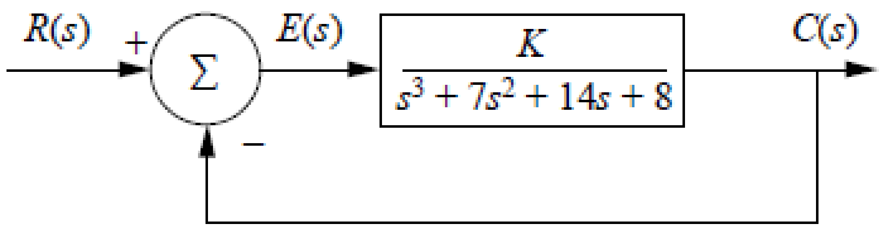
$$\frac{16}{s(s^2+2\zeta\omega_n s+\omega_n^2)}$$

thus $\omega_n^2 = 16$ or $\omega_n = 4$

and $2\zeta\omega_n = 0.8$ or $\zeta = \dfrac{0.8}{2\omega_n} = 0.1$

THE CORRECT ANSWER IS: C

72. A unity-feedback control system is shown in the figure below.



The number of poles in the open-loop characteristic equation for this system is most nearly:

- ○ A. 0
- ○ B. 1
- ○ C. 2
- ○ D. 3

72. Refer to the Control Systems section in the Instrumentation, Measurement, and Control chapter of the *FE Reference Handbook*.

see page 227 of FE Handbook

The open-loop characteristic equation is:

$$D(s) = s^3 + 7s^2 + 14s + 8 = 0$$

$$(s + 1)(s + 2)(s + 4) = 0$$

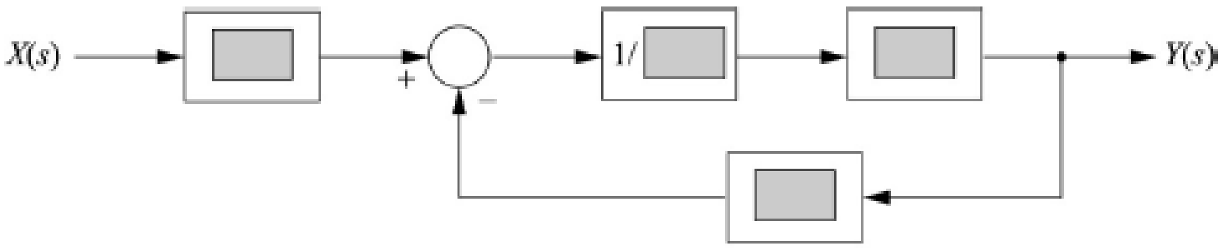
The open-loop characteristic equation has three poles.

THE CORRECT ANSWER IS: D

73. The transfer function for the block diagram below is given by:

$$\frac{Y(s)}{X(s)} = \frac{B(s)\ C(s)}{D(s)+A(s)\ C(s)}$$

Place the functions for $A(s)$, $B(s)$, $C(s)$, and $D(s)$ in the correct shaded locations on the block diagram.



Functions: $A(s)$ $B(s)$ $C(s)$ $D(s)$

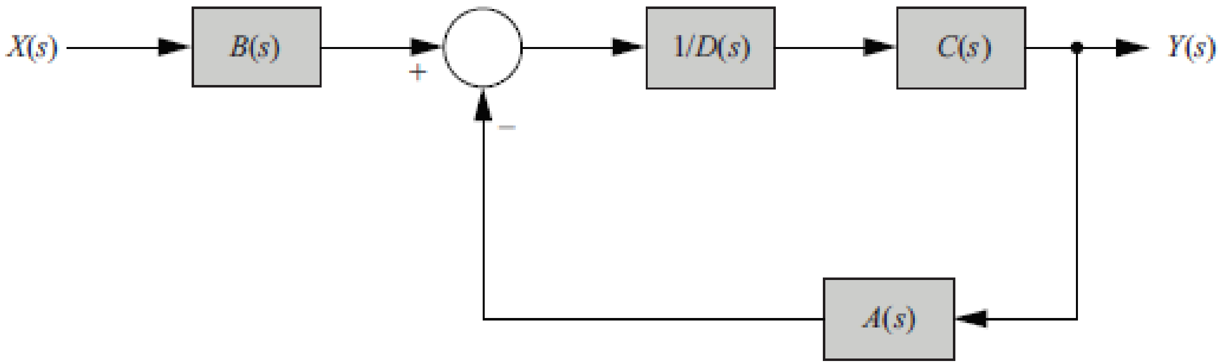
73. Refer to the Control Systems section in the Instrumentation, Measurement, and Control chapter of the *FE Reference Handbook*.

see page 226 of FE Handbook

$$\frac{Y(s)}{X(s)} = \frac{B(s)C(s)}{D(s)+A(s)C(s)} \cdot \frac{\frac{1}{D(s)}}{\frac{1}{D(s)}}$$

$$= \frac{B(s)C(s) \cdot \frac{1}{D(s)}}{1 + A(s)C(s) \cdot \frac{1}{D(s)}}$$

$$= B(s)\left[\frac{C(s) \cdot \frac{1}{D(s)}}{1 + A(s)C(s) \cdot \frac{1}{D(s)}}\right]$$



20. Refer to page 220 of the Measurement section in the Instrumentation, Measurement, and Control chapter of the *FE Reference Handbook*.

$$R = R_o\,[1 + \alpha(T - T_o)]$$

$$\Delta R = \frac{dR}{dT}\Delta T$$

$$= R_o \alpha \Delta T$$

$$= (100\ \Omega)\ (0.004°\mathrm{C}^{-1})\ (10°\mathrm{C})$$

$$= 4.0\ \Omega$$

THE CORRECT ANSWER IS: C