Problem 1:
Consider the feedback control system shown in Fig. 1. Design $k_p$ and $k_d$ such that the poles of the transfer function $Y(s)/R(s)$ equal $-2 \pm 2i$.

![Fig. 1. Feedback control system for Problem 1.](image)

Problem 2:
Use Routh’s stability criterion to determine how many roots with positive real parts the following equations have. Verify your answer with the Matlab function `roots`.
1) $s^4 + 8s^3 + 32s^2 + 80s + 100 = 0$
2) $s^4 + 2s^3 + 7s^2 - 2s + 8 = 0$

Problem 3:
1) Consider the feedback control system shown in Fig. 2. The stability properties of the system are a function of the proportional feedback gain $k_p$.
   a) Is the plant:

   $$P(s) = \frac{s + 1}{s(s - 1)(s + 6)}$$
stable? Explain why.

b) Determine the range of $k_p$ over which the feedback control system is stable.

\[ R(s) \xrightarrow{+} k_p \xrightarrow{-} \frac{s+1}{s(s-1)(s+6)} \xrightarrow{} Y(s) \]

Fig. 2. Feedback control system for Problem 3.1.

2) Find the range of controller gains ($k_p$ and $k_i$) so that the Proportional-Integral (PI) controlled system in Fig. 3 is stable.

\[ R(s) \xrightarrow{+} k_p + k_i(1/s) \xrightarrow{-} \frac{1}{(s+1)(s+2)} \xrightarrow{} Y(s) \]

Fig. 3. Feedback control system for Problem 3.2.