

EEEE273 - Quiz 3  
 SEMESTER 3, ACADEMIC YEAR 2013/2014  
 Date: 24 March 2014 Time: 15 minutes

**Question:**

Study the reference circuit and gain stage of 741 operational amplifier shown in Figure 1 carefully. Assume  $V_{BE}$  for npn =  $V_{EB}$  for pnp = 0.6 V, and  $\beta = 200$  for the npn transistors. Neglect dc base currents, EXCEPT for calculating  $I_{E16}$ .

Calculate  $I_{C16}$  for supply voltages of  $V^+ = +12$  V and  $V^- = -12$  V. By design  $I_{C13B} = 0.75 I_{REF}$ .

Write your answer using pen, in 4 decimal points, with proper Units for all the parameters.

[10 marks]

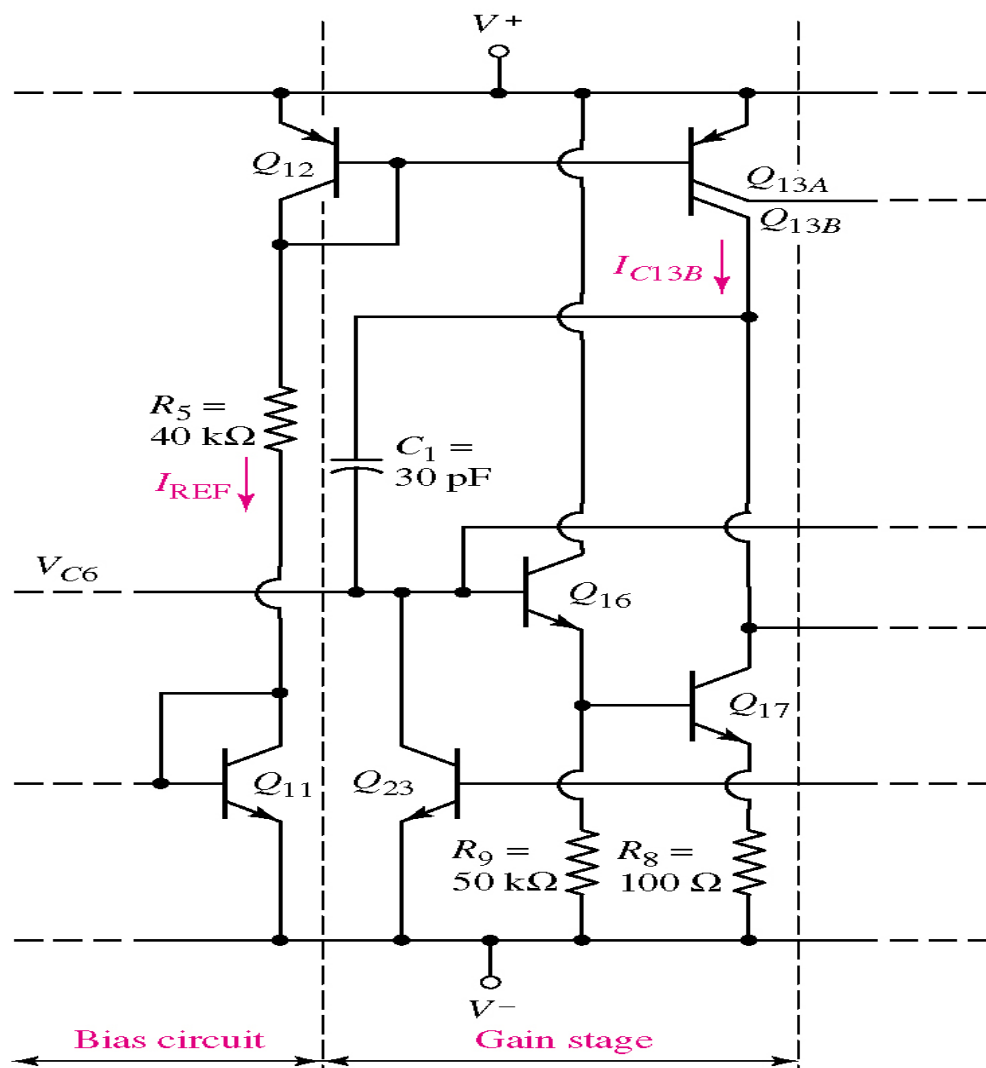


Figure 1: Reference circuit and gain stage of 741 op-amp.

**Answer:**

$$\begin{aligned} I_{REF} &= (V^+ - V - V_{EB12} - V_{BE11}) / R_5 && [1] \\ &= (12 - (-12) - 0.6 - 0.6) / (40k) && [1] \\ &= 0.570 \text{ mA} && [1] \\ \\ I_{C13B} &= 0.75 I_{REF} && [1] \\ &= 0.75 (0.570\text{m}) = 0.4275 \text{ mA} && [1] \\ I_{C17} &= I_{C13B} = 0.4275 \text{ mA} && [1] \\ \\ I_{C16} \approx I_{E16} &= I_{B17} + I_{R9} \\ &= I_{B17} + (I_{E17} R_8 + V_{BE17}) / R_9 && [1] \\ &= (I_{C17} / \beta) + (I_{C17} R_8 + V_{BE17}) / R_9 && [1] \\ &= (0.4275\text{m} / 200) + (0.4275\text{m} \times 100 + 0.6) / (50k) && [1] \\ &= 14.9925 \mu\text{A} && [1] \end{aligned}$$

$$g_m = \frac{I_C}{V_T}$$

$$r_o = \frac{V_A}{I_{CQ}}$$

$$V_T = 26 \text{ mV}$$