Name:	**Dr JBO**
Student ID Number:	**Model Answer**
Section:	
Lecturer: Dr. Jamaludin Bin Omar	

EEEB273 - Quiz 3
SEMESTER 2, ACADEMIC YEAR 2013/2014
Date: 31 December 2013 Time: 15 minutes

Question:

Study the bias circuit and input stage of **741 operational amplifier** shown in **Figure 1** carefully. Assume V_{BE} for npn = V_{EB} for pnp = **0.6 V**. Neglect dc **base currents**.

Determine the value of resistor R_5 if bias current for Q_1 is **8 µA**, and V^+ = **+12 V** and V^- = **-12 V**.

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

[10 marks]

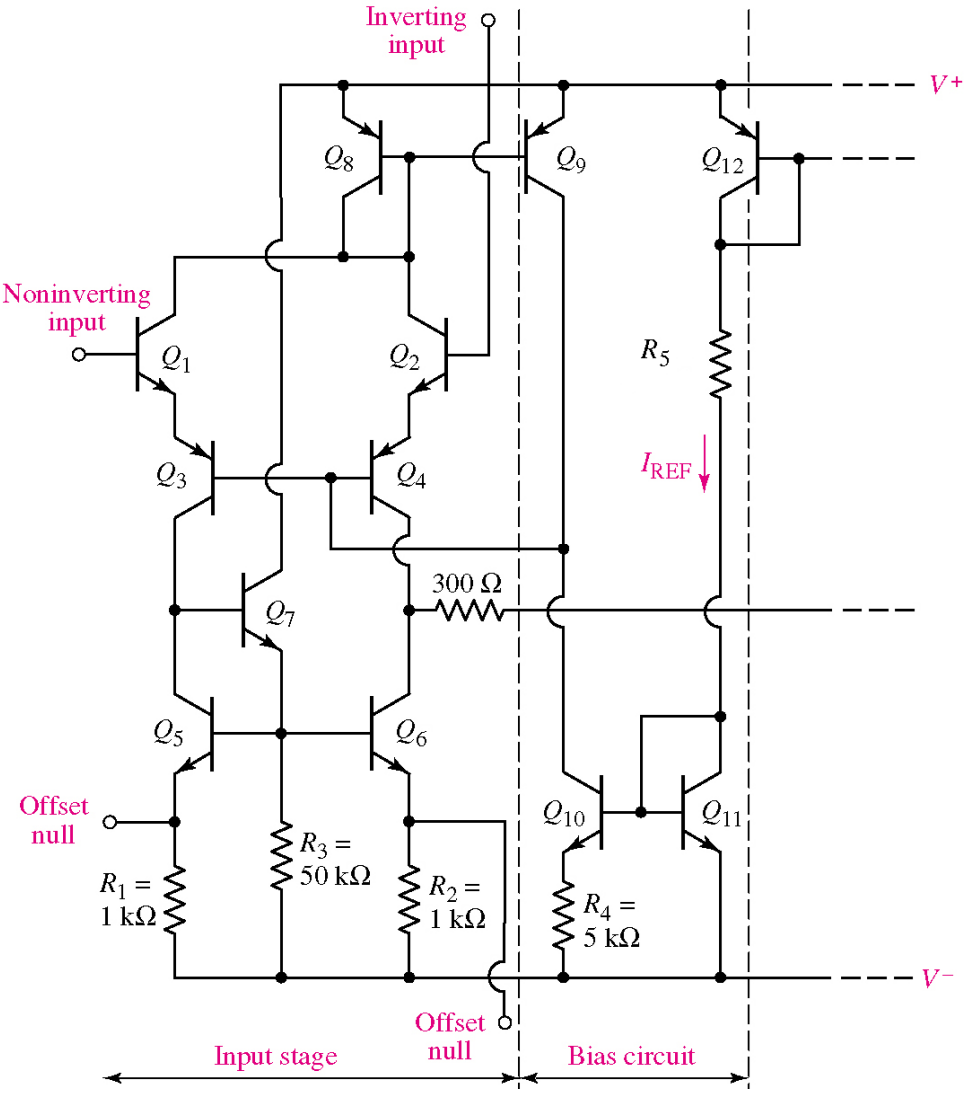

Figure 1: Bias circuit and input stage of 741 op-amp.

Answer:

I_{C1}	$= 8\ \mu A$		[1]
	$= I_{C8} / 2 = I_{C9} / 2$	$= I_{C10} / 2$	[1]
I_{C10}	$= 2 \times I_{C1}$	$= 16\ \mu A$	[1]
$I_{C10} R_4$	$= V_T \ln(I_{REF} / I_{C10})$		[1]
I_{REF}	$= I_{C10} \exp[I_{C10} R_4 / V_T]$		[1]
	$= (16\mu) \exp[(16\mu \times 5k) / (26m)]$		[1]
	$= 0.347$ mA		[1]
I_{REF}	$= (V^+ - V^- - V_{EB12} - V_{BE11}) / R_5$		
R_5	$= (V^+ - V^- - V_{EB12} - V_{BE11}) / I_{REF}$		[1]
	$= (12 - (-12) - 0.6 - 0.6) / (0.347m)$		[1]
	$= 65.694\ k\Omega$		[1]

$$i_C = I_S e^{v_{BE}/V_T}\ ;\text{npn}$$

$$i_C = I_S e^{v_{EB}/V_T}\ ;\text{pnp}$$

$$i_C = \alpha i_E = \beta i_B$$

$$i_E = i_B + i_C$$

$$\alpha = \frac{\beta}{\beta + 1}$$

;Small signal

$$\beta = g_m r_\pi$$

$$r_\pi = \frac{\beta V_T}{I_{CQ}}$$

$$g_m = \frac{I_{CQ}}{V_T}$$

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

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

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Determine the value of resistor R_5 if bias current for Q_1 is **8.5 µA**, and V^+ = **+12 V** and V^- = **-12 V**.

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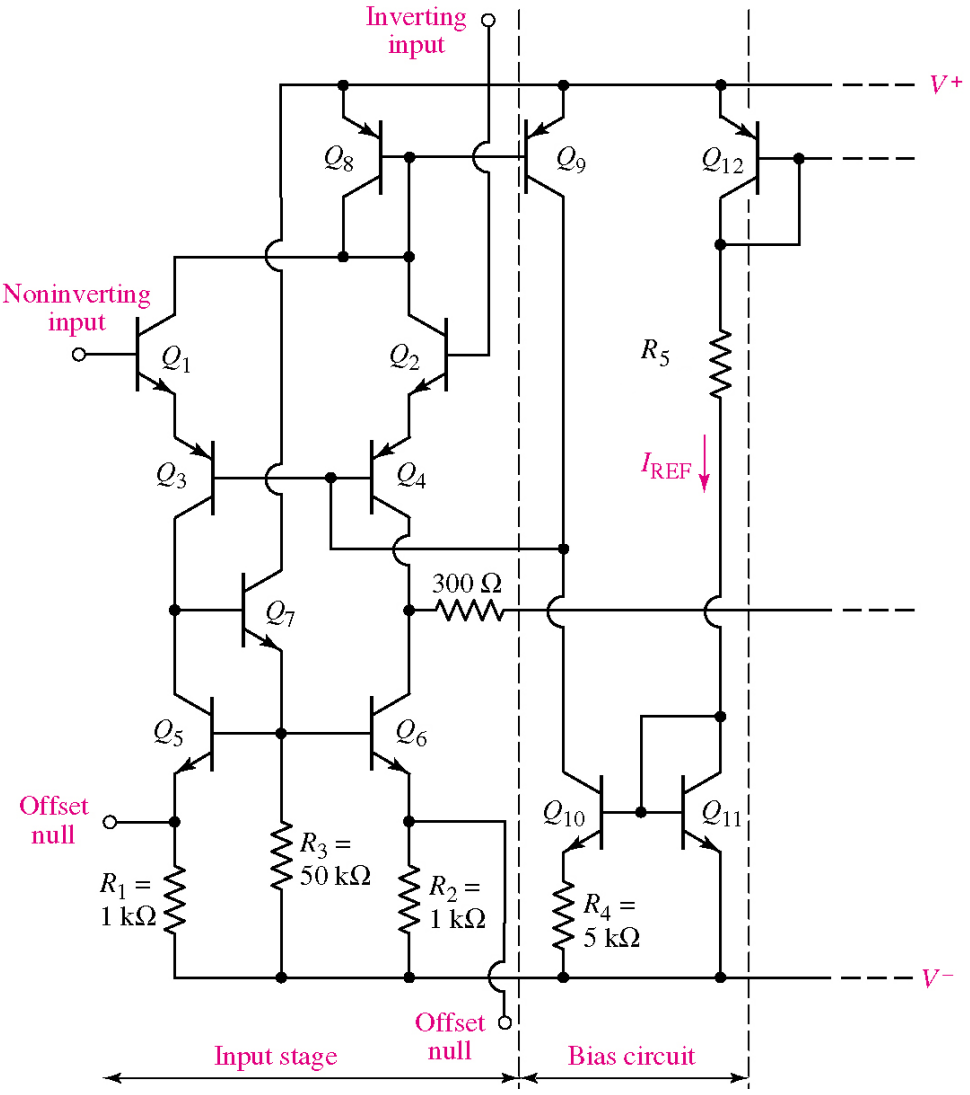

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I_{C10}	$= 2 \times I_{C1}$	=17 µA	[1]
$I_{C10} R_4$	$= V_T \ln(I_{REF} / I_{C10})$		[1]
I_{REF}	$= I_{C10} \exp[I_{C10} R_4 / V_T]$		[1]
	$= (17\mu) \exp[(17\mu \times 5k) / (26m)]$		[1]
	= 0.4469 mA		[1]
I_{REF}	$= (V^+ - V^- - V_{EB12} - V_{BE11}) / R_5$		
R_5	$= (V^+ - V^- - V_{EB12} - V_{BE11}) / I_{REF}$		[1]
	$= (12 - (-12) - 0.6 - 0.6) / (0.4469m)$		[1]
	= 51.012 kΩ		[1]

$i_C = I_S e^{v_{BE}/V_T}$; npn

$i_C = I_S e^{v_{EB}/V_T}$; pnp

$i_C = \alpha i_E = \beta i_B$

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; Small signal

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$r_\pi = \dfrac{\beta V_T}{I_{CQ}}$

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Determine the value of resistor R_5 if bias current for Q_1 is **8.5 µA**, and V^+ = **+10 V** and V^- = **-10 V**.

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

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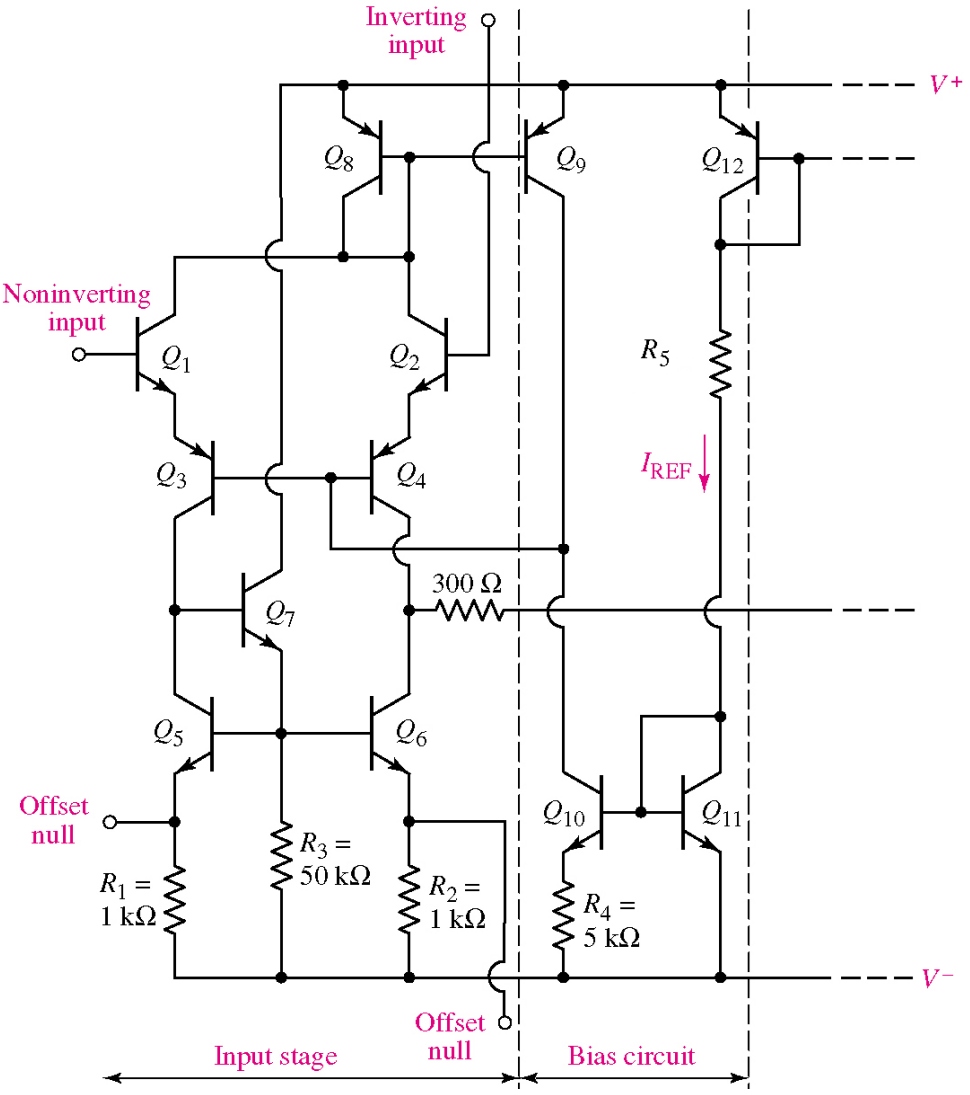

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	= 0.4469 mA		[1]
I_{REF}	$= (V^+ - V^- - V_{EB12} - V_{BE11}) / R_5$		
R_5	$= (V^+ - V^- - V_{EB12} - V_{BE11}) / I_{REF}$		[1]
	$= (10 - (-10) - 0.6 - 0.6) / (0.4469m)$		[1]
	= 42.062 kΩ		[1]

$i_C = I_S e^{v_{BE}/V_T}$; npn

$i_C = I_S e^{v_{EB}/V_T}$; pnp

$i_C = \alpha i_E = \beta i_B$

$i_E = i_B + i_C$

$\alpha = \dfrac{\beta}{\beta + 1}$

; Small signal

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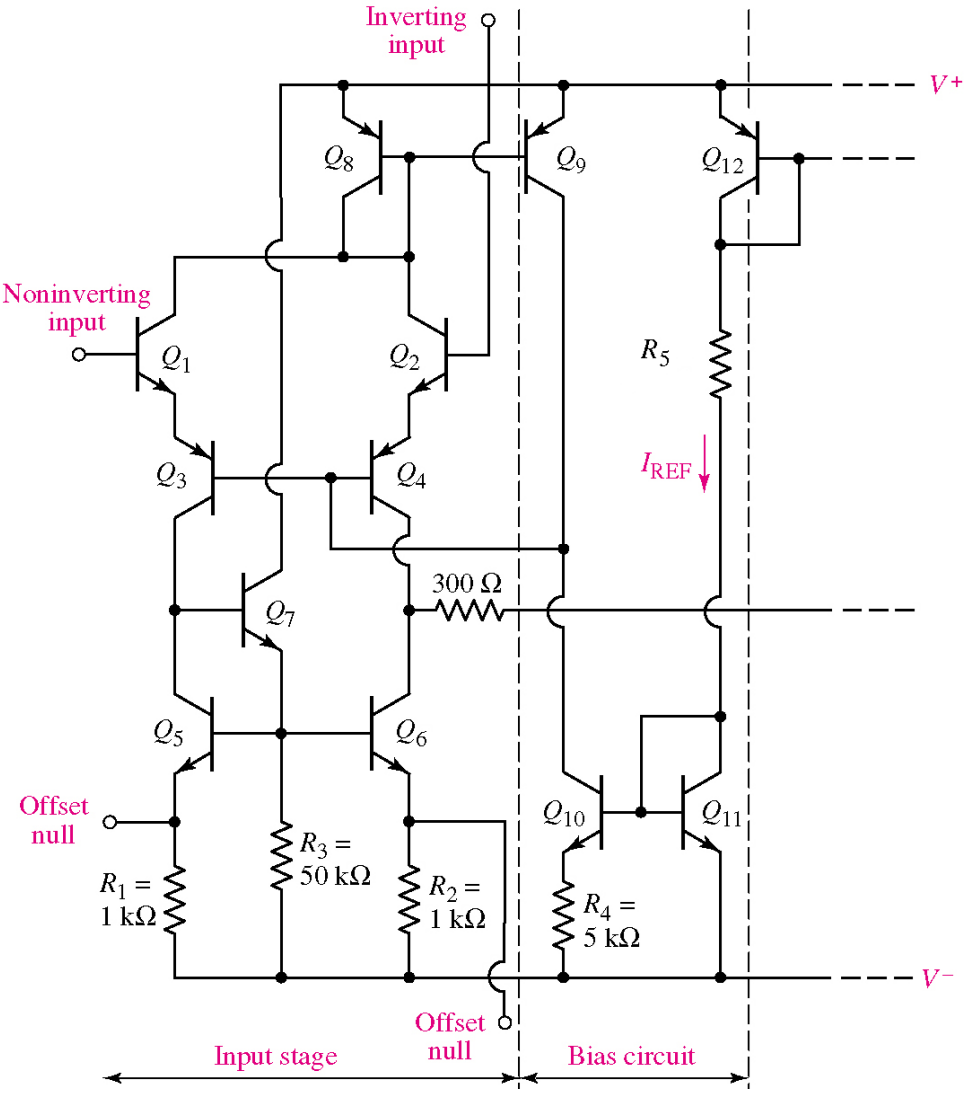

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I_{REF}	$= (V^+ - V^- - V_{EB12} - V_{BE11}) / R_5$		
R_5	$= (V^+ - V^- - V_{EB12} - V_{BE11}) / I_{REF}$		[1]
	$= (10 - (-10) - 0.6 - 0.6) / (0.347m)$		[1]
	$= 54.168\ k\Omega$		[1]

$i_C = I_S e^{v_{BE}/V_T}$; npn

$i_C = I_S e^{v_{EB}/V_T}$; pnp

$i_C = \alpha i_E = \beta i_B$

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