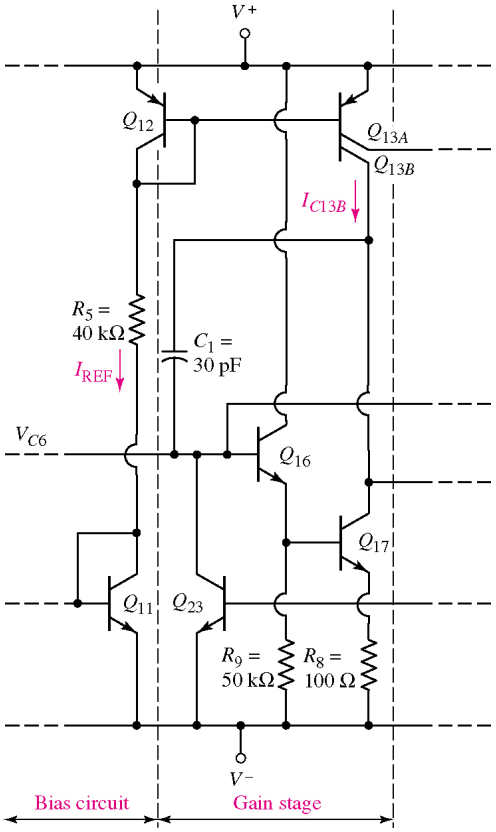
Name:	**Dr JBO**
Student ID Number:	**Model Answer**
Section:	
Lecturer:	Dr. Jamaludin Bin Omar

EEEB273 - Quiz 6
SEMESTER 1, ACADEMIC YEAR 2015/2016
Date: 27 August 2015 Time: 15 minutes

Question:

Gain stage for 741 op-amp is shown in **Figure 1**. Transistor Q_{13B} is scaled to **0.75** of transistor Q_{12}. Assume β **= 200** and V_{BE} **(on) =** V_{EB} **(on) = 0.6 V**. Given that I_{REF} **= 0.50 mA,** calculate $r_{\pi 16}$ and $r_{\pi 17}$. Show all your calculations clearly.

[10 marks]



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

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

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

$$i_E = i_B + i_C$$

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

; Small signal

$$\beta = g_m r_\pi$$

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

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

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

Answer:

I_{REF}	**= 0.50 mA**	
I_{C17}	**=** I_{C13B} **= 0.75** I_{REF}	**[2]**
	= (0.75)(0.50m) = 0.375 mA	**[1]**
I_{C16}	**≈** I_{B17} **+ (**I_{E17} R_8 **+** V_{BE17} **)/**R_9	**[2]**
	= I_{C17} **/** β **+ (**I_{C17} R_8 **+** V_{BE17} **)/**R_9	
	= 0.375m/200 + [(0.375m)(100) + 0.6]/50k	
	= 14.625 µA	**[1]**
$r_{\pi 16}$	**=** (β V_T) **/** I_{C16}	**[1]**
	= (200 x 0.026) / (14.625 µA) = 355.55 kΩ	**[1]**
$r_{\pi 17}$	**=** (β V_T) **/** I_{C17}	**[1]**
	= (200 x 0.026) / (0.375 mA) = 13.86 kΩ	**[1]**

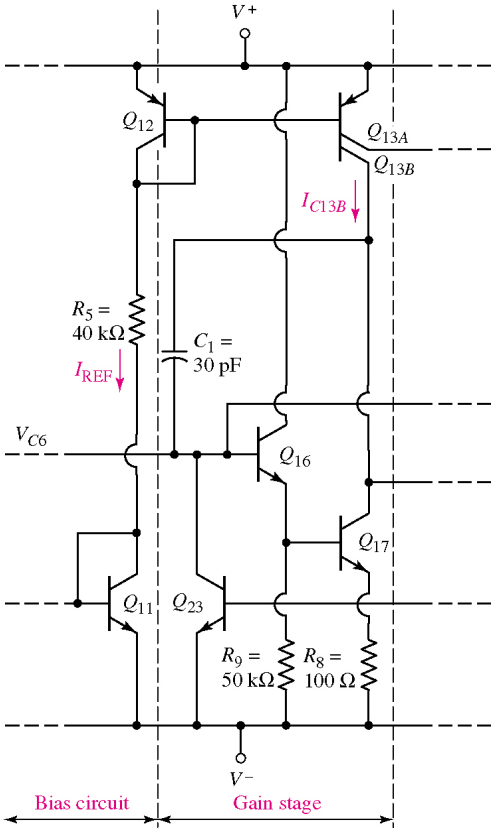
Name:	**Dr JBO**
Student ID Number:	**Model Answer**
Section:	
Lecturer:	Dr. Jamaludin Bin Omar

EEEB273 - Quiz 6
SEMESTER 1, ACADEMIC YEAR 2015/2016
Date: 27 August 2015 Time: 15 minutes

Question:

Gain stage for 741 op-amp is shown in **Figure 1**. Transistor Q_{13B} is scaled to **0.75** of transistor Q_{12}. Assume β **= 180** and V_{BE} **(on) =** V_{EB} **(on) = 0.6 V**. Given that I_{REF} **= 0.45 mA,** calculate $r_{\pi 16}$ and $r_{\pi 17}$. Show all your calculations clearly.

[10 marks]



$$i_C = I_S e^{v_{BE}/V_T}\text{; npn}$$
$$i_C = I_S e^{v_{EB}/V_T}\text{; pnp}$$
$$i_C = \alpha i_E = \beta i_B$$
$$i_E = i_B + i_C$$
$$\alpha = \frac{\beta}{\beta + 1}$$

; Small signal

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

Answer:

I_{REF} = 0.45 mA

I_{C17} = I_{C13B} = 0.75 I_{REF} **[2]**
= (0.75)(0.45m) = 0.3375 mA **[1]**

I_{C16} ≈ I_{B17} + (I_{E17} R_8 + V_{BE17})/R_9 **[2]**
= I_{C17} / β + (I_{C17} R_8 + V_{BE17})/R_9
= 0.3375m/180 + [(0.3375m)(100) + 0.6]/50k
= 14.55 µA **[1]**

$r_{\pi 16}$ = (β V_T) / I_{C16} **[1]**
= (180 x 0.026) / (14.55 µA) = 321.649 kΩ **[1]**

$r_{\pi 17}$ = (β V_T) / I_{C17} **[1]**
= (180 x 0.026) / (0.3375 mA) = 13.867 kΩ **[1]**

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

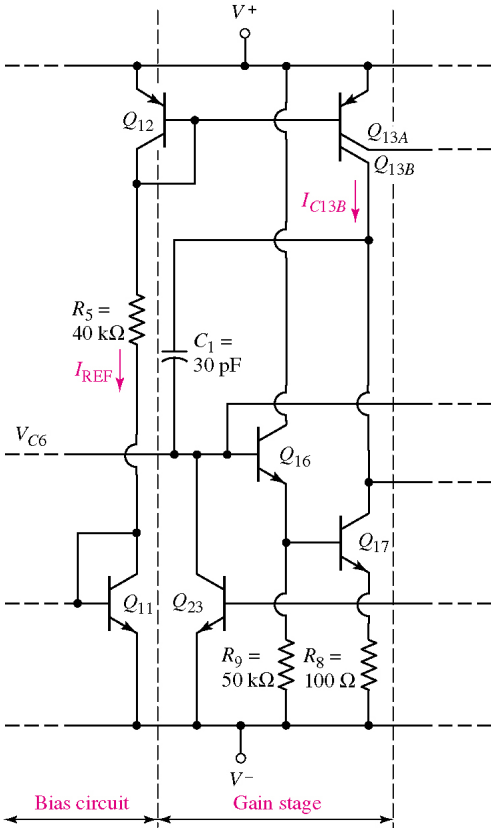
EEEB273 - Quiz 6
SEMESTER 1, ACADEMIC YEAR 2015/2016
Date: 27 August 2015 Time: 15 minutes

..

Question:

Gain stage for 741 op-amp is shown in **Figure 1**. Transistor Q_{13B} is scaled to **0.75** of transistor Q_{12}. Assume β **= 220** and V_{BE} **(on) =** V_{EB} **(on) = 0.6 V**. Given that I_{REF} **= 0.48 mA,** calculate $r_{\pi 16}$ and $r_{\pi 17}$. Show all your calculations clearly.

[10 marks]



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

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

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

$$i_E = i_B + i_C$$

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

; Small signal

$$\beta = g_m r_\pi$$

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

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

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

Answer:

I_{REF}	**= 0.48 mA**	
I_{C17}	**=** I_{C13B} **= 0.75** I_{REF}	**[2]**
	= (0.75)(0.48m) = 0.36 mA	**[1]**
I_{C16}	**≈** I_{B17} **+ (**I_{E17} R_8 **+** V_{BE17} **)/**R_9	**[2]**
	= I_{C17} **/** β **+ (**I_{C17} R_8 **+** V_{BE17} **)/**R_9	
	= 0.36m/220 + [(0.36m)(100) + 0.6]/50k	
	= 14.356 µA	**[1]**
$r_{\pi 16}$	**=** (βV_T) **/** I_{C16}	**[1]**
	= (220 x 0.026) / (14.356 µA) = 398.439 kΩ	**[1]**
$r_{\pi 17}$	**=** (βV_T) **/** I_{C17}	**[1]**
	= (220 x 0.026) / (0.36 mA) = 15.89 kΩ	**[1]**

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

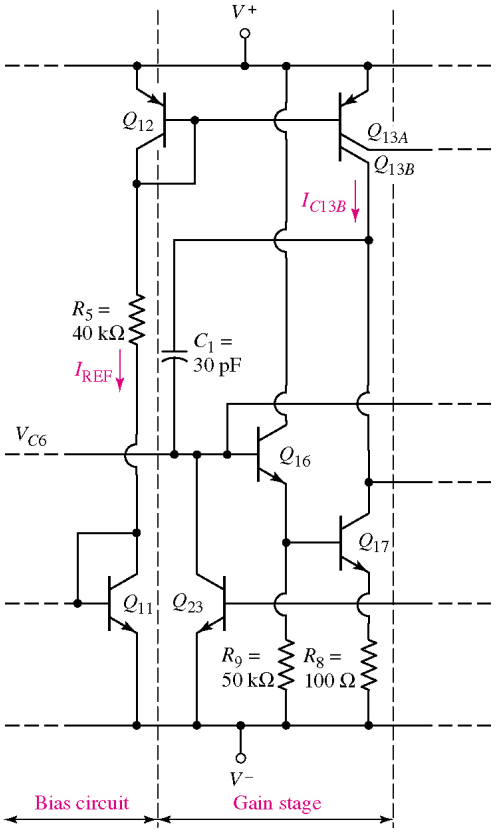
EEEB273 - Quiz 6
SEMESTER 1, ACADEMIC YEAR 2015/2016
Date: 27 August 2015 Time: 15 minutes

,,

Question:

Gain stage for 741 op-amp is shown in **Figure 1**. Transistor Q_{13B} is scaled to **0.75** of transistor Q_{12}. Assume β **= 210** and V_{BE} **(on) =** V_{EB} **(on) = 0.6 V**. Given that I_{REF} **= 0.52 mA,** calculate $r_{\pi 16}$ and $r_{\pi 17}$. Show all your calculations clearly.

[10 marks]



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

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

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

$$i_E = i_B + i_C$$

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

; Small signal

$$\beta = g_m r_\pi$$

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

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

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

Answer:

I_{REF}	**= 0.52 mA**	
I_{C17}	**=** I_{C13B} **= 0.75** I_{REF}	**[2]**
	= (0.75)(0.52m) = 0.39 mA	**[1]**
I_{C16}	**≈** I_{B17} **+ (**I_{E17} R_8 **+** V_{BE17} **)/**R_9	**[2]**
	= I_{C17} **/** β **+ (**I_{C17} R_8 **+** V_{BE17} **)/**R_9	
	= 0.39m/210 + [(0.39m)(100) + 0.6]/50k	
	= 14.637 µA	**[1]**
$r_{\pi 16}$	**=** $(\beta V_T) / I_{C16}$	**[1]**
	= (210 x 0.026) / (14.637 µA) = 373.027 kΩ	**[1]**
$r_{\pi 17}$	**=** $(\beta V_T) / I_{C17}$	**[1]**
	= (210 x 0.026) / (0.39 mA) = 14 kΩ	**[1]**