1. (a) Explain how an amplifier works in your own words.
   (b) Explain in your own words what \( R_i \) is.
   (c) Explain in your own words what \( R_o \) is.
   (d) Describe the ideal characteristics for an amplifier (i.e. ideal value for \( R_i, R_o, A_v \)).
   (e) Describe the characteristics for a buffer amplifier.
   (f) Describe Gain-Bandwidth Product in your own words.

2. Use the circuit below:

Amp1 is a CA3140 and Amp2 is an LM741. (See attached datasheet information)
   (a) State each amplifiers frequency response transfer function (\( V_o/V_{in} \) and \( V_o/V_1 \)).
   (b) State the overall transfer function (\( V_o/V_{in} \)).

3. Solve for the overall \( f_{3dB} \) of the circuit in #2. (You can use Matlab if you like)

4. \( V_s \) is an AC signal. Both amplifiers have the following characteristics:

\[
R_i = 100k\Omega, \quad R_o = 5k\Omega, \quad \text{Clipping levels: } L = \pm 12V \text{ (unloaded)}
\]

(a) State the value of \( A_v \) (or gain) for Amp1 (the gain \( V_2/V_1 \)) and Amp2 (the gain \( V_3/V_2 \)).
(b) Redraw this 2 stage amplifier using the voltage amplifier model. Make sure to label \( V_s, V_1, V_2, V_3, \) and \( V_o \) on the schematic.
5. (a) Find the overall gain of the circuit in #4, $A_v = \frac{V_o}{V_s}$. Express your answer as a ratio($V/V$) and in dB. [Round answer to the nearest whole number]
(b) Find $A_i = \frac{I_L}{I_s}$. Express your answer as a ratio($A/A$) and in dB. [Round the answer to the nearest whole number] Hint: Write an equation based on $V_o$ and $V_s$ that have $I_L$ and $I_s$ in them and relate the two.

6. Analyze the circuit below to obtain the transfer function, $V_o/V_{in}$. Assume an ideal op amp.

7. Sketch the straight line approximation for the Bode Plots for the equation from #6.

8. Redraw or add to the schematic below to show how to reduce the input bias current. State the symbolic value(s) of any components added to the schematic.

9. Find $I$ and $V_o$ assuming ideal diodes.
## Electrical Specifications

### For Equipment Design

The LM741 (V_{SUPPLY} = ±15V, T_A = 25°C) is a low-power, high-performance operational amplifier. The specifications are provided for various parameters under typical conditions. Here are the key specifications:

### Characteristics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Test Conditions</th>
<th>Typical Values</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Offset Voltage</td>
<td>V_{os}</td>
<td>25°C, 1kHz</td>
<td>±400μV</td>
<td>μV</td>
</tr>
<tr>
<td>Input Offset Current</td>
<td>I_{os}</td>
<td>25°C</td>
<td>±4μA</td>
<td>μA</td>
</tr>
<tr>
<td>Input Bias Current</td>
<td>I_{bi}</td>
<td>25°C, 1kHz</td>
<td>±60μA</td>
<td>μA</td>
</tr>
<tr>
<td>Common Mode Rejection Ratio</td>
<td>CMRR</td>
<td>25°C</td>
<td>≥70dB</td>
<td>dB</td>
</tr>
<tr>
<td>Output Current</td>
<td>I_{o}</td>
<td>±15V</td>
<td>±1mA</td>
<td>mA</td>
</tr>
<tr>
<td>Output Voltage Swing</td>
<td>V_{os}</td>
<td>±15V</td>
<td>±10V</td>
<td>V</td>
</tr>
</tbody>
</table>

### Typical Values

- **V_{os}**: ±400μV
- **I_{os}**: ±4μA
- **I_{bi}**: ±60μA
- **CMRR**: ≥70dB
- **I_{o}**: ±1mA
- **V_{os}**: ±10V

### Key Features

- **V_{os}**: ±400μV
- **I_{os}**: ±4μA
- **I_{bi}**: ±60μA
- **CMRR**: ≥70dB
- **I_{o}**: ±1mA
- **V_{os}**: ±10V

### Characteristics

- **V_{os}**: ±400μV
- **I_{os}**: ±4μA
- **I_{bi}**: ±60μA
- **CMRR**: ≥70dB
- **I_{o}**: ±1mA
- **V_{os}**: ±10V

LM741: Open Loop Frequency Response (Typ.)

![Open Loop Frequency Response](image)

**FREQUENCY (Hz)**

**VOLTAGE GAIN (dB)**

**FREQUENCY (Hz)**

**VOLTAGE GAIN (dB)**

<table>
<thead>
<tr>
<th>FREQUENCY (Hz)</th>
<th>VOLTAGE GAIN (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 Hz</td>
<td>120</td>
</tr>
<tr>
<td>100 Hz</td>
<td>110</td>
</tr>
<tr>
<td>1 kHz</td>
<td>100</td>
</tr>
<tr>
<td>10 kHz</td>
<td>90</td>
</tr>
<tr>
<td>100 kHz</td>
<td>80</td>
</tr>
<tr>
<td>1 MHz</td>
<td>60</td>
</tr>
<tr>
<td>10 MHz</td>
<td>40</td>
</tr>
</tbody>
</table>

The LM741 is designed for a wide range of frequencies, providing a high level of performance and reliability in various applications.