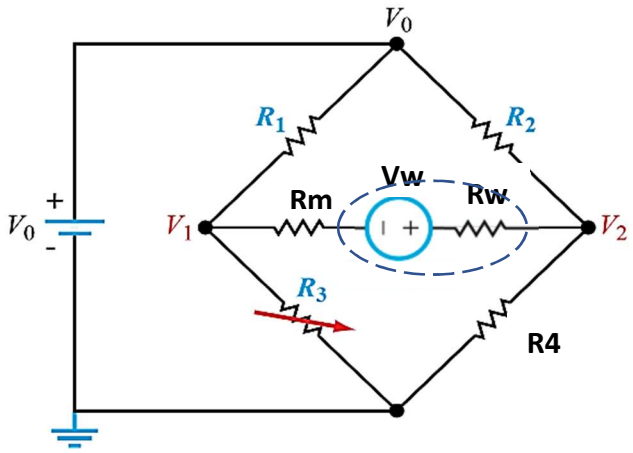
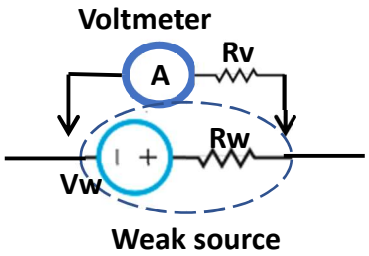
Test 1, 214 Hemmer sections Name_____

1. A 10 W USB power supply is designed to power a 10 W USB device at the end of a 1 meter cable (copper AWG20). Hint: For simplicity assume power can be converted to current using the nominal USB voltage of 5 V.
(a) What is Vth and Rth of the USB supply?
(b) Assume a 10 meter cable is used. What is the maximum power of the USB device that can be driven?
(c) If the 10 W supply is connected to a 20 W device, what is the voltage supplied to the load? Is it within USB specifications?

2. Consider a USB battery designed to drive a 2.5 W device. Assume the fully charged (100 %) battery has a Vth100 = 5.25 V and a fully discharged (0 %) battery has a Vth0 = 4.90 V.
(a) What is Rth for the battery?
(b) If the battery has a capacity of 100 A-hr, how long can the battery power the device?
(c) Batteries can be damaged if overcharged. Design a simple circuit to prevent this, using diodes.
(d) Approximately how many diodes are needed assuming VF=0.66 V?

3. A Wheatstone bridge, with resistors R1=R2=R4=R and variable R3~R, is used to measure the Thevenin voltage Vw of a weak voltage source (defined as having a large Rw) by monitoring current through a monitor resistor Rmo in series with the weak source. In short, the variable resistor is adjusted to minimize this current (close to zero as possible), and then a second voltmeter is used to measure (V2-V1). Assume the Wheatstone bridge is powered by a 100 V power supply with Thevenin resistance much smaller than R. Take R=10 kΩ. Assume the weak-source has Thevenin voltage and resistance given by Vw=1 V and Rw= 100 MΩ.
(a) Assume that the voltage across the monitor resistor Rmo can be set exactly to zero. What is the approximate percent error if (V2-V1) is taken as Vw?
(b) Assume the voltage across Rmo is measured by a voltmeter that can go down to Vm1=0.1 mV. What is the approximate percent error in the voltage measurement if Rmo=1 MΩ?
(c) Using the model of a voltmeter shown, (ie ammeter in series with large resistor Rv) what is the error if a voltmeter with resistance Rv=10 ΩW is used to measure the voltage of the weak-source directly? Hint: You can neglect the ammeter resistance.
(d) Now use the same voltmeter with resistance Rv=10 ΩW to measure the voltage (V2-V1) when the voltage across Rmo has been minimized. What is the percent error in this case? Hint: A rough estimate will do.
(e) If the voltmeter used to measure the voltage across Rmo has resistance Rv1=1 MΩ, what is the percent error in this case? Hint: Rmo=1 MΩ as above.





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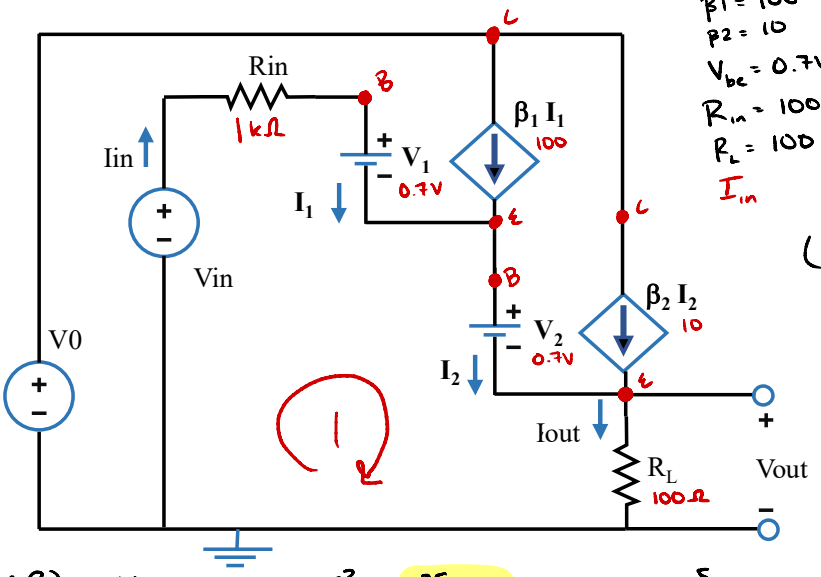
4. The circuit shown below has two dependent sources. For simplicity assume V1=V2=0.7 V. Take β1 = 100 and β2 = 10. Choose Rin = 1 kΩ and R_L = 100 Ω. Assume Vin > V1+V2.
(a) What is the voltage gain of the circuit? $(A_v = V_{out}/V_{in})$
(b) What is the current gain for the circuit? $(A_I = I_{out}/I_{in})$
(c) What are the limiting voltage and current gains in the limit of large beta.
(d) For an input voltage of Vin = 5 V and supply voltage V0 = 10 V, what is the power dissipated in each resistor?
(e) What is the power supplied by each source?



Values
$\beta_1 = 100$
$\beta_2 = 10$
$V_{be} = 0.7V$
$R_{in} = 1000$
$R_L = 100$
I_{in}

EQUATION

(a) $* I_{in} = I_1$
$I_2 = (1+\beta_1) I_1$
$\frac{V_{out}}{R_L} = (\beta_2+1)(\beta_1+1) I_1$
$V_{in} = I_1 R_{IN} + V_1 + V_2 + R_L(\beta_2+1) \times (\beta_1+1) I_1$
PLUGGED INTO JUPITER NOTEBOOK

(b) $A_I = \frac{I_{out}}{I_{IN}}$ VOUT = 0.99 × VIN − 1.3875

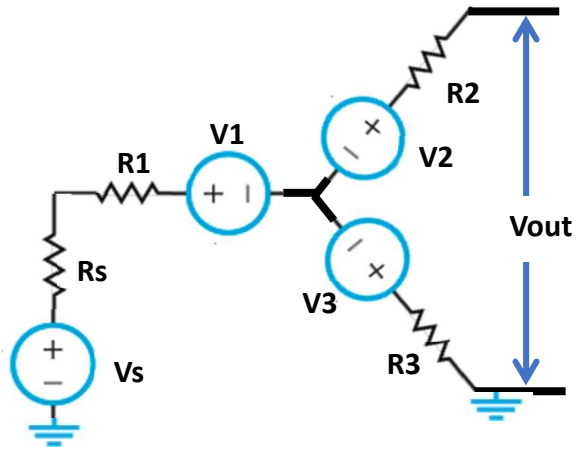
$\frac{V_{out}}{R_L} = \beta_1 I_1 + \beta_2 I_2$

(c.) $\beta_1 \beta_2 \gg 1$ C = 0
$V_{out} = \frac{(1+\beta_1)(1+\beta_2)}{(1+\beta_2)(1+\beta_2)} = 1$

(d) $V_{in} = 5V$ $V_0 = 10V$

(e) V_{in}: $P = V_{in} I_{in} = \frac{5^2}{1000} = \frac{25}{1000} W = 55.5 W$
V_0: $P = VI = \frac{25}{1000} W$
$P_{IN}: I_{IN} = \frac{5}{1000}$ $P = I^2 R = 0.025W$
$R_L = I_{out} = 5.55$ $P = I^2 R = (5.55)^2 100 = 3000W$

5. The circuit shown includes Wye power source. Assume the output is loaded with a resistor RL. For simplicity assume R1=R2=R3=R. Also assume Vs=10, Rs=100, V=1, R=100, RL=10 where voltages are in Volts and resistances are in Ohms.
(a) If V1=V2=V3=V=100 what are the node voltages?
(b) If V1=V2=V3=V=100 what are the mesh currents?
(c) What is the Thevenin voltage at the output?
(d) What is the Thevenin resistance at the output?
(e) What is the Thevenin voltage at the output if V1=0, V2=V, V3=-V, V=100



(A) $V_1 + V_2 + V_3 = 100$
$100 - 10 = 90V = 90V$
NODE 2 = 100V
NODE 3 = 0V

(B) $I_1 = \frac{V_s}{R_s+R_1} - \frac{V_1}{R_s+R_1} + \frac{V_s}{R_s} = 0.05A$ High
$I_2 = \frac{V_2}{R_s+R_1} - \frac{V_3}{R_3} = -0.09A$ For 2

(C) $V_{th} = V_{RL} = V_s \cdot \frac{R}{R_{eq}} = 1V - \frac{10}{300} = 0.633V$
$V_{th} = 0.633V$

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Extra credit. A 120 W, 12 V battery has the voltage-charge characteristics shown below. Assume a full charge is 10 kW-hr.
(a) Design a charging circuit to prevent overcharging.
(b) What is the maximum current that can be supplied to the battery by this charger circuit.
(c) How long would it take to charge the battery at this current?
(d) How does state-of-charge depend on time?