Fundamentals of Engineering Design

New Jersey Institute of Technology

N J I T

A Gateway Coalition School

The Electrical Engineering Module
FED 101 EEM

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INTRODUCTION

The field of electrical engineering is broad. Most of the products that we deal with in our daily lives have connections with electrical engineering. We are users of electrical engineering to light our way, control our indoor climate, communicate information and provide us with entertainment. The automobiles we drive, the computers we use, and the appliances we rely upon are heavily dependent on electrical engineers in their design. The purpose of the Electrical Engineering Module is to acquaint the student with one of the many aspects of electrical engineering and leads to the design of a useful electronic circuit.

OBJECTIVES

A student having successfully completed the EE module will be able to :

1. **Understand the basic concepts of voltage, current and resistance in dc circuits.**
2. **Apply Ohm's law and Kirchoff's laws to simple dc circuits.**
3. **Measure voltage, current and resistance using a digital volt ohm meter (DVOM)**
4. **Identify resistance values using the standard color code.**
5. **Wire simple circuits using an electronic designer's "proto-board."**
6. **Measure the characteristics of diodes, transistor as a switch and as a current amplifier.**
7. **Understand the basic operation of simple diode and transistor circuits.**
8. **Connect and verify the operation of a transistor as a switch and as a current amplifier.**
9. **Keep a laboratory notebook and use it to record data in a proper engineering manner.**
10. **Participate in a guided-design project with his/her group, leading to a working design of a useful product.**

MODULE ORGANIZATION

The EE module will be completed in fourteen weeks. Each week the class will meet for one140 minute period. Emphasis will be on laboratory hands-on experience by the group. Each period will began by a brief lecture – discussion of the expected accomplishments of the period and the methods needed to achieve them. The groups will then work in a hands-on environment with the involvement of the course instructor. Daily progress is required to attain the final goal of the EE module, a working design.

Students are to maintain a laboratory notebook documenting the experimental results and observations. Notebooks should be dated and signed each time laboratory work is performed.

The design project will be specified in the 8^{th} week of the module. Groups will be expected to have a paper design in the form of block diagram in the 9^{th} week and discuss them with the instructor.

In the 13^{th} week projects are complete. (constructed, demonstrated and presented orally.)

Week 14 is reserved for summary discussion and feedback to students.

EVALUATION OF STUDENT PERFORMANCE

1. LABORATORY NOTEBOOK

Students are expected to complete all the assigned experimental work and document their work in a laboratory notebook. The method of keeping a notebook and specifics on information it should contain will be presented in the course.

2. QUIZ

Basic dc calculations using Ohm's Law and Kirchoff's Laws are necessary to understand the material in the EE module. At least one short quiz will be given to evaluate each students grasp of fundamental circuits. Date will be announced. Sample quizzes are included in this package.

3. DESIGN

Each group is expected to demonstrate a working design project. This will be accomplished by constructing the circuit, submission of written report and an oral presentation. The written report and oral presentation is to be of professional quality using the methods and format and writing techniques discussed in the Humanities course. Details of these reporting methods will be outlined by the instructor.

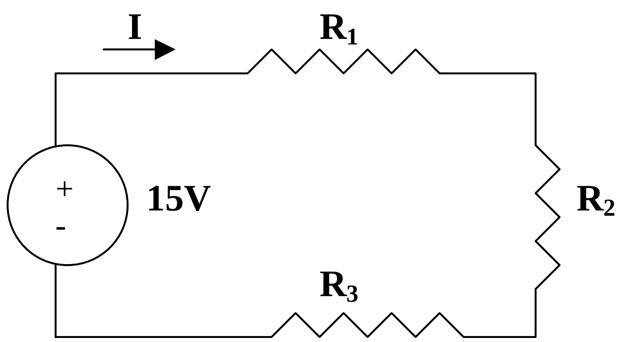
LABORATORY EXPERIENCE 1

1. Check out kit of electrical parts, DVOM and proto-board.

2. Get acquainted with the resistance scales of the DVOM. Measure at least ten resistors including your own body resistance (from left hand to right hand). Use the color code provided, to verify the measured values and sort all the resistors in the kit unto useful groups for later use.

3. Examine the "proto-boards." Note the power supply connections +5Vand ±15V. Draw careful sketch of the proto-board in your notebook. Indicate wiring connections existing among the in holes.

4. Wire the following series circuit:



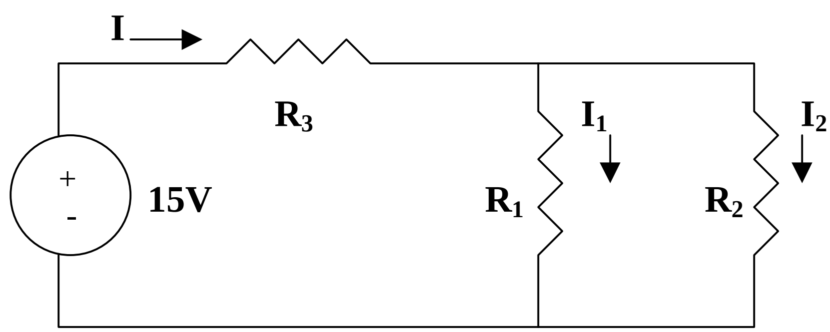
Choose R1, R2 and R3, each to be several thousand ohms (kΩ). For example R1 ≈ 15K; measure each before wiring into the circuit. Almost any available values of R are OK.

Measure I, and the voltage across each resistor and the 15V power supply. Record all data in your notebook with a sketch of the circuit. Verify Kirchoff's voltage law and Ohm's law.

Calculate the values of I and the three voltages using Ohm's law. Do your measured values agree with the calculated values? If not find the reason for the discrepancy and correct.

LABORATORY EXPERIENCE 2

1. Wire the following circuit:



Use the same resistors as in part 4. of laboratory 1

Calculate I, I1, I2, the 15V supply voltage and the voltage across R1.

Do your measures values agree with your calculated values? If not find the reason for he discrepancy and correct.

<u>From this point on, all experimental work must be documented in your laboratory notebook.</u>

Verify Kirchoff's voltage and Kirchoff's current law.

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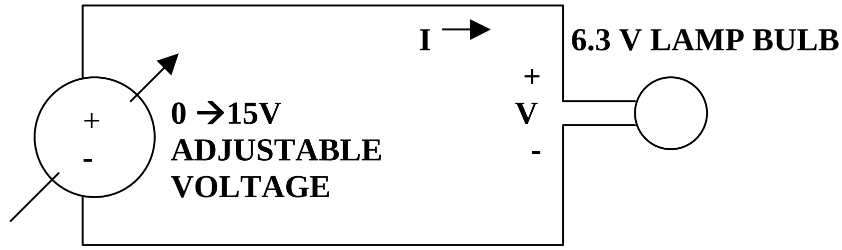
LABORATORY EXPERIENCE 2 (continued)

2. Wire the following circuit:



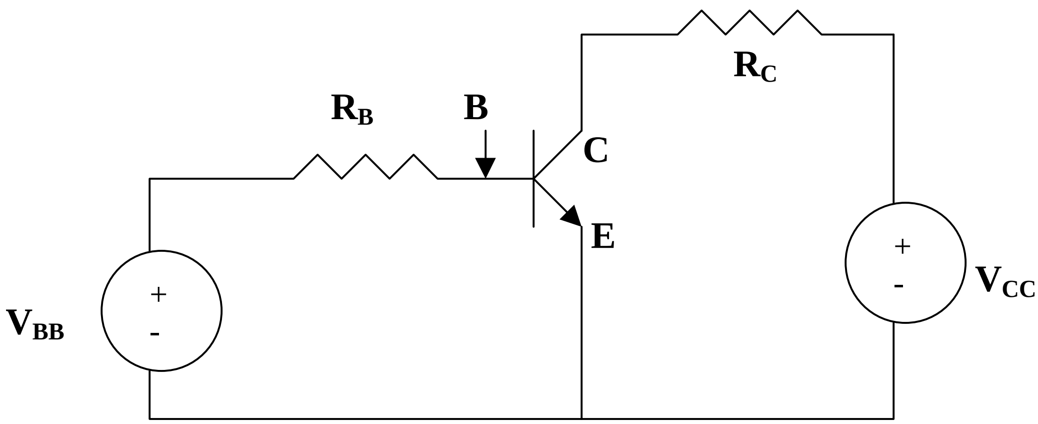
Take data of I vs. V for the 6.3V lamp. Do not let V exceed 7.0 volts. Take sufficient data to plot a smooth curve of I vs. V. (Plot I on the ordinate and V on the abscissa). Plot also power P (in watts) vs. V. Indicate a point on the power graph at which you being to see the light from the bulb filament. Use graph paper and also use a computer program to draw the curve.

Note that you will need to switch the leads and scale of your DVOM for each reading of I and V. Your instructor will discuss an alternate method after you complete this part 2.

3. Repeat the measurement of part 2 but replace the 6.3V lamp with a diode in series with a resistor. Try to get data form current values form 0.1 mA to 10 mA (use first 10k and then 1k resistor for higher current values.) connect the diode in “reverse direction” in series with a 1 M resistor and see if you can read the “reverse current”.

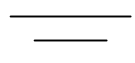
LABORATORY EXPERIENCE 3

Introduction: Transistors are three terminal (wire) devices. Their operation has been discussed by your instructor. The usual wiring for the common emitter connection is shown below:

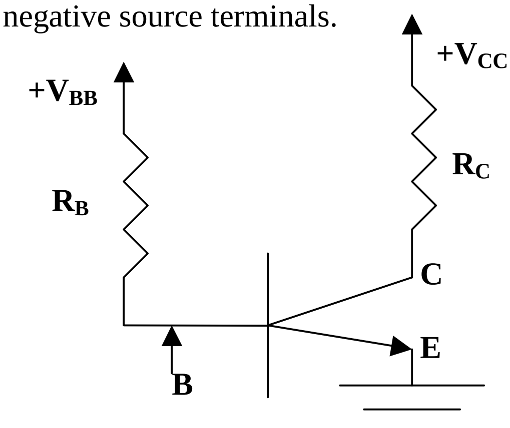


Emitter is connected to the common negative terminal of each voltage source. Such arrangement is called <u>common emitter connection.</u>

Conventional circuits diagrams simplify schematics by eliminating the voltage sources and showing instead arrows going to the source terminals.

The symbol 

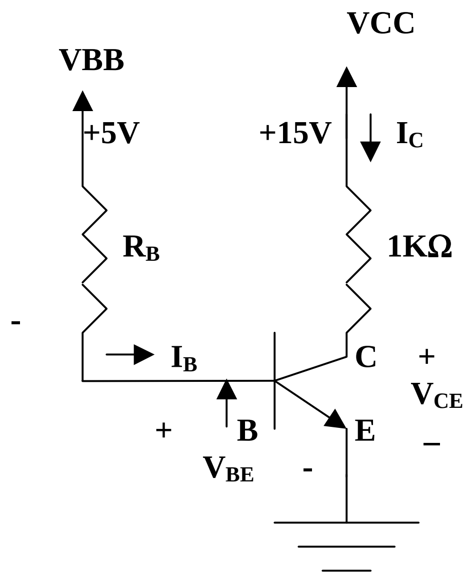
indicates a common terminal (ground), which in this case is connected to the negative source terminals.



Conventional circuit diagram for common emitter connection.

1. Transistor operation

   Wire the following circuit:



Measure the quantities needed to complete the following table:

Rb	Vce	Vbe	Ib(cal)	Ic (cal)	Ic/Ib
22kΩ					
100kΩ					
2.2MΩ					

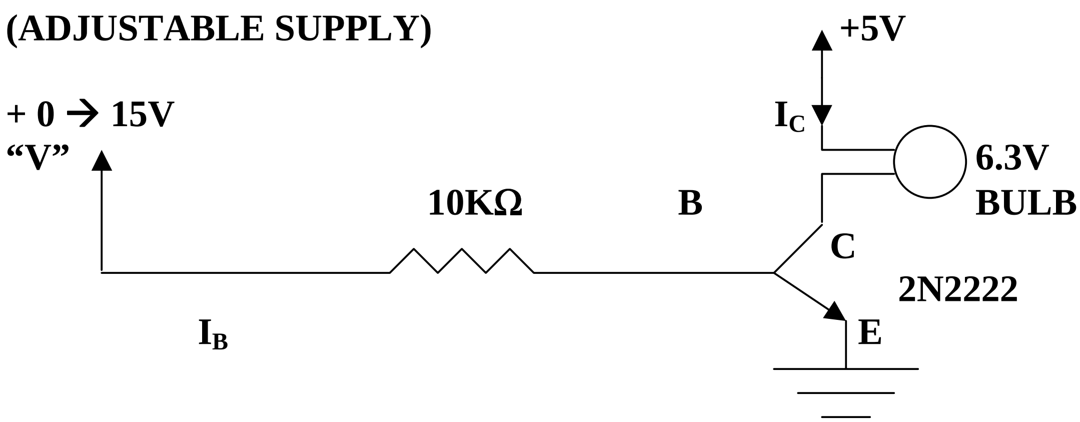
2. For each value of Rb above, using measurements, calculate Ib and Ic. Note: Use K.V.L.

   VCC = Ic(1k) + Vce

   VBB = Ib(RB) + Vbe

3. Compute Ic/Ib for each value of Rb above.

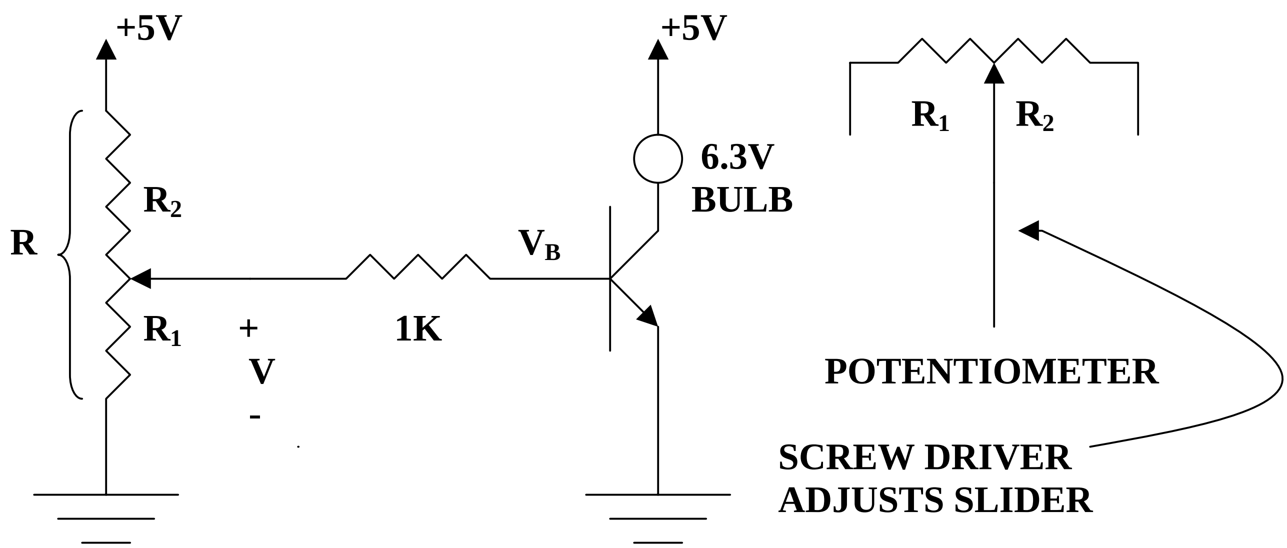
4. Wire the following circuit:



Vary V. Observe two conditions: (1) bulb is "just off" (almost no light) and (2) bulb reaches maximum brightness. Measure Ib, Ic and "V" for these two conditions:

(1) Bulb is "just off" (almost no light)
(2) Bulb is lighted to maximum brightness

5. Repeat the measurement described in 4 but instead of adjusting the power supply voltage use a resistive voltage divider using a potentiometer, as shown below.



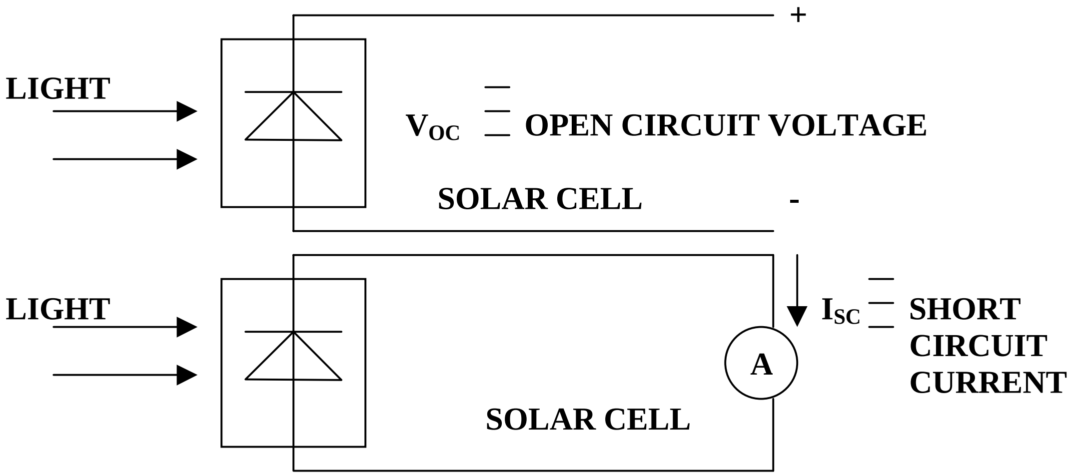
The potentiometer of resistance R may be thought of as two resistors R1 and R2 connected in series. The resistor values vary as the slider is moved but always R1 + R2 = R. Use a + 5k potentiometer and the resistor in the base circuit of about 1 k.

Note the ratios of R1/R2 and values of V for two conditions:

The bulb ”just off” and “full brightness.”

LABORATORY EXPERIENCE 4

1. Measure the open circuit voltage and short circuit current of the solar cell.



For thee solar cell make a plot of I short circuit vs. light intensity in foot candles. To obtain data, a light source and light meter will be provided. Try to arrange the solar cell and the light meter in the same plane and the same distance from the light source. Once a suitable arrangement is set up try not to move the components. Take at least 10 data sets.

The light source is a reflector-type flood lamp. The brightness is varied by means of a dimmer control". If weather permits, use natural sunlight to obtain one data point.

2. Place a 10Ω resistor across the solar cell and measure the voltage across this resistor. Do this for sunlight or maximum flood lamp brightness. Calculate the current and power from the solar cell.

3. Photoresistor:

   Measure the resistance of the photoresistor as a function of the light intensity. Include ambient room light as one data point. Take at least 10 data sets.

4. Design a circuit using a voltage source, photoresistor, and a fixed resistor so that a voltage can be obtained that will vary with light intensity. Build and test this circuit to verify its operation. Record all data needed to verify this circuit design.

FED EE MODULE

Project Specifications

- Each group is required to design a circuit that will turn on a light when the sensor is in the dark and turn off the light when the sensor is exposed to the ambient room light

- The circuit will be constructed and demonstrated to the instructor that it operates as required.

- A short report explaining what was required, how the circuit was designed o meet the requirements and a schematic diagram with component values will be prepared and handed in.

- The report should also discuss the possibility of powering the project using batteries which will be recharged using solar cells of the type measured in class. It should include an approximate calculation of the number of such solar cells that would be required.

THE DESIGN PROJECT
WEEK 8

1. Design projects are discussed. Groups should have a block diagram ready to show the instructor.

2. Once the functional block diagrams are understood, groups begin to design and construct the circuit. All work, even circuits that fail to operate must be documented in the notebook.

3. Charging a Ni/Cd battery is presented by the instructor. The concept of energy storage and units of ampere – hours explained.

WEEKS 9, 10 & 11

Groups continue to work on and complete the project construction. Instructors participate in a "guided-design" environment.

WEEK 12

Working design circuit is demonstrated to the instructor

WEEK 13 & 14

The final report and oral presentation requirements are reviewed.

APPENDICES

- **Notebook requirements**
- **Notes on Electricity**
- **Sample Quizzes**
- **Notes on Solar Cell Battery Charger**
- **Resistor Color Code**
- **Suggested Format for Report**
- **Suggestions for the Oral Presentation**
- **Course Outline FED 101**

NOTEBOOK REQUIREMENTS

Each group of students is to maintain a record of every measurement and trial circuit in a laboratory notebook. The notebook must be bound, not loose leaf. An inexpensive "Composition" notebook can be used. At each laboratory meeting the notebook should be dated, and each group member will initial the starting point. All circuits used should be sketched and labeled. Do Not erase errors. Simply cross them out. When recording data be sure to include the units (i.e. mA, Volts etc). When finished with a laboratory session note the time and date. If graphs are required you may attach them to blank pages in the notebook. Notebooks will be examined at various times to help you master the correct procedure of keeping a laboratory notebook. Remember do not copy your "scratch notes" or redo your work after class. Neatness is not as important as completeness.

DIRECT CURRENT ELECTRICITY

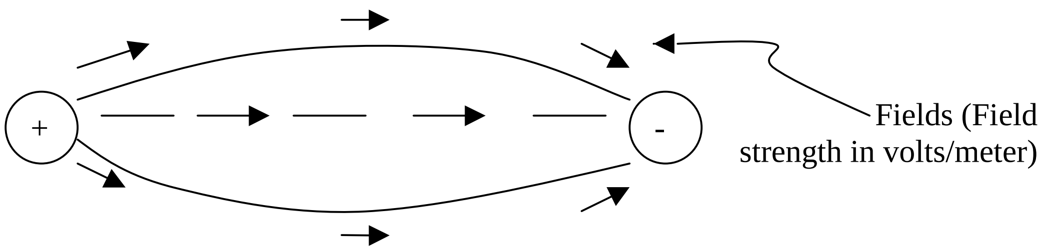
ELECTRON	Mass	= 9.1072	x 10 E-31	kilograms
	Charge	= 1.60186	x 10 E-19	coulombs

The electron is responsible for our electronic marvels. It is easily controlled, very fast and very small. There is no other physical quantity like it in this world!

SIMILARITIES of electrical and mechanical systems:

	Pressure	Flow	Quantity
Electrical	Volts	Amperes	Coulomb
Mechanical	PSI	Gal/Min	Gallons

ELECTRIC FIELDS are associated with charged particles. The filed is strongest near a charge and weaker as distance increases. Like charges repel, unlike charges attract.



The COULOMB (Q) is a fundamental electrical unit. It is equal to the charge on 6.24 x 10 E18 free electrons.

Coulomb's Law gives the force between two charged bodies:

F	=	K	Q1 Q2/O^2	where K is:
K	+	9	(10 E9)	(Newton Meter^2/Coulomb^2)

ELECTRICAL UNITS – CONCEPTS AND DEFINITIONS

VOLTS - A MEASURE OF ELECTRICAL "PRESSURE" (V)
AMPS - A MEASURE OF ELECTRICAL "FLOW" (I)
OHMS - A MEASURE OF ELECTRICAL "RESISTANCE" (R)

The work done is moving charge through an electric field is measured as an electric potential (electromotive force).

ELECTRICAL POTENTIAL = WORK/CHARGE

One Volt is equal to a joule/coulomb in MKS units.

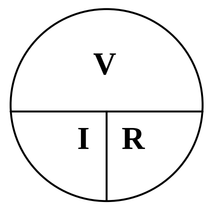
Any random flow of tree electrons is changed by the presence of an electric field. A steady flow of electrons creates a DIRECT CURRENT, with direction of the current flow assigned to positive charge.

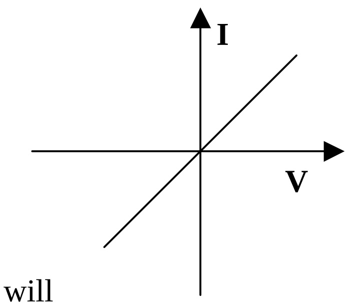
One AMPERE is equal to a coulomb/second in MKS units.

The ability of material to resist the flow of electrons is measured by its electrical RESISTANCE, measured by the ratio of volts to amps, in a unit called the OHM.

One OHM is equal to a volt/ampere in MKS units.

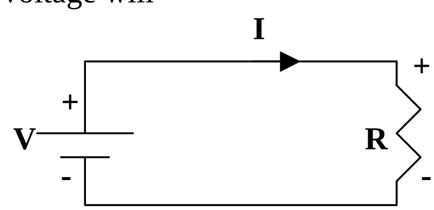
<u>OHM'S LAW R = V/I</u>





The graph of Ohm's Law shows that an increase in voltage will increase the current in direct proportion.

Double the volts - Double the amps
Half the volts - Half the amps
Negative volts - Negative amps



<u>EXAMPLES</u> Apply Ohm' s Law to this circuit

1) V = 120 volts, R = 60 ohms, I = ?
I =

2) V = 60 volts, I = 0.08 amperes, R = ?
R =

3) I = 1.5 amps, R = 80 ohms, v = ?
V =

<u>ELECTRICAL UNITS</u>

Electrical quantities have a wide range of numbers. We use prefix symbols to represent the significant zeros of a quantity. For example, current may be expressed in:

Microamperes	0.000001 amperes	10 E-6 Amps
Milliamperes	0.001 amperes	10 E-3 Amps
Amperes	1.0 amperes	1 Amp
Kiloamperes	1000 amperes	10 E +3 Amps

Voltage may be expressed with the similar prefixes:
Microvolts, millivolts, volts, kilovolts
Practical resistance values are usually expressed in:
Ohms, kilohm (E+3), or Megohm (E +6) values

EXAMPLES Change the units to the required value(apply dimensional analysis methods)

4) Change 0.05 V into mV.
0.05 V =

5) Given R = 0.25 Mohm and I = 0.5 mA, find V (volts)
V = R I =

6) If V = 10 volts and I = 120 microamps, find R (ohms)
R = V/I =

ELECTRICAL POWER

In general, power is defined as the rate of doing work.

Mechanical Work = Force x Distance (newton meters)
Electrical Work = Voltage x Charge (joules)
POWER = WORK/TIME (one watt = joule/second)
The Electrical Power in watts is : P = V Q/t, since
I = Q/t, we measure power by: P = V I
Conversion Factors for Practical Units –
746 Watts/Horsepower
(1 Horsepower + 550ft. –Lb/sec)

EXAMPLES – Unit Conversions

7) How many horsepower are in a 100 watt "LOAD"?

100 W x

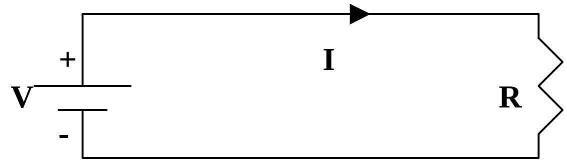
8) How many output watts are provided by a 3 Hp motor?

3 Hp x

FINDING ELECTRICAL POWER BY ALTERNATE EQUATIONS

P = V I = V^2/R = I^2 R

EXAMPLES Given this circuit:



9) Find the power dissipation in this circuit for

R = 60 ohms and v = 120 volts.

P = v^2/r =

10) Find the maximum voltage which should be connected across a 1 Kohm, 2 watt resistor.

Vmax =

In practice, electrical devices are DERATED to obtain Longer Lifetime and improved reliability. This 2 W resistor should be derated 50% so only 1 W is actually dissipated.

The operational wattage of any electrical device can be derated below a maximum rating by applying this relation:

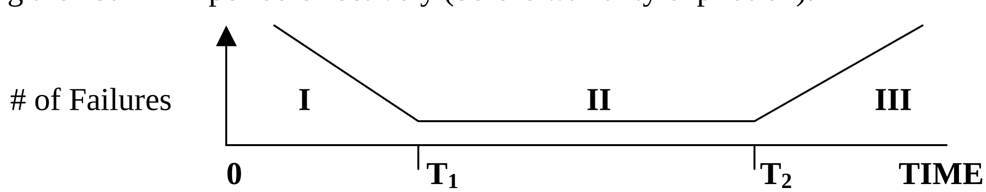
Actual Power = Rated Power x Derating Factor

RELIABILITY

Device reliability is measured by the PROBABILITY of failure under given specifications, environmental conditions and time. A useful measure of reliability is the MEAN TIME BETWEEN FAILURES (MTBF) constant for exponential failures.

Reliability = 1.0 exp – (t/MTBF)

Many systems exhibit the classical "bath tub" failure curve. Early failures may be found by using the "burn-in" period effectively (before warranty expiration).



HEAT is destructive to electrical components. Many electrical motors have their Lifetime doubled for a 10 degree centigrade decrease in their operation temperature.

A semiconductor integrated circuit chip should be cool enough for you to keep your dinger on it without discomfort.

EXAMPLES – Derating & Reliability Concepts

11) What is the maximum voltage that should be applied to a 1K ohm, 2 W resistor derated to 1 watt?

Vmax = P R =

12) What is the resistance of a 100 watt Lamp operating on 115 VOC?

R = V^2/P =

13) What is the reliability of an electrical system with a MTBF of 2 years after three months of operation?

Reliability = 1.0

14) Given a specific MTBF, how much time passes before a reliability of 75% is reached for normal conditions?

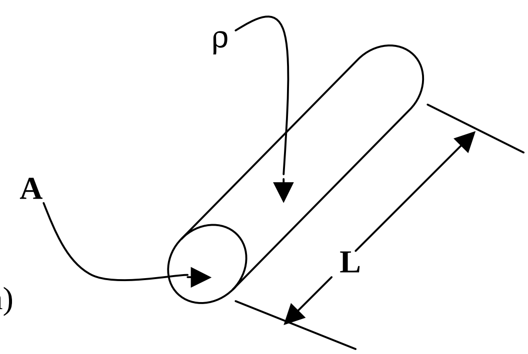
t (0.75) =

RESISTANCE AND RESISITIVITY

The general equation for calculating resistance is

R = ρ L/A

Where: ρ = Resistivity
L = Length
A = Area
(cross section)



EXAMPLES – Resistance Calculations

15) Find the resistance of a round carbon rod, 8 cm Long. Diameter of 0.01 cm, with P. = 3.5 x 10 E-6 ohm-cm.

R =

16) Find the resistance of 400 feet of copper wire if its diameter is

R =

17) AWG #14 wire has a diameter of about 0.08 inches. What is the total resistance for a two wore, 200 foot run of copper conductor?

Rt =

18) If aluminum conductors are used for a 200 foot run of conductors, what is their total resistance?

Rt =

KIRCHOFF'S LAWS

KVL – The sum of the voltage about any closed loop is 0.

KCL - The sum of the currents at a junction or node is 0.

SERIES AND PARALLEL CIRCUITS

In a series circuit, only one current can flow

In a parallel circuit only one voltage can exist.

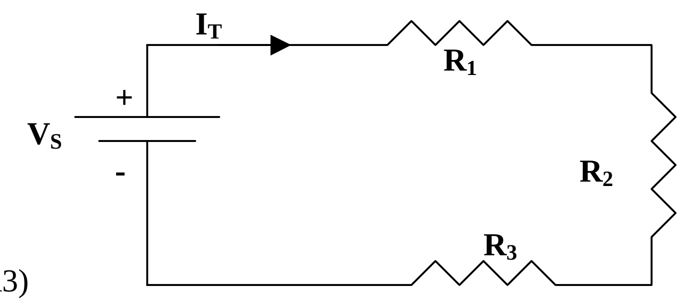
Three resistors and battery can show the basic series and parallel circuit arrangements.

1) All resistors in series

It = I1 = I2 = I3

Vt = V1 + V2 +V3

(Rtotal = R1 = R2 + R3)

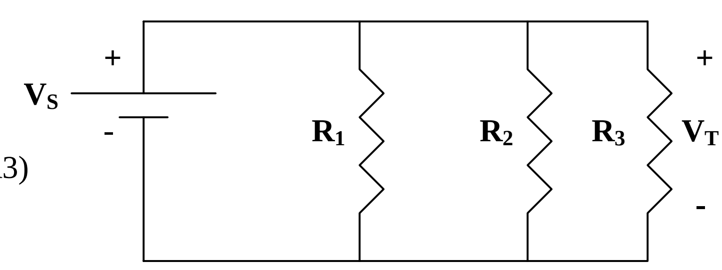


2) All resistors in parallel

Vt = V1 = V2 = V3

It = I1 + I2 + I3

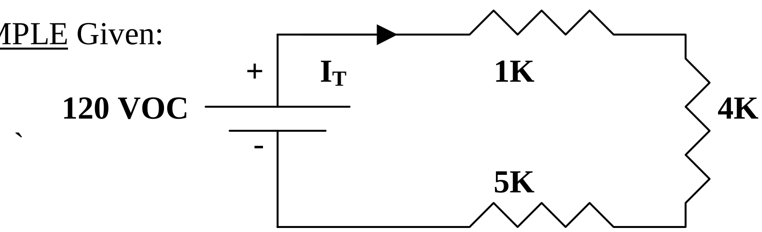
(1/Rt = 1/R1 + 1/R2 + 1/R3)



ANALYSIS OF SERIES CIRCUITS

1) Only one current flows in a series circuit.
2) All voltages about a loop add up to zero.
3) V, I and R are related by Ohm's Law (I = V/R).

EXAMPLE Given:



Find: All electrical properties of this circuit
(Vt, It, V1, V2, V3, Rt, Pt, P1, P2, P3)

Solution: (Apply KVL, KCL, Ohm's Law, Rt equation)

Rt = R1 + R2 + R3 =

It = Vt / Rt =

V1 = R1 I1 = R1 It =

V2 = R2 I2 = R2 It =

V3 = R3 I3 = R3 It =

KVL Check: does Vt = V1 + V2 + V3 ?

Pt = Vt It =

P1 = V1 I1 =

P2 = V2 I2 =

P3 = V3 I3 =

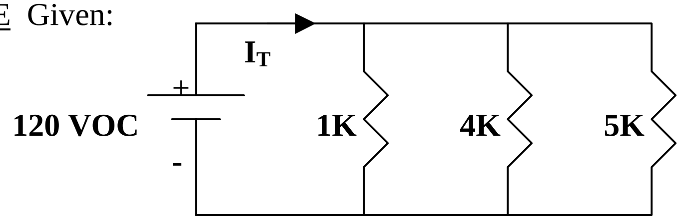
ANALYSIS OF PARALLEL CIRCUITS

1) Only one voltage exists in a parallel circuit.

2) All currents at a point add up to zero.

3) V, I and R are related by Ohm's Law (I = V/R).

EXAMPLE Given:



Find: All electrical properties of this circuit
(Vt, It, V1, V2, V3, Rt, Pt, P1, P2, P3)

Solution: (Apply KVL, KCL, Ohm's Laws, Rt equation)

1/Rt = 1/R2 + 1/R2 + 1/R3 =

Rt =

It = Vt/Rt =

I1 = V1/R1 = Vt/R1 =

I2 = V2/R2 = Vt/R2 =

V3 = V3/R3 = Vt/R3

KCL Check: Does It = I1 +I2 + I3 ?

Pt = Vt It =

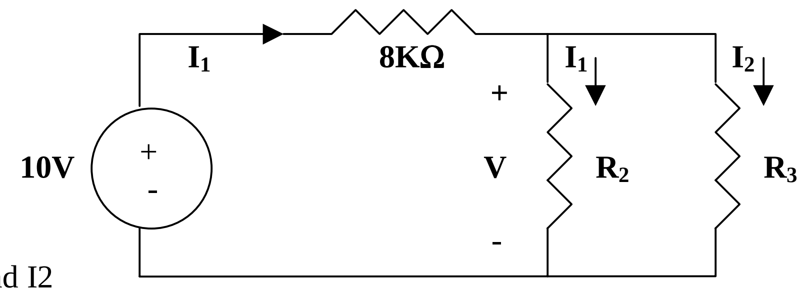
P1 = V1 I1 =

P2 = V2 I2 =

P3 = V3 I3 =

ANALYSIS OF SERIES/PARALLEL CIRCUITS

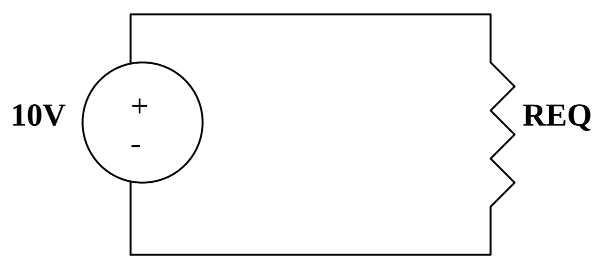
EXAMPLE



Find: I, I1 and I2

R_2=3KΩ R_3=6KΩ

Solution: The circuit can be reduced to a single equivalent resistor in parallel with 10V.

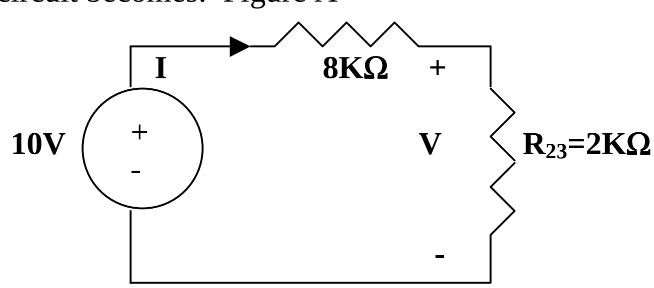


To obtain Reg note that R2 and R3 are in parallel. Therefore we can find a single resistor to replace R2 and R3.

$$\text{Thus } R23 = \frac{R2 \bullet R3}{R2 = R3} = \frac{(3K) \bullet (6k)}{3K + 6K}$$

R23 = 2k Ω

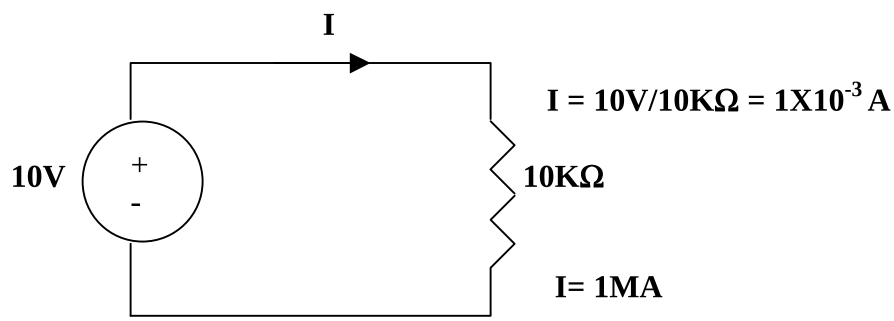
The circuit becomes: Figure A



Note that "V" is the voltage across the parallel resistors R2 and R3.

Now the total resistance Reg = 8KΩ + 2KΩ = 10RΩ

The simplified circuit is:



Returning to Figure A.

V = I (R23) = (1ma) (2K)

V = 2V this is the voltage across the parallel resistor R2 and R3.

Finally using OHM's LAW

I, = $\frac{2V}{3K\Omega}$ =0.667ma, I2 = $\frac{2V}{6K}$ = 0.333ma

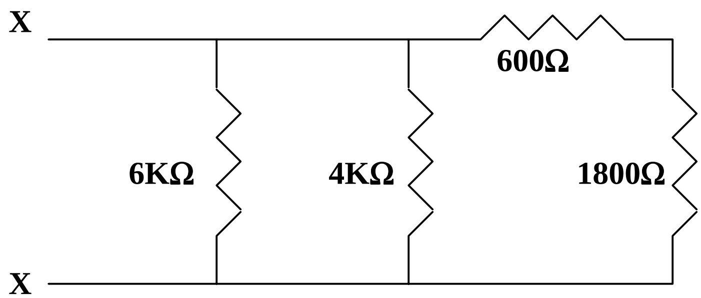
Checking KCL I = I1 + I 2
1ma = 0.667 ma + .333ma
Check!

FED 101D QUIZ ON BAISC DC CONCEPTS

NAME ____ ID# ____________________________

CLOSED NOTES & BOOKS *SHOW ALL WORK* FALL 2000

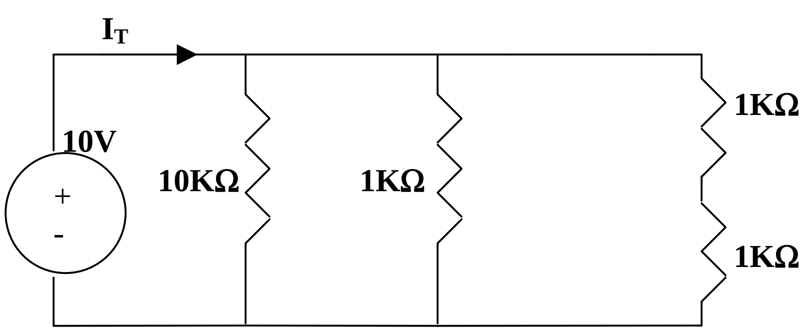
#1 FIND RXX (TOTAL RESITANCE BETWEEN X – X)



ANS ______________

#2

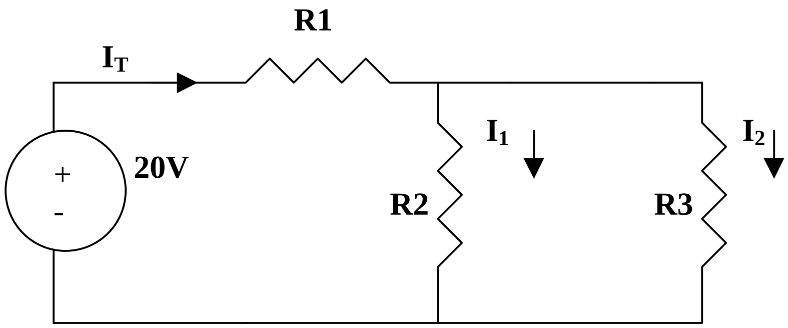
Find I T



ANS______________

#3

Find I T & I2



R2 = 30 KΩ
R3 = 15 KΩ
R1 = 10 KΩ

FED 101

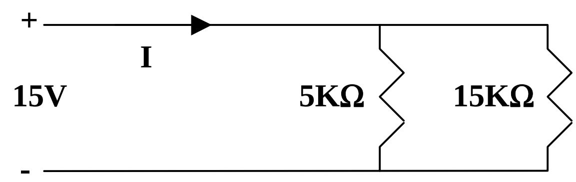
ELECTRICAL ENGINEERNG MODULE

Application of Basic Laws (OHM-KV-KCL)

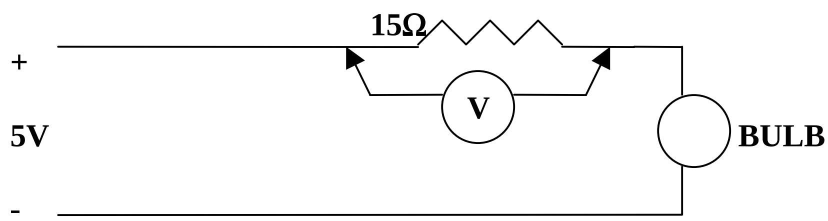
CLOSED BOOKS & NOTES

1.

FIND: I



2.

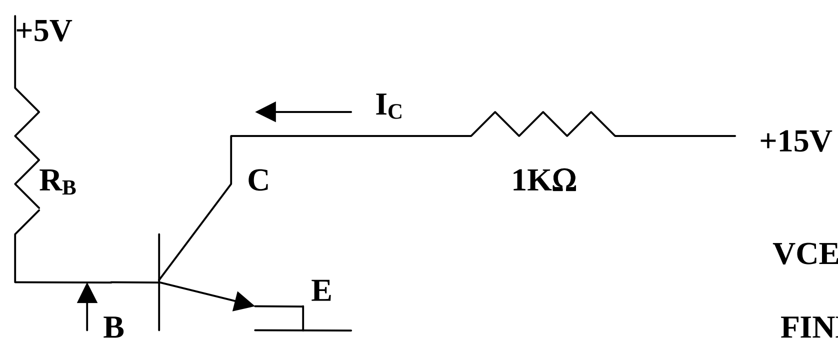


Voltmeter **V indicates 1.5 volts**

FIND: (a) the current <u>through</u> the BULB

(b) the voltage <u>across</u> the BULB

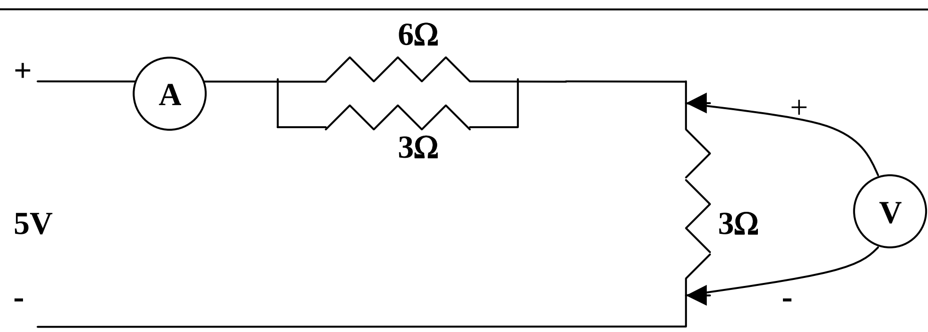
3.



VCE = 5V

FIND: IC

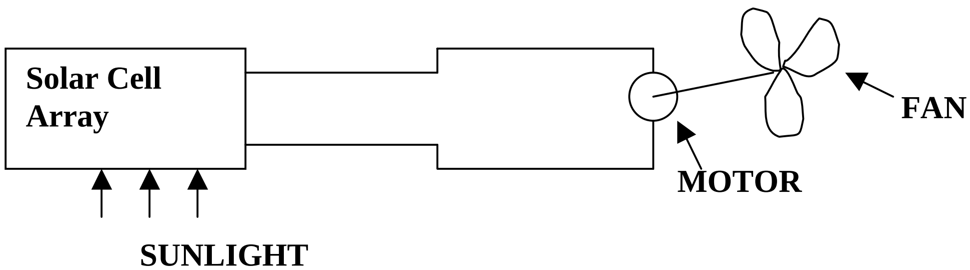
4.



FIND: (a) The ammeter reading

(b) The voltage

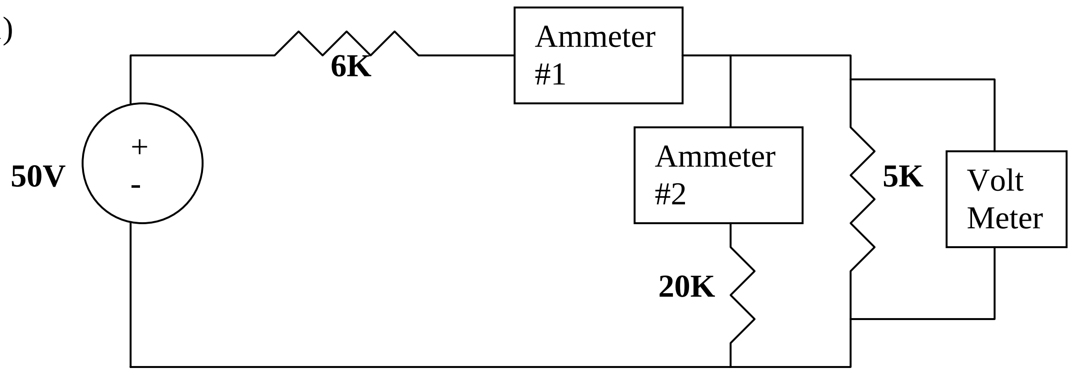
5.



Redraw the circuit to include an ammeter to measure the motor current and a voltmeter to measure the voltage output of he solar cell array

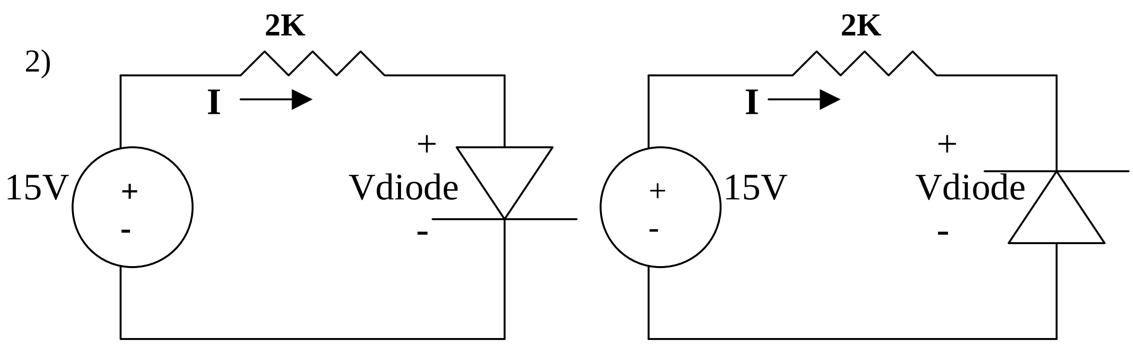
Dr. Frank FED 101 EE Module Quiz 93-10-13

1)



In the circuit shown above calculate the reading of Ammeter #1, Ammeter #2 and the Voltmeter.

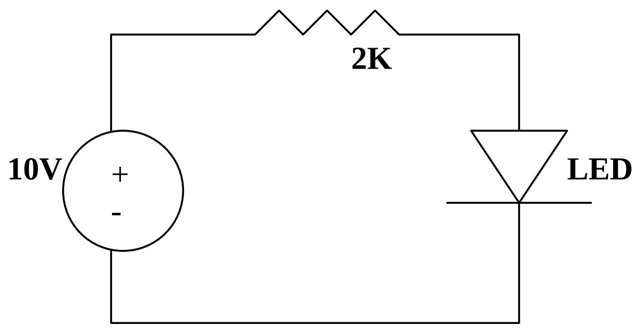
2)



For circuits a and b find the approximate value of I and V diode. Assume the diode is a silicon diode of the type you used in the lab

3) State one difference in the electrical characters of an LED and an ordinary diode

4)



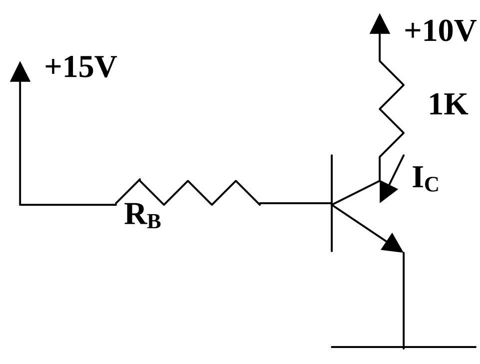
In the circuit shown above if the 2k resistor was changed to a 1k resistor which of the following would happen – pick best choice

a) The LED would get brighter
b) The LED would get dimmer
c) The LED would go out
d) There would be no change in the brightness of the LED
e) The LED would overheat and burn out

5) For a typical transistor such as the 2N2222 which you used in the lab what is the range of values you would expect to find for hfe?

6)

Make Reasonable Assumptions

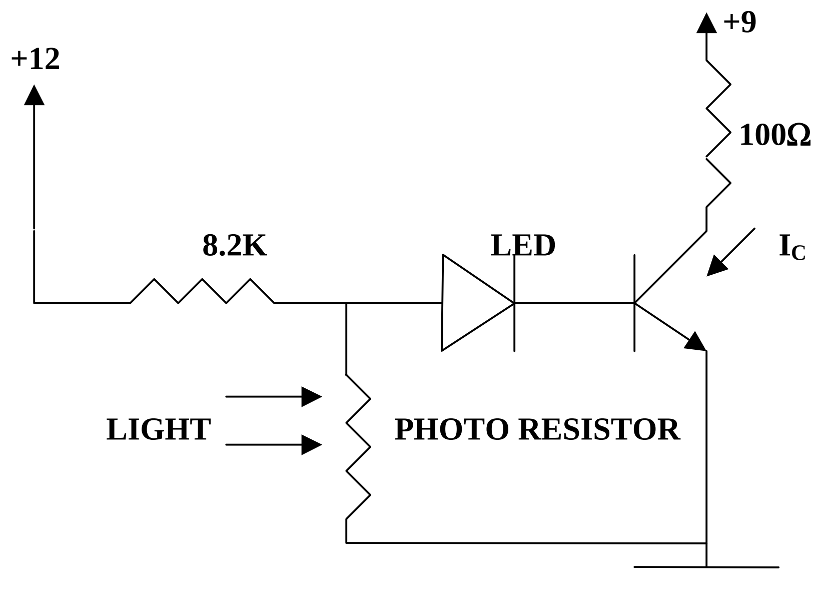


a) If you wanted to be sure Ic ≥ 5 ma what would be a reasonable value to choose for RB?
b) What is the largest value I c can have for any value of RB?

7) A solar cell in bright sunlight has an open circuit voltage (as measured voltmeter) of 3 volts. When an ammeter is connected across the cell the current is 0.5 ma.

8) A photo transistor is being used to detect whether a red LED is off or on. Explain briefly how a red filter placed in front of he photo transistor could be helpful.

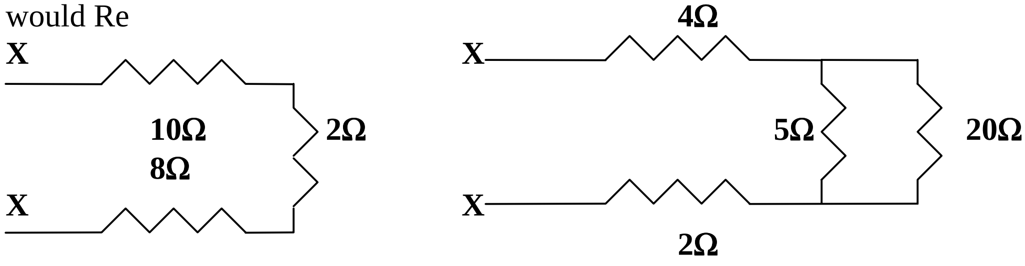
9)



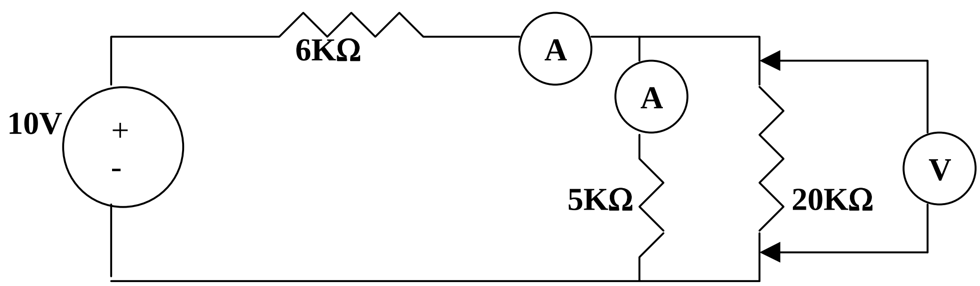
The photo resistor has a very large resistance when it is dark. As the light shining on it gets brighter it's resistance decreases. At what value of resistance of the photo resistor will Ic = 0? Make reasonable assumptions.

FED 101 EE MODULE

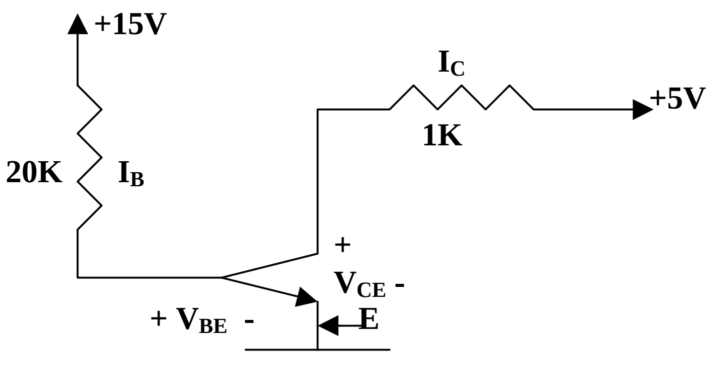
#1 For each circuit. Find the total resistance between point x – x that an ohmmeter would Re



#2 Find the reading of the voltmeter, ammeter #1 and ammeter #2 in the circuit shown.



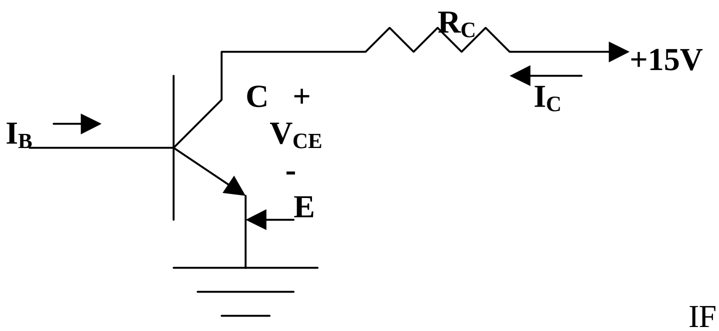
#3



IF: VBE = 0.7 V
AND VCE = 3V

FIND: IC AND IB

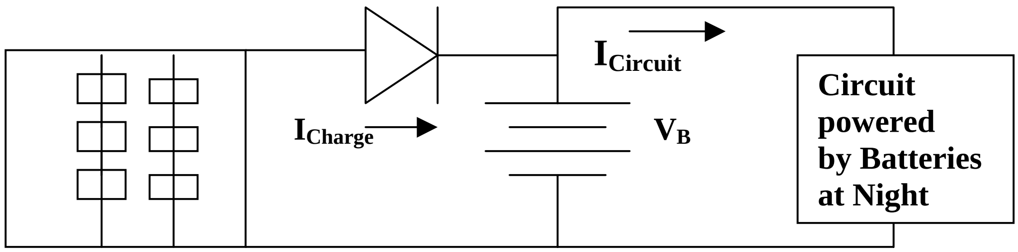
#4



=

IF: IB is adjusted to give
IC = 10m
Vce = 5v
FIND: RE

Notes on Charging Batteries Using Solar Cells



Array of Solar Cells

The principle involved in designing this type of circuit is:

Charge Out during Night = Charge In during Day

The charge is expressed in Amp hours or MA hrs.

For example if circuit draws 175 ma for 12 hours during night and solar cells are exposed to bright sunlight for 9 hours during the day

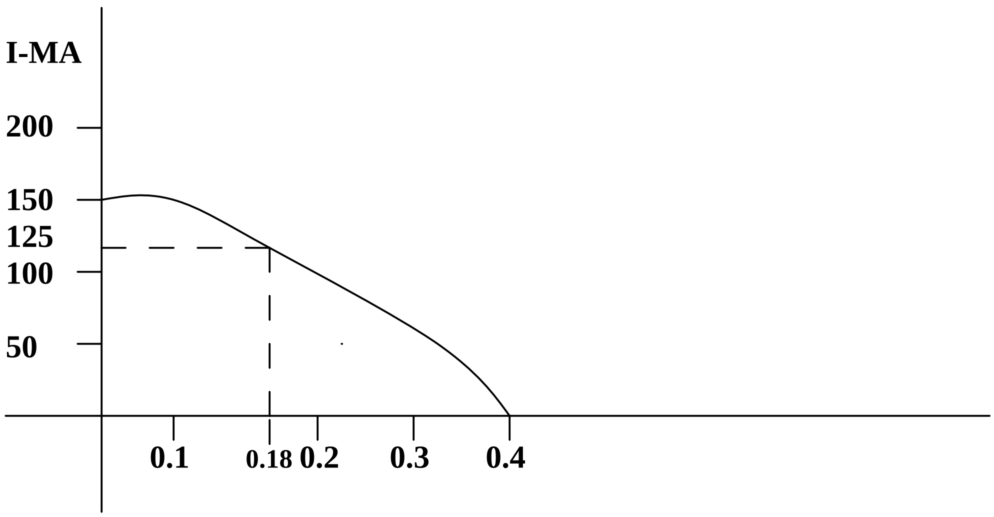
175ma x 12 hours = I charge x 9 hours

I charge = 175 x 12/9 = 233.3ma

We must provide a charging current of 7, 233.3ma if system is to work.

Another idea necessary to design the type of system is that to charge a battery the voltage from the solar cells must equal the battery voltage plus the voltage drop in the diode (0.7v). What is the purpose of the diode?

Assume each solar cell has a volt ampere characteristic as shown:

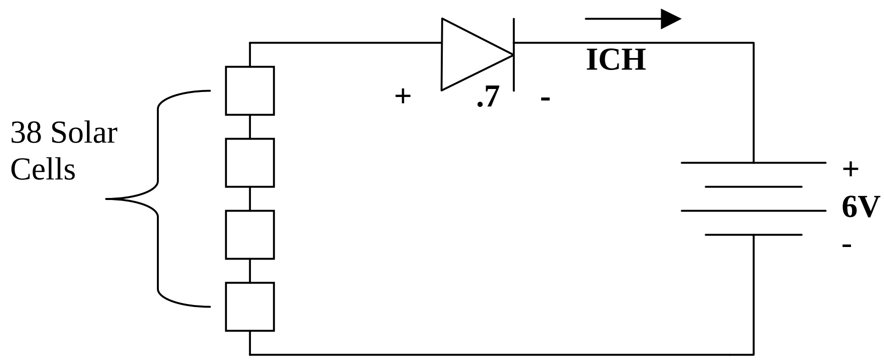


V-VOLTS

Volt – AMP characteristic of solar cell choose an operating point some reasonable point near middle where product VI is large. For sample design let VB = 6V. We must put Ns solar cells in series so total voltage of the Ns cells is 6.7v

Ns(.18) = 6.7

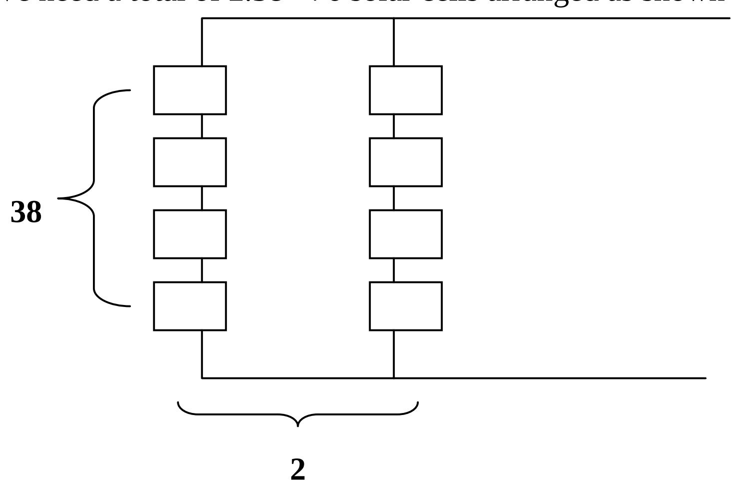
Ns = 37.2 ⇒ use 38 cells in series



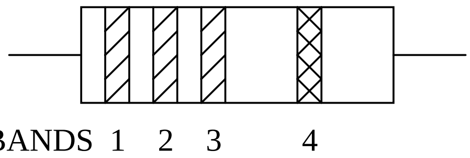
In the circuit shown above, the solar cells would charge the battery with a current of 125ma as cells in series have the same current and 125ma is the current of one cell at our operating point.

Since 250ma is larger than 233.3, the design is satisfactory.

We need a total of 2.38 =76 solar cells arranged as shown



RESISTOR COLOR CODE



R = (BAND 1) (BAND 2) X 10(BAND 3)

BAND COLOR	VALUE
Black	0
Brown	1
Red	2
Orange	3
Yellow	4
Green	5
Blue	6
Violet	7
Gray	8
White	9

BAND 4 SPECIFIES RESISTOR TOLERANCE

RED 2% GOLD5% SILVER10% NONE 20%

EXAMPLE: RED RED YELLOW SILVER represents 220 k, 10% resistor

F.E.D. FINAL REPORT

- COVER
    - PROJECT TITLE
    - GROUP NAME
    - GROUP MEMBERS
    - DATE
    - FOR PROF STRANO FED 101

1A. TABLE OF CONTENTS

- ABSTRACT (A PAGE MAX)
    - EXPLAIN DESIGN REQUIREMENTS
    - SUMMARIZE THE DESIGN PROCESS USED
    - REPORT ON OUTCOME OF DESIGN

- DESIGN PROCEDURE
    - STEP –BY-STEP EXPLANATION, TO THE READER, OF WHAT WAS DONE IN THE LABORATORY
    - CIRCUIT DIAGRAM
    - ALL MEASUREMENTS (TABLE)
    - ALL CALCULATIONS
    - PHOTO OR DRAWING OF PROTO BOARD CIRCUIT

- CONCLUSIONS & RECOMMENDATIONS
    - APPLICATIONS
    - COMMENTS ON SUGGESTED IMPROEMENTS OF THE DESIGN

- OVERALL: SOME USEFUL HINTS:
    - WRITE IN <u>THIRD PERSON PAST TENSE IMPERSONAL</u>
    - NUMBER THE PAGES
    - LABEL THE FIGURES
    - CIRCUIT DIAGRAMS & FIGUES SHOULD BE DRAWN BY COMPUTER OR WITH STANDARD DRAFTING INSTRUMENTS
    - USE WORD PROCESSOR TO CHECK YOUR SPELLING
    - <u>REFERENCES</u>, CITE ANY MATERIAL USED THAT IS NOT <u>YOUR ORIGINAL WORK</u>
    - ALL GROUP MEMBERS SIGN THE COVER SHEET AT BOTTOM

FED 101 COURSE OUTLINE
(EE MODULE)

WEEKS	TOPIC
1	Introduction, formation of groups. Lecture on DC Electricity. Distribution of laboratory equipment
2	Measurement of voltage, current and resistance. Color code for resistors. Use of the “proto board. (Laboratory experience #1)
3,4	Kirchoff’s Law lecture followed by experiments on , parallel and series parallel circuits. Verification of KCL and KVL by measurement. Measure of non-linear elements light bulb and a diode (Laboratory Experience #2)
5,6	Quiz on DC Circuits. Lecture on transistor function at the terminals. Measurements of common emitter transistor circuits. Use of the transistor as a switch. Introduction to the Potentiometer. (Laboratory Experience #3)
7	Lecture on solar cells and photo resistors. Measurement of solar cell and photo resistor characteristics. Use of a photo resistor circuit as a detector of light. Lecture on charging a battery using solar cells (laboratory Experience #4)
8	Defining the design project. Demonstration of a commercial product, (solar powered lawn light) that inspired the project. Block diagram concepts. Student begin the design process.
9, 10, 11	Student design the circuits for the project. Circuits are wired and tested. All progress is documented in the laboratory notebook. Professor helps guide the design.
12	Design project complete and a working circuit demonstrated to the instructor. Discuss final report.
13, 14	Final report due and oral presentation begin. Feedback to students