Lesson	Objectives	Material
4.1	Linear functions and Graphing	Crazy Taxi
4.2	Linear functions and Graphing	Functions and Graphing
4.3	DC Circuits: Kirchhoff's Voltage Law	Kirchhoff's Voltage Law (KVL)
4.4	DC Circuits: Kirchhoff's Current Law	Kirchhoff's Current Law (KCL)
4.5	DC Circuits: Analysis 1	Kicker Circuit
4.6	DC Circuits: Analysis 2	Circuit Analysis
4.7	DC Circuits: Analysis 3	Circuit Puzzles

Prerequisite Assumptions

Before beginning the lesson, students should understand,

- DC Resistive Circuit equivalent modeling,
- DC Series and parallel connected resistor equivalence,
- Combined DC Parallel and Series connected Resistors
- Application of Ohm's Law and the Power Rule

Specific Objectives

By the end of this lesson, you should be able to;

- ✓ Solve a linear function
- ✓ Understand the slope-intercept form of a linear function
- ✓ Graph a linear function
- ✓ Apply the voltage and current division rules in DC resistive circuit analysis
- ✓ Apply Kirchhoff's Voltage Laws when conducting DC resistive circuit analysis
- ✓ Apply Kirchhoff's Current Laws when conducting DC resistive circuit analysis
- ✓ Apply modeling techniques to analyze complicated DC resistive circuits.

Problem Situation 4.1 – Crazy Taxi

 https://tapintoteenminds.com/3act-math/crazy-taxi/

1) What do you think the fare would be for the 30 km traveled?

2) Can you determine the fare for the 30 km traveled?

3) Create an equation to model the cost *vs*. km. Can you tell what 'kind' of equation it is?

4) Create a graph to show km travelled vs cost. Make sure to label the axis. What is the shape of the curve?

Cost ($)	Distance (km)
	1
	2
	3
	4
	5
	10
	15
	20
	25
	50

5) From the graph, can you determine how far the person could get if they had $25? Can you also calculate the distance?

Problem Situation 4.2 – Functions and Graphing

A **function** is the mathematical relationship in which **each** *input* has a **single** *output*. It relates the input (*independent variable*) to the output (*dependent variable*). Typically, this is written as *f(x)* where x is the input to the function *f*. This is read as "f of x". Often *f(x)* will be given another variable name, such as "y", to simplify the amount of writing. This would be written y = *f(x)*.

Example:

You are having a meeting and want to get cookies for everyone. You order two cookies for each person and then one spare cookie for sampling.

I will use *x* as the "number of people attending the meeting"

> *f(x)* = 2*x* + 1   (2 times *x* plus 1)

Evaluate the function when 2 people are attending: x = 2

> *f(2)* = 2 * 2 + 1

> *f(2)* = 5   thus, for two people you would need 5 cookies

Evaluate the function when 14 people are attending: x = 14

> *f(14)* = 2 * 14 + 1

> *f(14)* = 29   For 14 people you would need 29 cookies.

1) Evaluate the following function when m = 3.5

$$f(m) = \frac{4}{m} * 1.2$$

2) Evaluate the following function when c = -4.2

$$f(c) = \frac{3}{4}c - 0.9$$
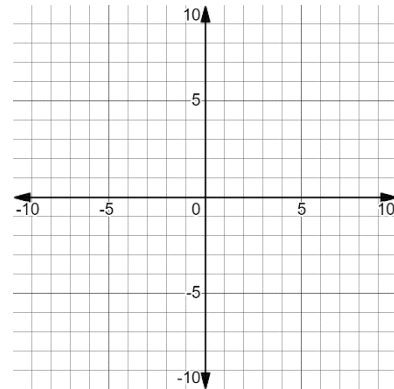
3) Evaluate the following function when *x* = 7.98

$$f(x) = 2.7x + 14$$

4) Evaluate the following function when *x* = 12
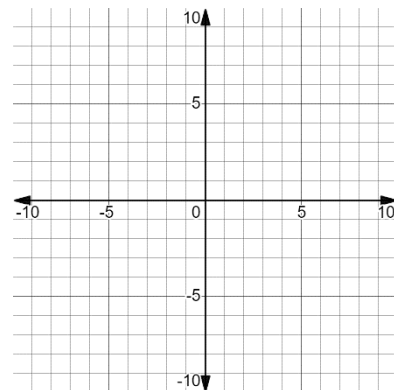
$$f(x) = -3.1x - 1.2$$

5) Graph the following linear function by determining *at least* two points on the line. Label everything.
$f(x) = 4x + 1$

x	f(x) = y

6) Graph the following linear function by determining at least two points on the line. Label everything.
$f(x) = 6 - 2x$

x	f(x) = y

A standard method for an equation is the slope intercept form: **y = mx + b**
where m = the slope or the rise/run and b = y-intercept or where the graph crosses the y-axis

7) Identify the slope and y-intercept for the equations that you just graphed.
$f(x) = y = 4x + 1$

Slope = _____

y-intercept = _____

8) $f(x) = y = 6 - 2x$

Slope = _____

y-intercept = _____

Problem Situation 4.3 – Kirchhoff's Voltage Law (KVL)

Gustav Kirchhoff was a German physicist that did research in the field of electronics in the mid-1800s. He discovered fundamental theories about electronics. The first theory we will study is **Kirchhoff's Voltage Law**, which states that the voltages (*potential*) in any CLOSED circuit path (a *loop*) always sums to zero. You only get the voltage out that goes in, or all of the voltage is distributed along the loop such that all the voltages cancels out. Voltage potential cannot be lost or gained within a circuit.

Kirchhoff's Voltage Law: In a closed loop, start at ground, the zero-potential point (though you can start anywhere), and trace a closed loop while summing the voltages (– to + is positive and + to – is a negative) you come across until the trace returns to ground (where you started) and you have completed the closed loop. The sum of the voltages of every loop will always equal zero.
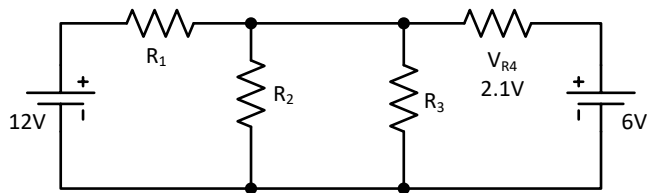
1) Analyze the following circuit using Kirchhoff's Voltage Law to determine V_{R1} and V_{R3}.
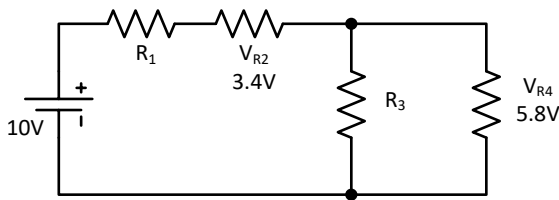
V_{R1} = _____

V_{R3} = _____

2) Analyze the following circuit using Kirchhoff's Voltage Law to determine V_{R1}, V_{R2} and V_{R3}.


V_{R1} = _____

V_{R2} = _____

V_{R3} = _____

**Problem Situation 4.4 – Kirchhoff's Current Law (KCL)**

Gustav Kirchhoff's second law is about the current in a circuit. ***Kirchhoff's Current Law*** states the current at a node (where circuit loops connect) must always sum to zero. Like water pipes coming together, all the current entering the connection point (*node*) must exit. Current will never disappear or grow in a circuit. All the current entering a node must leave that node. It is often helpful to label each node with a number in order to keep track of things. Ground is often labeled "0". KCL is obvious when you only have two paths (*branches*) because you only have a single "in" and a single "out" but it is most useful when you have three or more branches.

1) Analyze the following circuit using Kirchhoff's Current Law to determine **I$_{R1}$**.
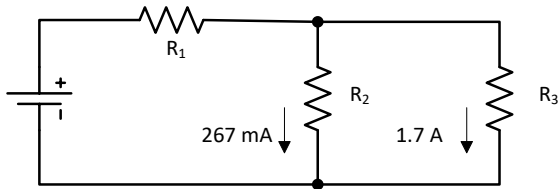
I$_{R1}$ = _____

2) Analyze the following circuit using Kirchhoff's Current Law to determine **I$_{R2}$**.
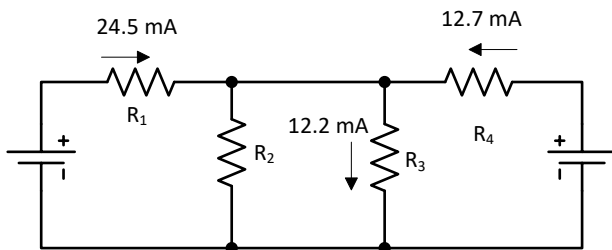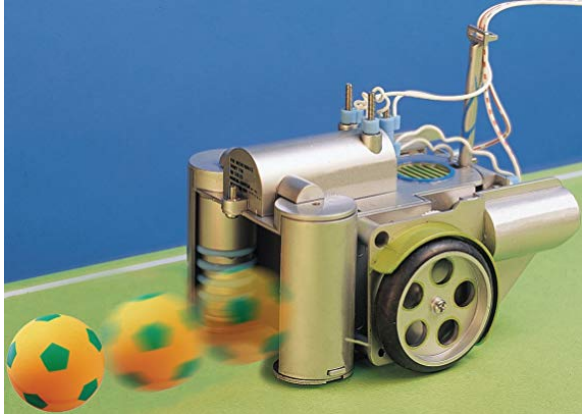

I$_{R2}$ = _____

Problem Situation 4.5 – Kicker circuit.

The autonomous robot below "sees" a ball and "kicks" it.
The ball activates a <u>switch</u> that <u>energizes</u> the kicker motor (<u>resistive load</u>).
Assume that there are only 20 Ω resistors available to use in the circuit.

1) What requirements do you "know" and what must you assume in order to design a circuit for this application?

2) Sketch your design and give your justifications.

3) How would you "validate" your design to verify that it satisfies the requirements and design parameters both as given and assumed?

4) Does your design satisfy the "requirements" specified for this circuit?
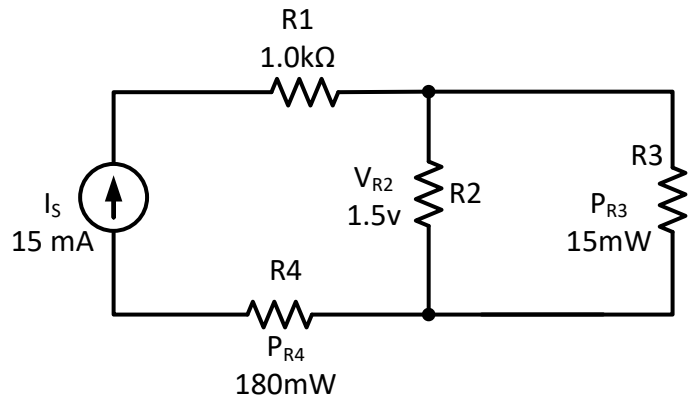
Problem Situation 4.6 - Circuit Analysis

1) Analyze the following circuit to determine the missing information in the table.

R	Value (Ω)	Current (mA)	Voltage (V)	Power (mW)
R1	300	32.26	9.68	312
R2		19.37		
R3				
R4	1200			
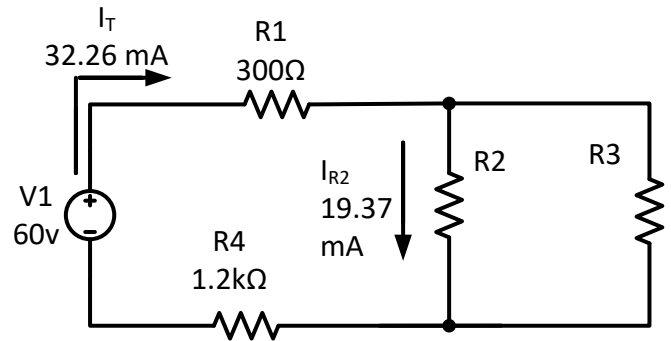
I_T
32.26 mA

R1
300Ω

V1
60v

I_{R2}
19.37 mA

R2   R3

R4
1.2kΩ
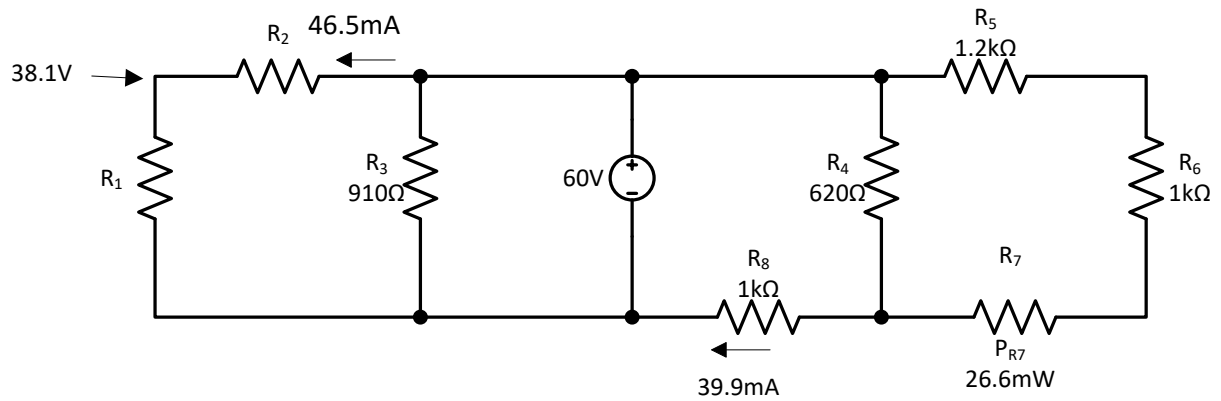
2) Analyze the following circuit to determine the missing information in the table.

R	Value (Ω)	Current (mA)	Voltage (V)	Power (mW)
R1	1000	15		
R2			1.5	
R3				15
R4		15		180

R1
1.0kΩ

I_S
15 mA

V_{R2}
1.5v   R2
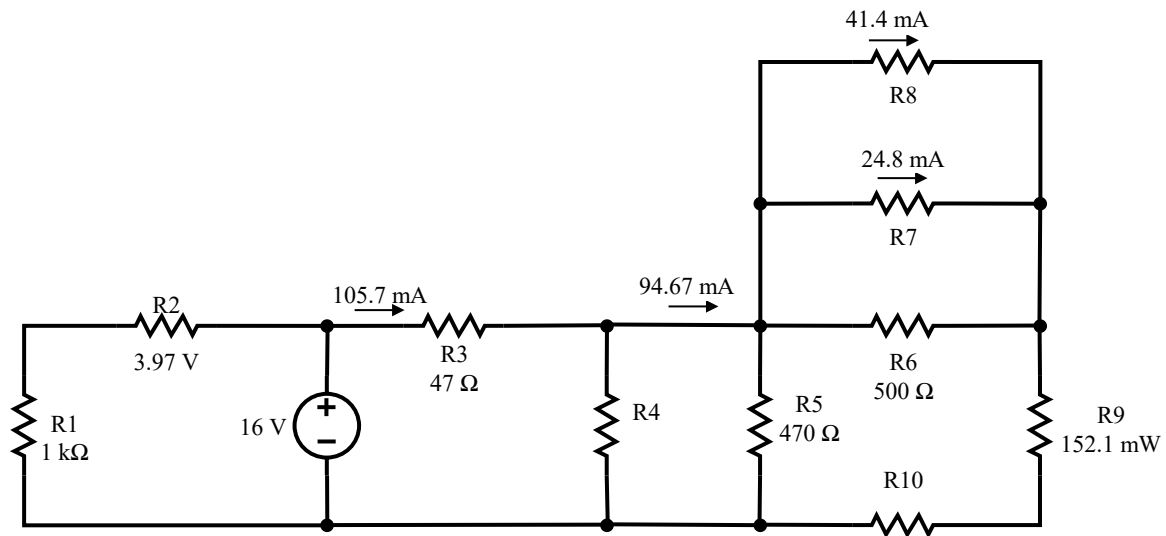
R3
P_{R3}
15mW

R4
P_{R4}
180mW

Problem Situation 4.7 – Circuit Puzzles

1) Determine the information on the table for the following circuits. Watch your units.

Component	Resistance (Ω)	Current (mA)	Voltage (V)	Power (W)
R_1				
R_2		46.5		
R_3	910			
R_4	620			
R_5	1200			
R_6	1000			
R_7				0.0266
R_8	1000	39.9		

Component	Resistance (Ω)	Current (mA)	Voltage (V)	Power (mW)
R1	1000			
R2			3.97	
R3	47	105.7		
R4				
R5	470			
R6	500			
R7		24.8		
R8		41.4		
R9				152.1
R10				