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Outcome 1:

Homework – 1.1

For the conditions in *figure 1.1.1* below calculate;

(a) the combined resistance of R_1 and R_2.

(b) the total resistance of the network R_1, R_2 and R_3

(c) the current 'I' supplied by the battery.

(d) the P.D. (potential difference) V_p across the parallel resistors R_1 and R_2 and the P.D. V_3 across R_3.

(e) the current I_1 flowing in R_1 and I_2 flowing in R_2.

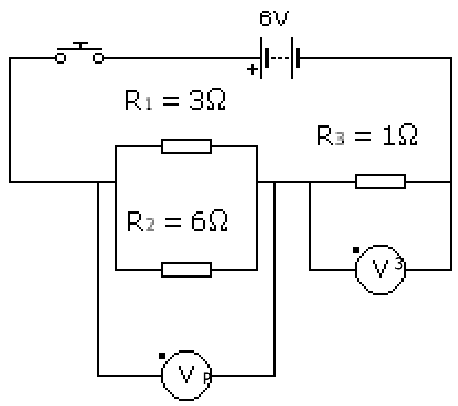


Figure 1.1.1

Homework – 1.2

(a) state Kirchhoff's 1st and 2nd laws.

(b) For the circuit below calculate;

(i) the total effective resistance between points A and B in the network.

(ii) the P.D. across R_2 and the P.D. across R_3.

(iii) the current flowing in each resistor I_1, I_2 and I_3.

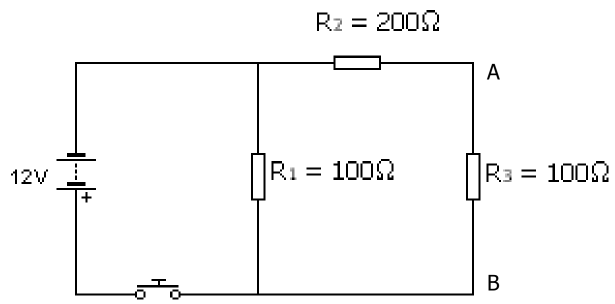
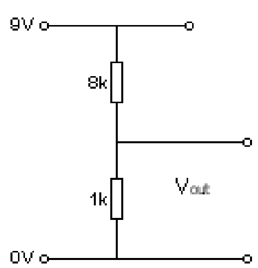


Figure 1.2.1

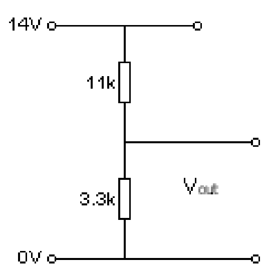
Homework – 1.3

(a) Calculate the output voltage for each of the potential divider circuits shown below

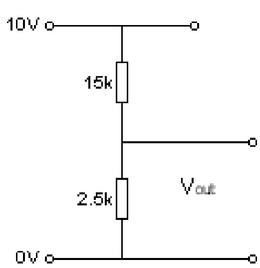
(i)



(ii)



(iii)



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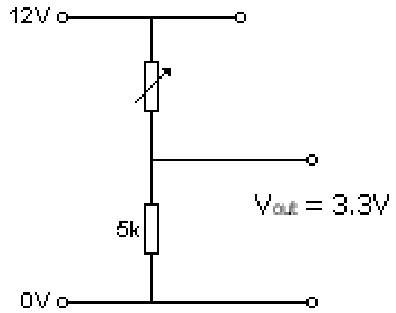
(b) Calculate the variable resistor setting in the potential divider shown.



Homework – 1.4

A 2.5k linear potentiometer is used as a potential divider for a 9V supply *figure 1.4.1*. The 'wiper' on the 'pot' is set at B, a point four fifths of the way along the track from point C at the end of the potentiometer.

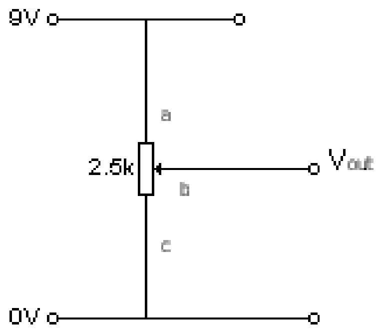


Figure 1.4.1

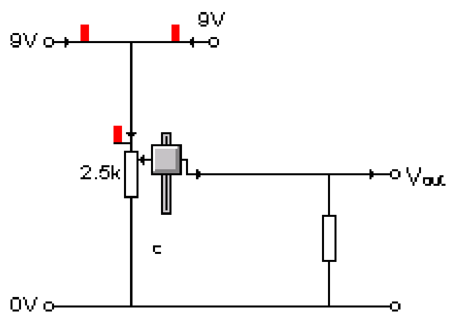


Figure 1.4.2

(a) What is the resistance of length B, C of the track.
(b) What is the output voltage V_{out} at this setting.
(c) If a resistor is now connected as a 'load' across the output as shown in figure 1.4.2, what effect will this have on the output voltage when
  (i) the load resistance is 20k and,
  (ii) when the load resistance is 2k.
  (iii) Comment on your findings.

Homework – 1.5

The *figure 1.5.1* below shows a diagramatic sketch of a simple bi-polar (junction transistor) configuration.

(a) Copy the diagram and complete the transistor symbol to represent an N.P.N device and identify.
  (i) the emitter
  (ii) the base
  (iii) the collector.

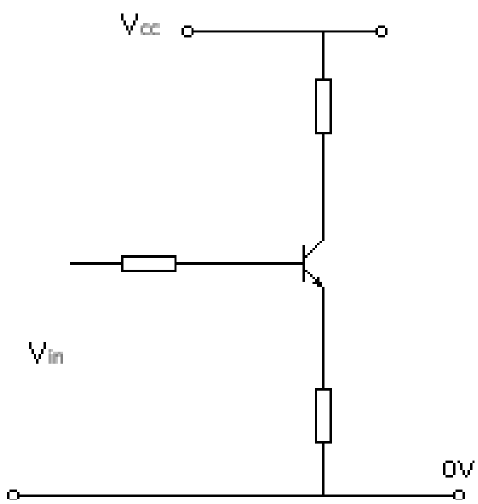


Figure 1.5.1

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(b) Label the diagram showing
- (i) V_b – base voltage relative to ground.
- (ii) V_e – emitter voltage relative to ground.
- (iii) V_{ce} – voltage between collector and emitter junctions.
- (iv) V_{be} – voltage between base and emitter junctions.
- (v) V_l – voltage across load resistor.

(c) On the diagram clearly show the conventional current flow for;
- (i) I_c – collector current.
- (ii) I_b – base current.
- (iii) I_e – emitter current.

(d) Indicate the output when connected in "common emitter mode".

(e) Explain the term current gain as applied to the transistor.

(f) Clearly descibe the operation of the transistor explaining what is meant by 'saturation'.

Homework – 1.6

In the circuit shown below state whether the transistor will be switched on if,

(a) R_1 = 10k ; R_2 = 1k ; V_{cc} = +4.5V

(b) R_1 = 10k ; R_2 = 100k ; V_{cc} = +4.5V

(c) R_1 = 4k7 ; R_2 = 10k ; V_{cc} = +15V

(d) R_1 = 2k2 ; R_2 = 10k ; V_{cc} = +24V

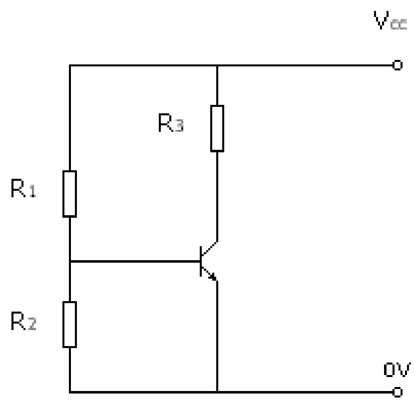

Figure 1.6.1

Homework – 1.7

In the circuit shown below the base emitter junction voltage V_{be} is 0.7V.

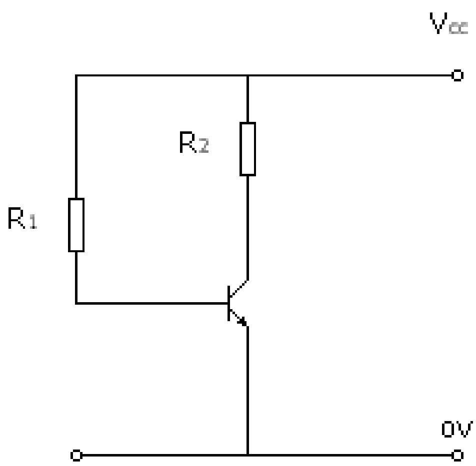

Figure 1.7.1

(a) If V_{cc} = +4.5V, I_c = 25mA and R_1 = 3k9, calculate
   (i) the base current I_b.
   (ii) the current gain A_I.

(b) If I_b = 20μA and I_c = 2mA and V_{cc} = 9V, calculate;
   (i) R_1
   (ii) R_2
   (iii) A_I

(c) If V_{cc} = 6V, R_1 = 100k, R_2 = 1k, calculate
   (i) the P.D. across R_1
   (ii) I_b
   (iii) I_c if h_{fe} = 60
   (iv) The P.D across R_2

(d) If V_{cc} = 6V and I_b = 20μA, calculate the value of R_1

Homework – 1.8
In the circuit shown below calculate the value of R_b if the base current is 10μA.

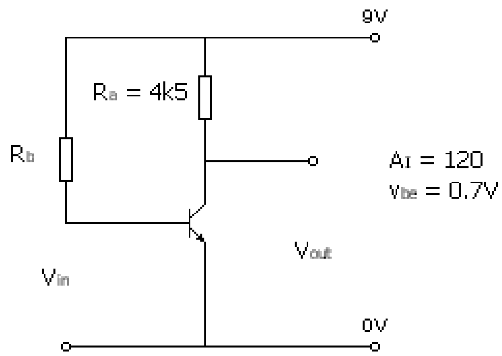

Figure 1.8.1

Determine also the output voltage V_c.

Homework – 1.9

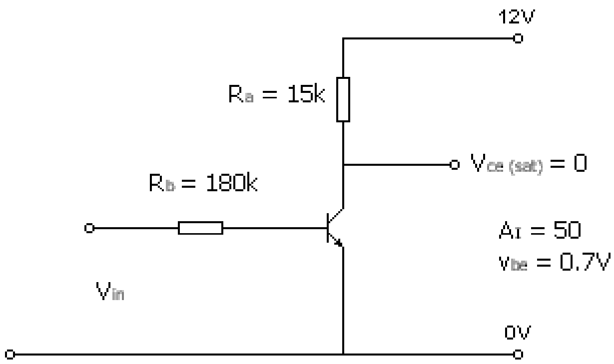

Figure 1.9.1

In the circuit above determine the value of I_c, I_b and V_i which will result in saturation of the transistor.

Homework – 1.10
In the circuit shown below calculate the output voltage and the voltage gain of the circuit for the conditions shown. State any assumptions you make.

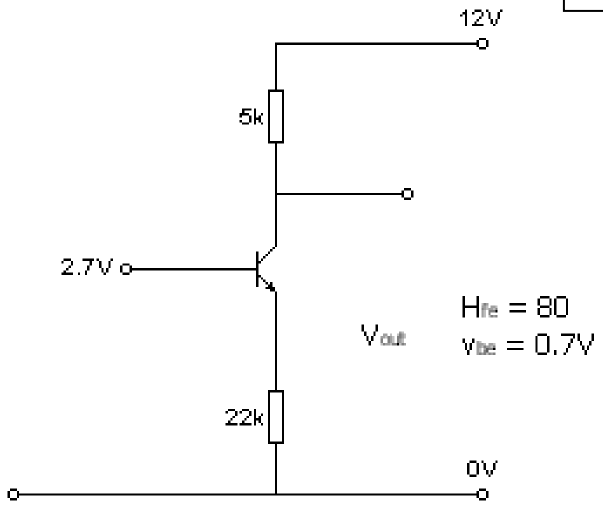

Figure 1.10.1

Homework – 1.11
For each of the six simple transistor circuits shown below, *figure 1.11.1,* calculate;

(a) the emitter voltage; (V_e)

(b) the emitter current (I_e);

(d) the base current (I_b).

(i)

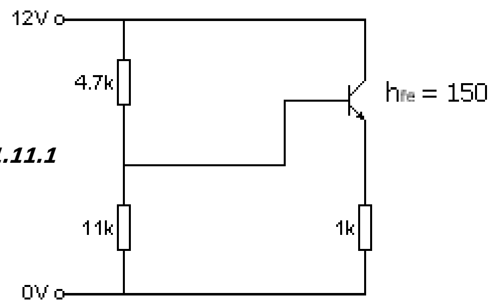

Figure 1.11.1

(ii)

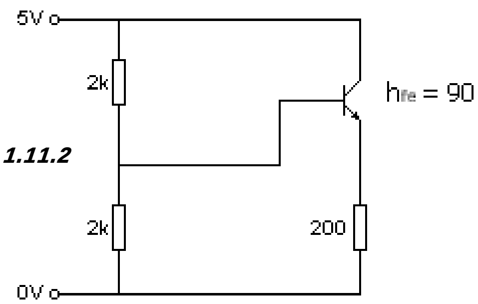

Figure 1.11.2

(iii)

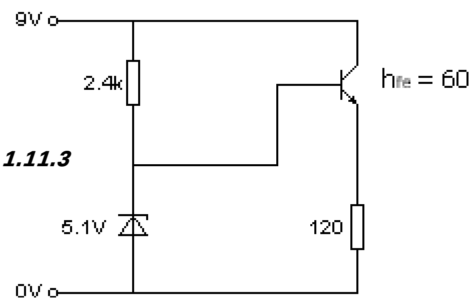

Figure 1.11.3

(iV)

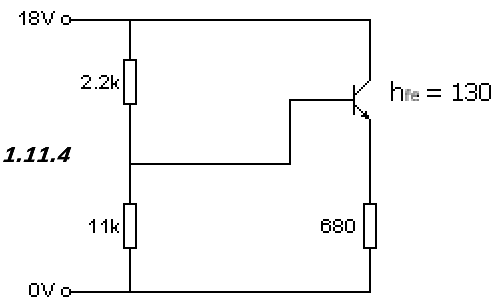

Figure 1.11.4

(V)

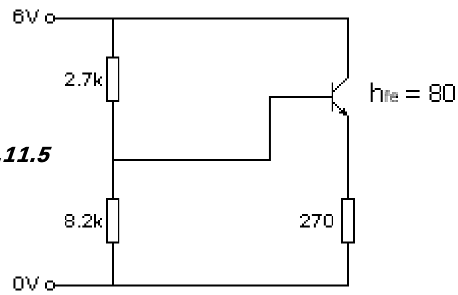

Figure 1.11.5

(Vi)

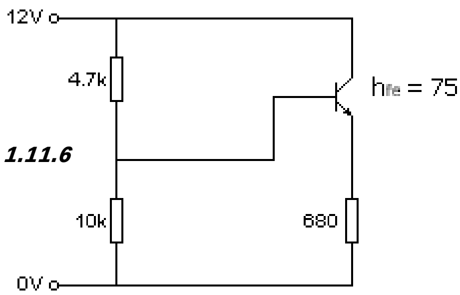

Figure 1.11.6

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Homework – 1.12

In the circuit shown, *figure 1.12.1,* the transistor has a gain of 50 (hfe). Complete the table, *fig.Q8b* by calculating the values of;

(i) base current, I_b;

(ii) the collector current, I_c;

(iii) V out, for each value of V_{in} given.

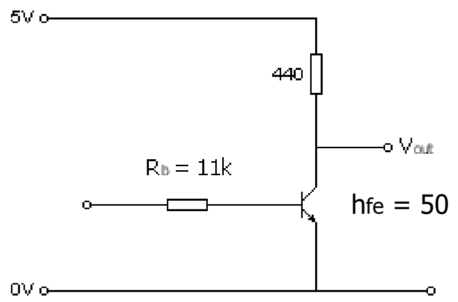
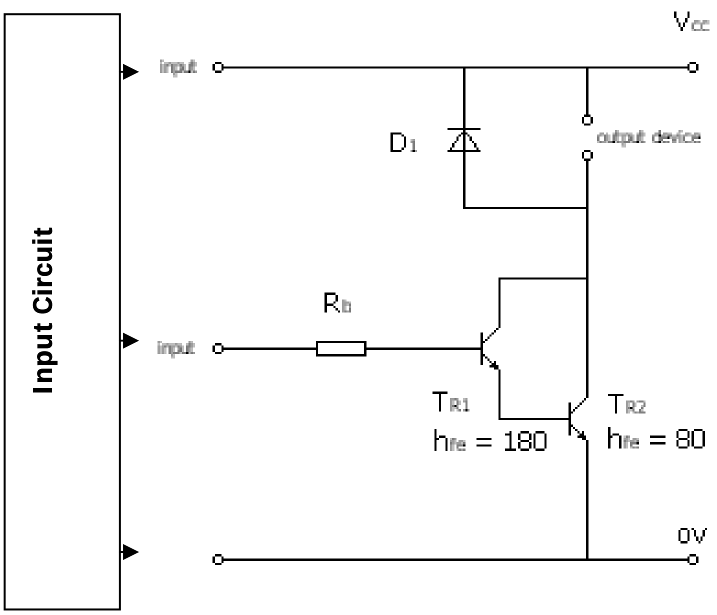


Figure 1.12.1

Homework – 1.13

The diagram below is part of a circuit which is suitable for processing the input from various types of sensors and providing an appropriate output.



(a) (i) Name the switching circuit shown and describe its operation and advantage.
(iii) State the overall gain h_{fe} for the arrangement.

(b) State the purpose of the diode D1 in the circuit.

(c) For each of the applications given below, sketch the input part of the circuit diagram that would be suitable and the output device which would be appropriate.
(i) Thermostat for the aquarium.
(ii) A rain detector to automatically close skylights.
(iii) A window "open" alarm.
(iv) Automatic window shades for bright sunlight.

Homework – 1.14

The *figure 1.14.1* below shows a partly completed circuit diagram of an alarm circuit which is used to detect an <u>increase</u> in light level on a piece of laboratory equipment.

(i) Complete the diagram by inserting the components between points X, Y and Y, Z which will allow it to perform this function.

(ii) Describe how this circuit operates explaining the function of each component.

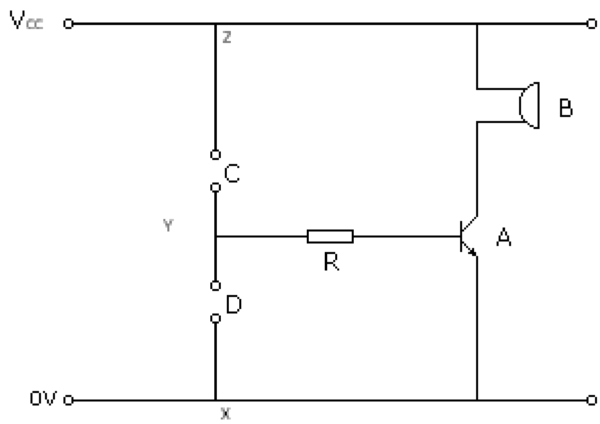


Figure 1.14.1

Homework – 1.15

Figure 1.15.1 is an incomplete circuit diagram of a frost alarm.

(i) Name the component to be inserted in the circuit at X, Y and complete the circuit diagram.

(ii) What is the purpose of the resistor R_1.

(iii) Modify the above diagram to show how it could be used as a high temperature alarm.

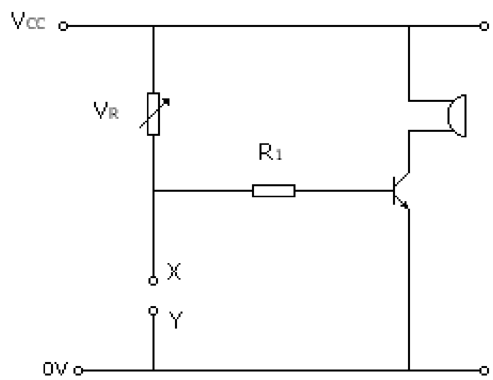


Figure 1.15.1

Homework – 1.16

For the circuit shown in *figure 1.16.1* the slider of the variable resistor is moved from X to Y.

(i) Describe the effect this has on the operation of the rest of the circuit.
(ii) Modify this circuit so that the lamp will light when the ambient light falls below a prescribed level.
(iii) Describe how the transistor could be protected from back e.m.f produced by the output device shown.

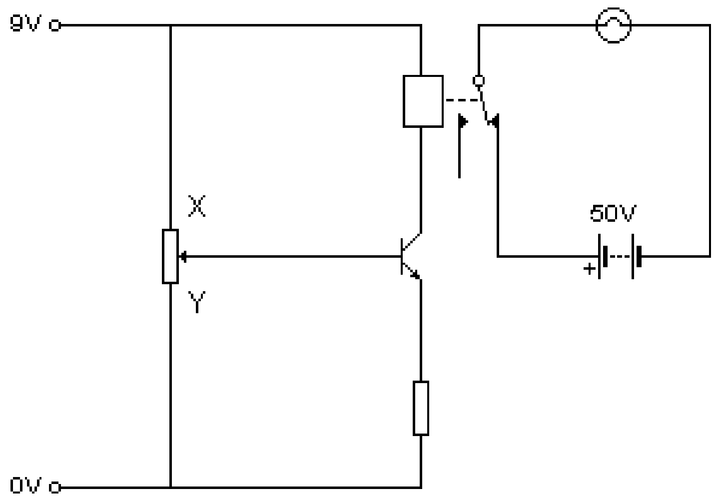


Figure 1.16.1

Homework – 1.17

For the transistor circuits shown below, in *figure 1.17.1*;

(a) Name the configuration of the transistors.
(b) Calculate:
(i) the current flowing through the load resistor;
(ii) the base current in each transistor;
(iii) the power dissipated in each transistor.

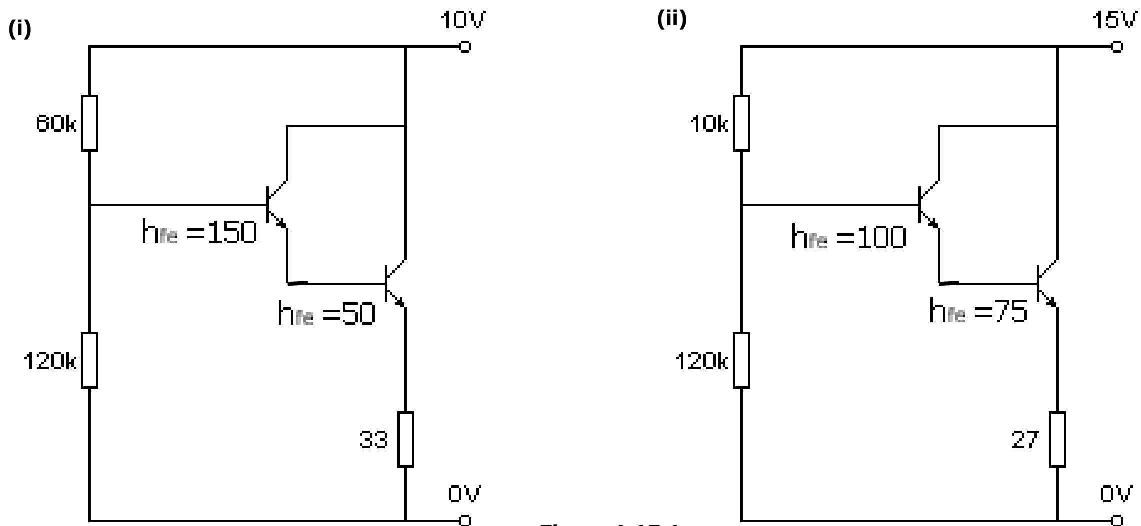


Figure 1.17.1

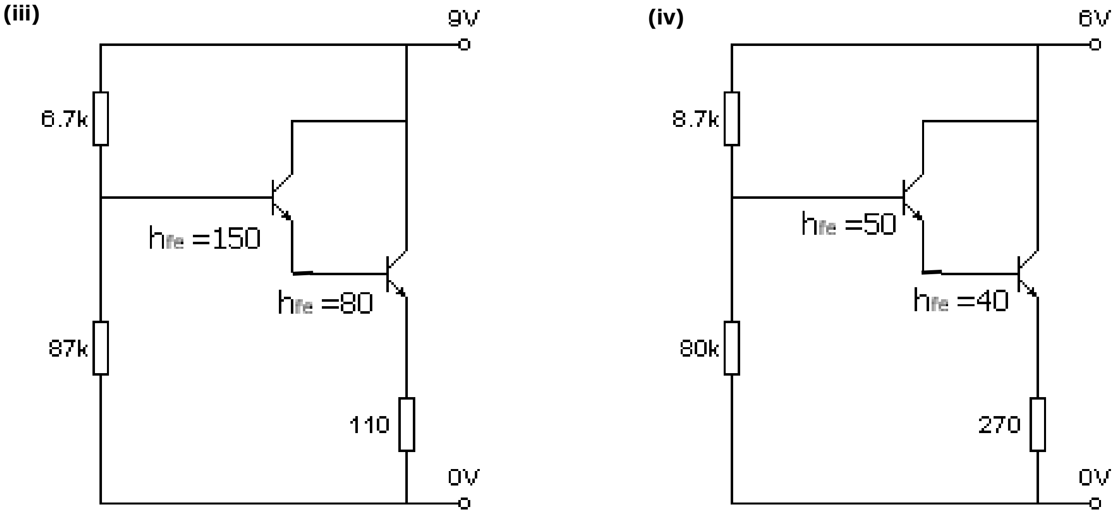


Figure 1.17.1 (continued)

Homework – 1.18

(a) Compare the characteristics of bi-polar (junction transistors) and MOSFET's with reference to their operation and use.

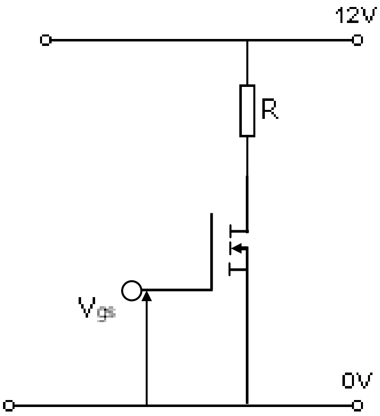


Figure 1.18.1

(b) In the MOSFET circuit figure 1.18.1 if V_{gs} = 4.4V and V_{ds} = 0.4V. Calculate the value of R if R_{ds} = 3.8Ω.

Homework – 1.19

Push-pull amplifiers can be found in control circuits. Describe and illustrate a control application detailing the operation of the circuit.

Homework – 2.1

Operational Amplifiers (Op. Amps) were originally made from discrete components and were designed to solve mathematical equations electronically by performing operations such as addition, etc. in analogue computers. Present day op. amps in integrated circuit form have many uses. One of the main ones being as high gain voltage amplifiers.

(a) Describe the chief properties of practical op. amps refering to;
  (i) open loop gain
  (ii) input impedance
  (iii) output impedance.

(b) Describe these properties as displayed by an 'IDEAL' op. amp.

(c) Sketch the basic diagram for an op. amp. which is supplied from a dual balanced d.c. power supply showing inputs and outputs.

(d) Describe its operation as a **difference amplifier**.

(e) Sketch a typical voltage characteristic graph on the axis shown in *fig. 2.1.1* below and describe the behaviour of the device over a range of inputs using the terms *saturation, linear range, difference input*.

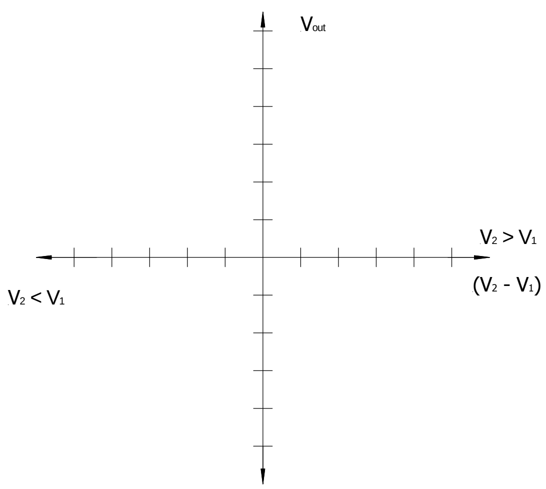


Figure 2.1.1

Homework – 2.2

(a) An inverting amplifier has a power supply of ±9V and the input voltage V_i = +1V. What is the value of the gain and the output voltage V_o when,
  (i) R_f = 20k and R_i = 10k
  (ii) R_f = 200k and R_i = 10k
  (iii) Sketch the circuit for the above examples.

(b) Repeat the above question when the op. amp is arranged as a non-inverting amplifier.

Homework – 2.3

An op. amp summing amplifier has 2 inputs. The power supply is ± 15V, and R_f = 30k the input resistors R_i each being 15k.

(a) Make a diagramatic sketch of circuit diagram for this arrangement.

(b) Calculate the output voltage V_o when
  (i) V_1 = +1V and V_2 = +4V
  (ii) V_1 = +1V and V_2 = -4V

Homework – 2.4

Op. amps are sometimes used in voltage-follower mode.

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(a) Sketch this arrangement clearly labelling the diagram.
(b) Describe briefly how it operates.
(c) State a possible use for this configuration.

Homework – 2.5
The *figure 2.5.1* below represents a practical op. amp configuration.

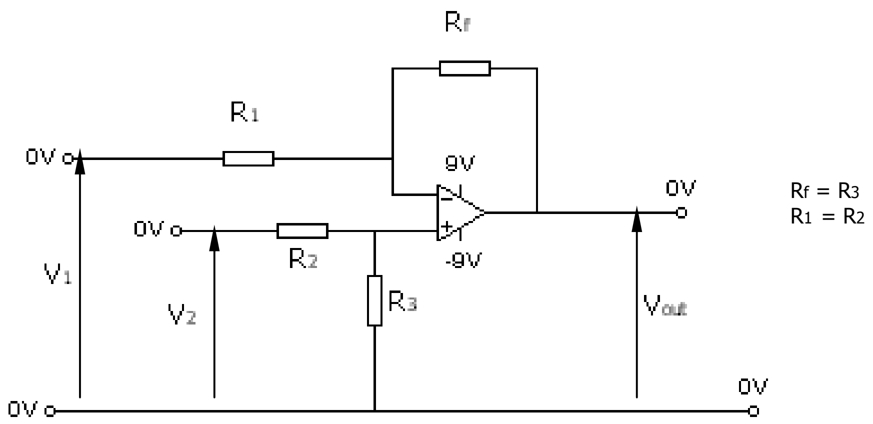

Figure 2.5.1

(a) Name this configuration and describe its operation refering to the inputs and outputs and values of reistors.
(b) Calculate the output voltage in each of the following cases.
(i) $R_f = R_i = 1M$; $V_1 = 2.4V$; $V_2 = -4V$
(ii) $R_f = 1M$; $R_i = 100k$; $V_1 = 4.5V$; $V_2 = 3.5V$

Homework – 2.6
An op. amp circuit is shown in the *figure 2.6.1* below.

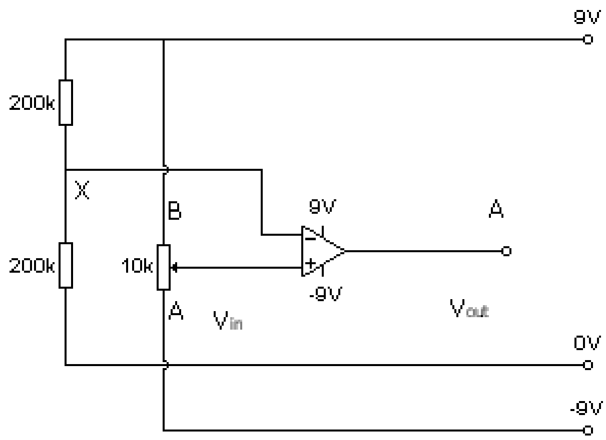

Figure 2.6.1

(a) Name this configuration
(b) State the voltage at point 'x'
(c) Sketch a graph of V_{in} (horizontal) against V_{out} (vertical) to show the relationship of V_{in} and V_{out} as the slider on the variable resistor moves from A to B.

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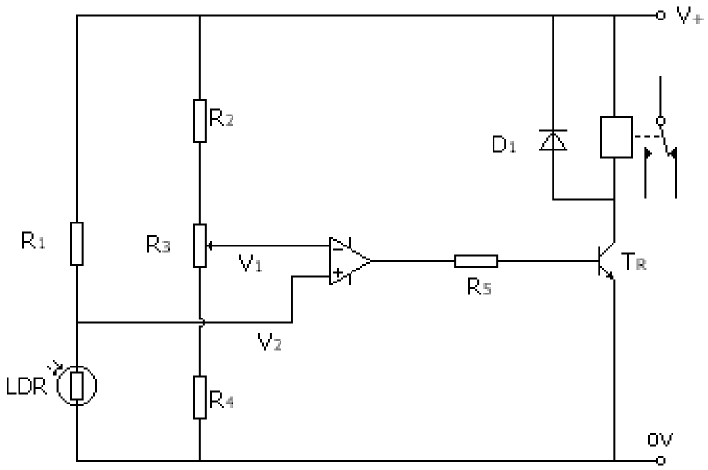
(d) The output is to be used to operate a darlington pair buffer amplifier which will drive a relay. Sketch a suitable arrangement for this circuit.
(e) Replace the darlington pair with a MOSFET buffer and sketch this arrangement.
(f) State two advantages of MOSFET's over bi-polar transistors.

Homework – 2.7

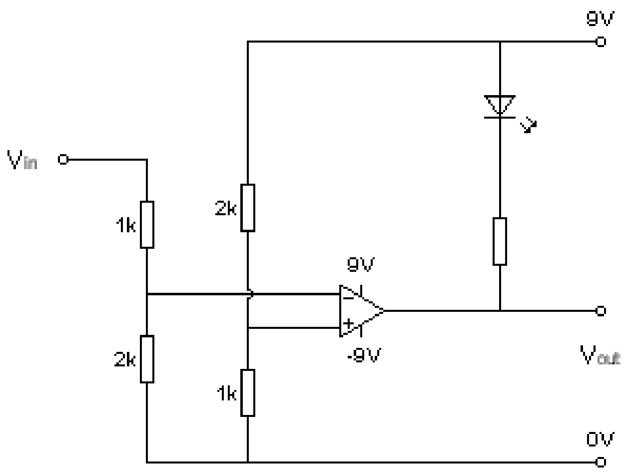
The circuit below shows a light activated switch which operates a relay.



(a) State the op. amp configuration used in this circuit.
(b) If the op. amp output is to be negative in normal daylight describe how the voltage levels V_1 and V_2 compare to give this.
(c) Describe what happens in darkness to ;
  (i) the LDR
  (ii) the relative values of V_1 and V_2.
  (iii) the output from the op. amp
  (iv) the transistor T_r
  (v) the relay
(d) State the function of the diode D1 in the circuit
(e) Show the modified circuit which will reverse the operation of the relay.

Homework – 2.8

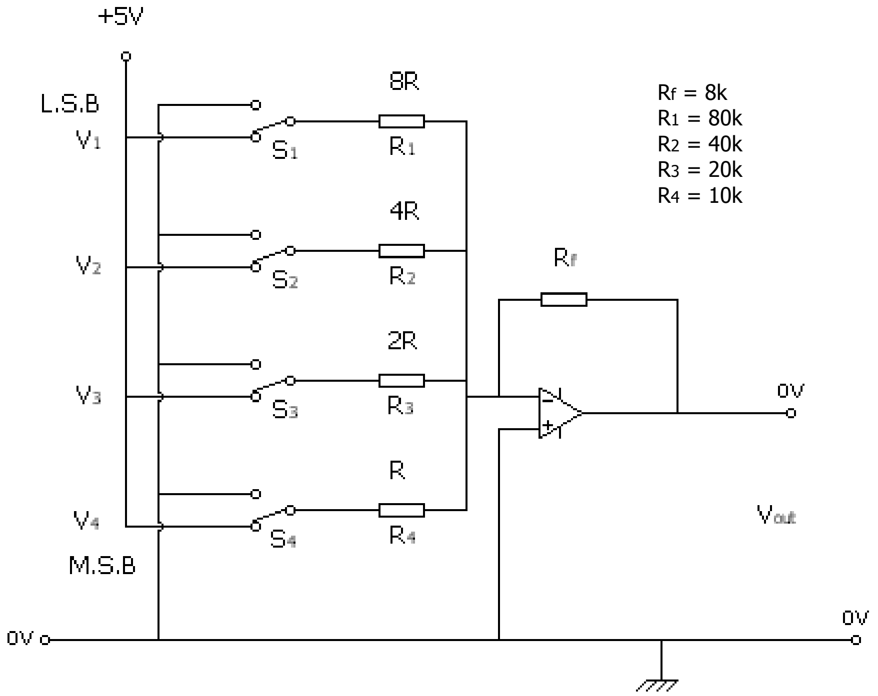
(a) Calculate the voltage at the non-inverting input of the op. amp shown.
(b) Calculate the output voltage when V_{in} = 0.
(c) Describe the operation of the LED as V_{in} varies from 0 to 9V.



Homework – 2.9

The figure below shows a diagramatic sketch of a simple digital to analogue converter. The output V_{out} is governed by the position of the switches S_1 to S_4 which may be set high 1 (5V) or low 0 (0V).

The relative value of resistors R_1 – R_4 are chosen such that each is twice the value of the previous i.e: 8R, 4R, 2R, R. *(MSB – Most Significant Bit, LSB – Least Significant Bit)*



(a) Write down the equation for the output of a summing amplifier having 4 inputs and show that;

$$V_{out} = -(0.1V_1 + 0.2V_2 + 0.4V_3 + 0.8V_4)$$ *Volts for the values of R_1, R_2, R_3 & R_4 and R_f given.*

(b) Calculate the output voltage for the switch positions shown ie. All inputs high and also for all inputs low when R = 10k and R_f = 8k.

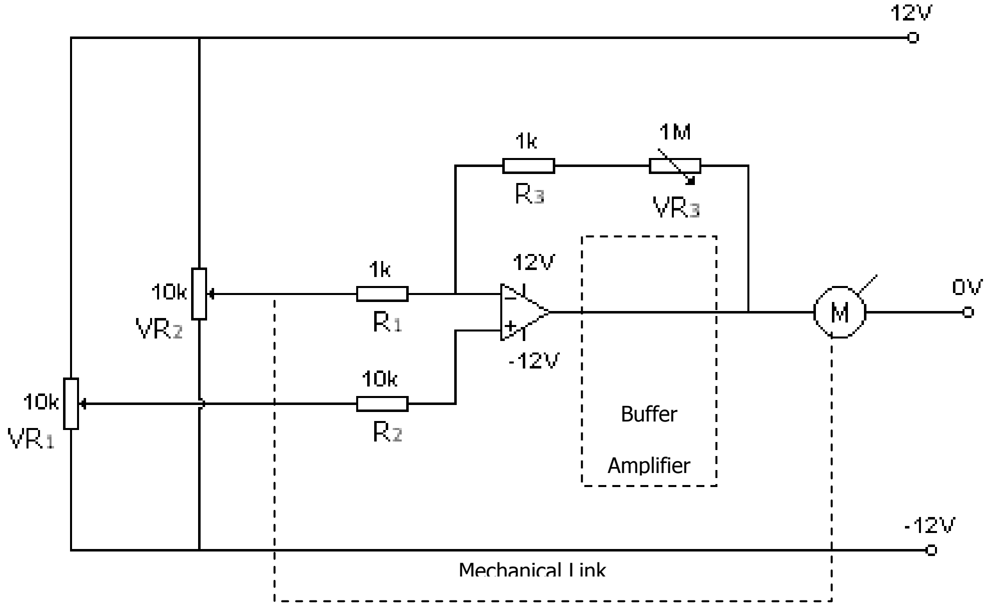
(c) Complete the table below by computing the output for all possible combinations of the 4 switches where V_1, V_2, V_3 & V_4 can be either 0V or 5V.

S_4	S_3	S_2	S_1	V_{out}
0	0	0	0	
0	0	0	1	
0	0	1	0	
0	0	1	1	
0	1	0	0	
0	1	0	1	
0	1	1	0	
0	1	1	1	
1	0	0	0	
1	0	0	1	
1	0	1	0	
1	0	1	1	
1	1	0	0	
1	1	0	1	
1	1	1	0	
1	1	1	1	

(d) Show how the above system may be modified by adding an additional op. amp device which will give a positive output equal to 2 x V_{out}.

Homework – 2.10

The system below is used to position an aerial remotely by adjusting V_{r1} to the required set position causing the aerial to move correspondingly.

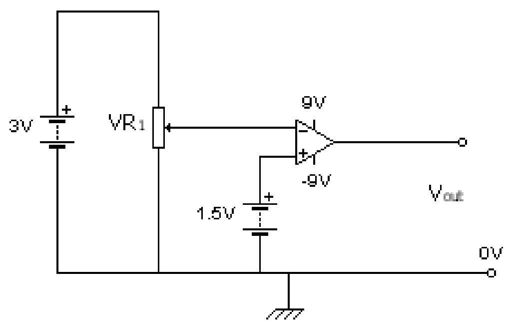


(a) Sketch a suitable buffer amplifier which will meet the requirements of this system.

(b) Identify the amplifier configuration and describe how this system operates.

Homework – 2.11

An op. Amp is connected as shown below.



(a) Name the op. Amp configuration.

(b) Explain what happens to V_o as R_1 is adjusted from 0 - R_1.

(c) Show on a sketched graph how the value of V_{out} varies as R_1 is adjusted.

Homework – 3.1
For each of the logic gates specified below;

(a) Sketch the appropriate *ANSI* symbol and *BS3939* symbol
(b) Construct the truth table for the gate having *Inputs* A & B and *output* Z.

Gates – AND, NOT, NAND, NOR, OR, & XOR.

Homework – 3.2
A vehicle can be started only when the following conditions are satisfied.

- the brake is ON.
- the gearbox is in NEUTRAL.
- The seat belt is ENGAGED.

(a) What single logic device can be used to accomplish this, and construct the truth table for this circuit.
(b) If only two input NAND gates are available, draw the logic diagram with the outputs of each gate clearly identified.

Homework – 3.3
A central heating boiler will ignite if there is a demand for hot water or if the room temperature is below a set level but only if the pilot light is lit.
Draw the logic circuit diagram that satisfies the condition and construct the truth table for the output.

Homework – 3.4

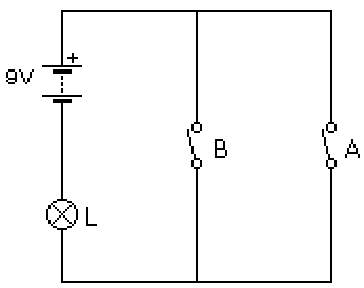


Figure 3.4.1

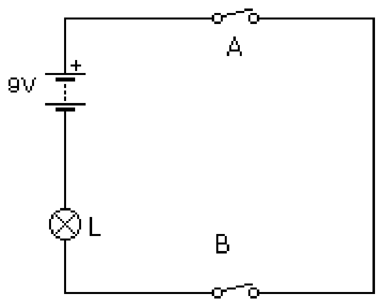


Figure 3.4.2

The electrical circuits shown in *figures 3.4.1 & 3.4.2* can be regarded as logic gates with inputs A & B and output Z.

(a) Sketch the equivalent gates.

(b) Refering to figure 3.4.3,
  (i) Regarding switches A, B, & C as inputs and lamp L as output, construct a truth table for the system assuming a **closed** switch is **high** and the lamp **on** is **high**.
  (ii) Illustrate this system using 2 input logic gates. Show the output of each gate.

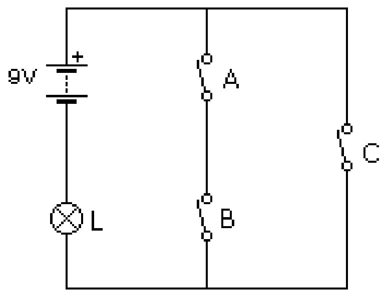
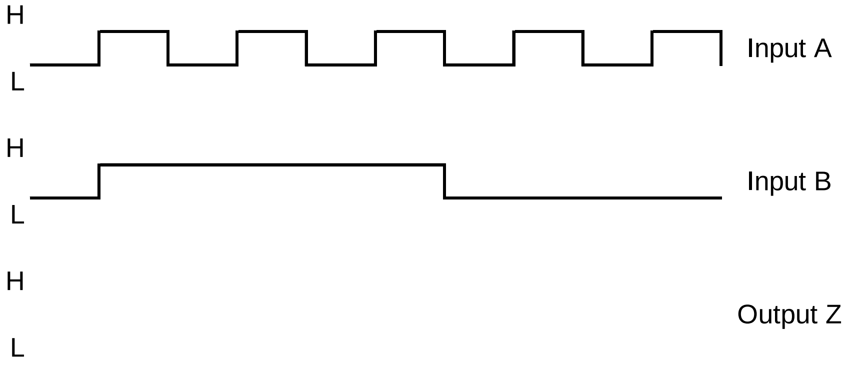


Figure 3.4.3

(c) The diagram below shows the voltage waveforms applied to inputs *A* and *B* of standard two input logic gates.



(i) Carefully copy this diagram and in the space provided sketch in relevant position of the output waveform for an *AND* gate.

(ii) Repeat this for two input *NAND, OR, NOR, X-OR* and *X-NOR* gates.

Homework – 3.5

The *NAND* gate is known as a 'universal logic gate' since it may be used to produce all other types of gate functions. Construct diagrams showing how *AND, OR, NOT, NOR, X-OR*, and *X-NOR* gates can be produced using only two input *NAND* gates. Indicate the output of each gate in the circuit.

Homework – 3.6

Write the truth table for each of the gate circuits shown below.

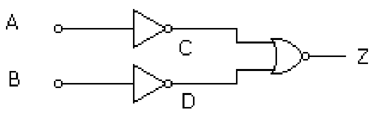


Figure 3.6.1

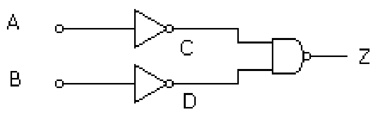


Figure 3.6.2

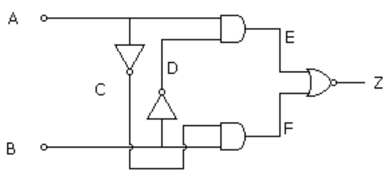


Figure 3.6.3

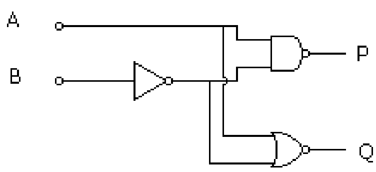


Figure 3.6.4

Homework – 3.7

For the circuits shown in *Q3.6.1, 2, 3 & 4* above construct the equivalent circuits using *NAND* gates only.

Homework – 3.8

(a) For the gates listed in *Q1* write the boolean expressions for the outputs.

(b) Write down the boolean expression for the gates shown in *figure's 3.8.1, 3.8.2, 3.8.3, 3.8.4*.

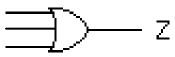


Figure 3.8.1

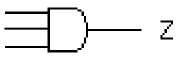


Figure 3.8.2

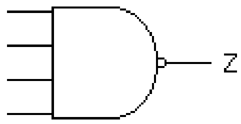


Figure 3.8.3

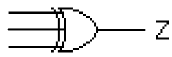
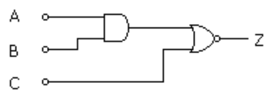
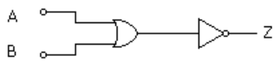


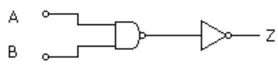
Figure 3.8.4

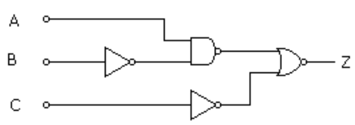
Homework – 3.9

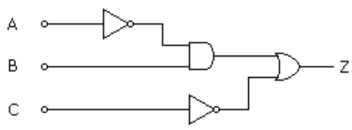
Derive the boolean expression for each of the circuits shown in the *figures* below, and construct the truth table.

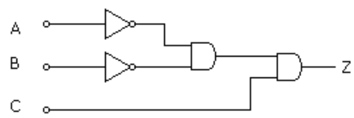












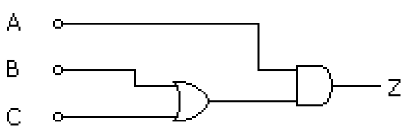
Homework – 3.10

For each of the pairs of circuits shown

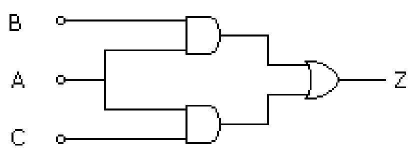
(a) Write the boolean expression.

(b) Construct their truth table and show they are equivalent

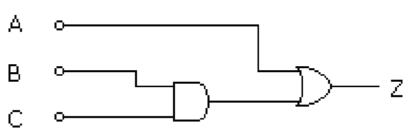
(c) Draw equivalent arrangements using only 2 input *NAND* gates.



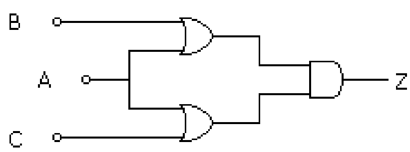
(a)



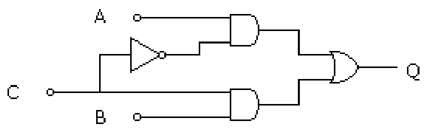
(b)



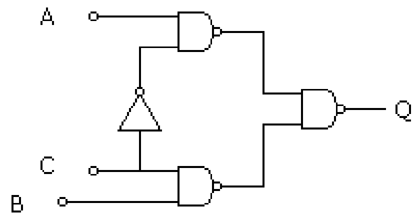
(c)



(d)



(e)



(f)

Homework – 3.11

Write the boolean equation for the following truth tables.

A	B	C	Z
0	0	0	**1**
0	0	1	**0**
0	1	0	**0**
0	1	1	**1**
1	0	0	**0**
1	0	1	**0**
1	1	0	**0**
1	1	1	**1**

(a)

A	B	C	Z
0	0	0	**0**
0	0	1	**0**
0	1	0	**0**
0	1	1	**1**
1	0	0	**0**
1	0	1	**0**
1	1	0	**1**
1	1	1	**1**

(b)

A	B	C	Z
0	0	0	**0**
0	0	1	**1**
0	1	0	**0**
0	1	1	**0**
1	0	0	**0**
1	0	1	**1**
1	1	0	**0**
1	1	1	**0**

(c)

Homework – 3.12

For each of the following boolean equations, draw a logic circuit diagram.

(a) F = A + B + C + D *(using only two input gates)*

(b) $Z = \overline{A} + (\overline{B . C})$

(c) $F = (\overline{A . B}) . \overline{C}$

(d) Z = A + B + (C . D)

Homework – 3.13

A food processing plant uses four different liquids, *U, V, X & Y,* in an automatic production process. Level sensors in a tank containing liquid 'X', and a similar tank containing liquid 'Y' send a logic 1 signal to the control system when the level exceeds a set value. Also sensors send a logic 1 signal to the control system when the temperature of liquids *U,* and *V,* full below a set value.

Design a control system which will give an audible warning when *both* liquids *X* and *Y* exceed the set level, a visual warning when the temperature of *both* liquids *U* & *V* drop below the set value and a signal to shut down the plant if liquid U or V is at too low a temperature.

Convert the circuit to NAND gates only.

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Homework – 3.14
A chemical process involves maintaining the difference in pressure of two gases ***A*** and ***B*** within prescribed limits. Pressure sensors *a* and *b* detect the pressure of each gas and the signals obtained are processed to produce a logic 1 output if the difference in pressure between ***A*** and **B** are too great. A logic 1 signal is also produced by each sensor *a* and *b* when the pressure of each gas exceeds a maximum safe operating pressure. Design a logic system which will shut down the process by producing a logic 1 if the pressure difference is too great, or the pressure of either gas exceeds the safe pressure. Construct the circuit to use *NAND* gates only.

Homework – 3.15
Design a logic circuit having 3 logic input signals *A, B*, and *C* which may be either logic 1 or logic 0, such that the output will be logic 1 when the *majority* of inputs are at logic 1.

(a) Draw up a truth table for this system and from this derive the boolean expression.

(b) Draw the logic circuit diagram using a selection from the full range having up to 4 inputs each.

Homework – 3.16
A simple arithmetic and logic unit (ALU) has these inputs *A, B*, and *C* and output *F*. In operation,

When C = 0, output F = 1 when A = B; and
When C = 1, output F = 1 when A = B = 1.

(a) Using the above data construct the truth table for this unit.
(b) Derive the boolean equation for the output *F*.
(c) Using *NOT* gates and 2 input *AND* gates and 2 input *OR* gates, construct the logic circuit diagram.
(d) Draw the simplified equivalent NAND gate circuit and express this as a boolean expression.

Homework – 3.17
(a) Construct a truth table for a 2 input exclusive *OR* gate.
i.e. the output **F is 1 when A = 1, B = 0** and
F is 1 when A = 0, B = 1.
(b) Write down the boolean expression.
(c) Draw a logic circuit diagram for this function using *NOT, AND*, and *OR* gates only.
(d) Draw the equivalent *NAND* gate circuit for this function.

Homework – 3.18
Logic gates are available in integrated circuit 'packages' the two most common types being the **TTL** and **CMOS** families.
(a) What do the acronyms **TTL** and **CMOS** mean.
(b) Compare the performance of each type with reference to
  (i) Power supply.
  (ii) Current requirements.
  (iii) Input impedance.
  (iv) Switching speed.
  (v) Fan out.
  (vi) Unused outputs.