KLS Vishwanathrao Deshpande Institute of Technology

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

University / Model Question Paper Scheme & Solution

Faculty Name	:	Deepak Sharma
Course Name	:	Automotive Electronics
Course Code	:	BEC714C
Year of Question Paper	:	Model
Date of Submission	:	15/07/2025

Faculty Member | HoD 15-07-25 | Dean (Acad.)

Head of the Department
Dept. of Electronic & Communication Engg.
KLS V.D.I.T., HALIYAL (U.K.)

AY: 2025-26

Department: E&CE
Semester / Division: 7th A & B
Subject with Sub. Code: Automotive Electronics (BEC714C)
Faculty Name: Prof. Deepak Sharma **Max. Marks: 100**

Note: Answer any one full question from each part; each full question carries 10 marks.

	Module 1	
1A	Explain four stroke cycle of engine	**(10)**
B	Explain High Voltage circuit and distribution for spark pulse generation	**(10)**
	OR	
2A	Explain use of electronics in automobiles	**(10)**
B	Explain brake configuration and force acting on wheel	**(10)**
	Module 2	
3A	Explain electronic suspension system	**(10)**
B	Explain the microprocessor architecture	**(10)**
	OR	
4A	Explain the microcomputers in control system	**(10)**
B	Explain digital to analog converter	**(10)**
	Module 3	
5A	Explain the analogue to digital converter	**(10)**
B	With the need diagram explain hall effect position sensor	**(10)**
	OR	
6A	Explain Engine crankshaft angular position sensor Explain magnetic reluctance position sensor	**(10)**
B	Explain electronic engine control system	**(10)**
	Module 4	
7A	With neat diagram explain electronic ignition control system	**(10)**
B	Define engine performance terms	**(10)**
	OR	
8A	With neat diagram explain digital cruise control system	**(10)**
B	With neat diagram explain throttle actuator	**(10)**
	Module 5	
9 A	Explain accelerometer based airbag system	**(10)**
B	Explain collision avoidance radar warning system	**(10)**
	OR	
10 A	Explain low tire pressure warning system	**(10)**
B	Explain Automotive GPS Navigation system sign post navigation	**(10)**

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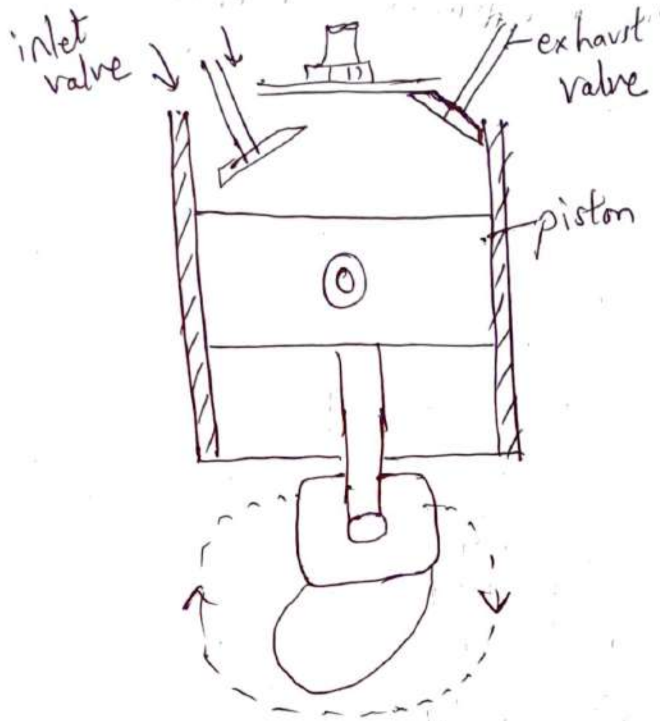
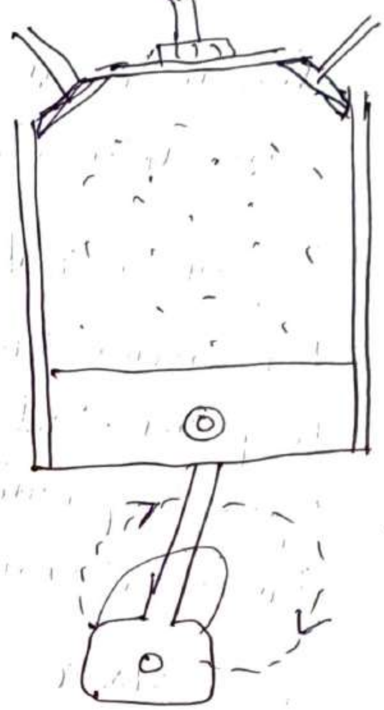
1) a. Explain 4 stroke cycle of Engine.

→ 1.) Intake
2.) Compression
3.) Power
4.) Exhaust

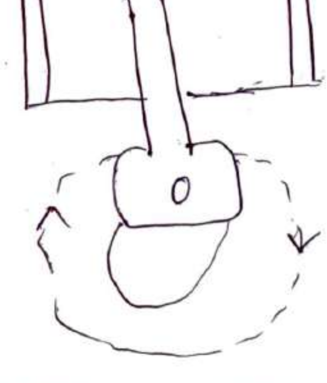
Intake



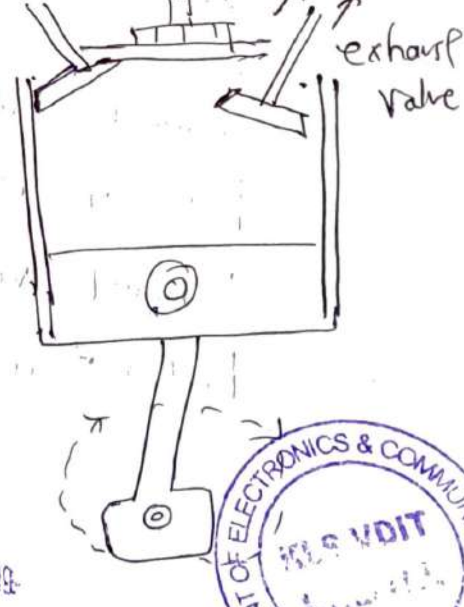
Compression



Power



Exhaust



- Intake Stroke

* Piston moves from up to down
* Intake valve opens
* Exhaust valve closed
* Vaccuum draws mixture of air & gasoline into cylinder
* Intake valve closed

- Compression stroke

* Piston moves from down to up
* Compresses fuel mixture
* Spark is produced
* Burning of mixture

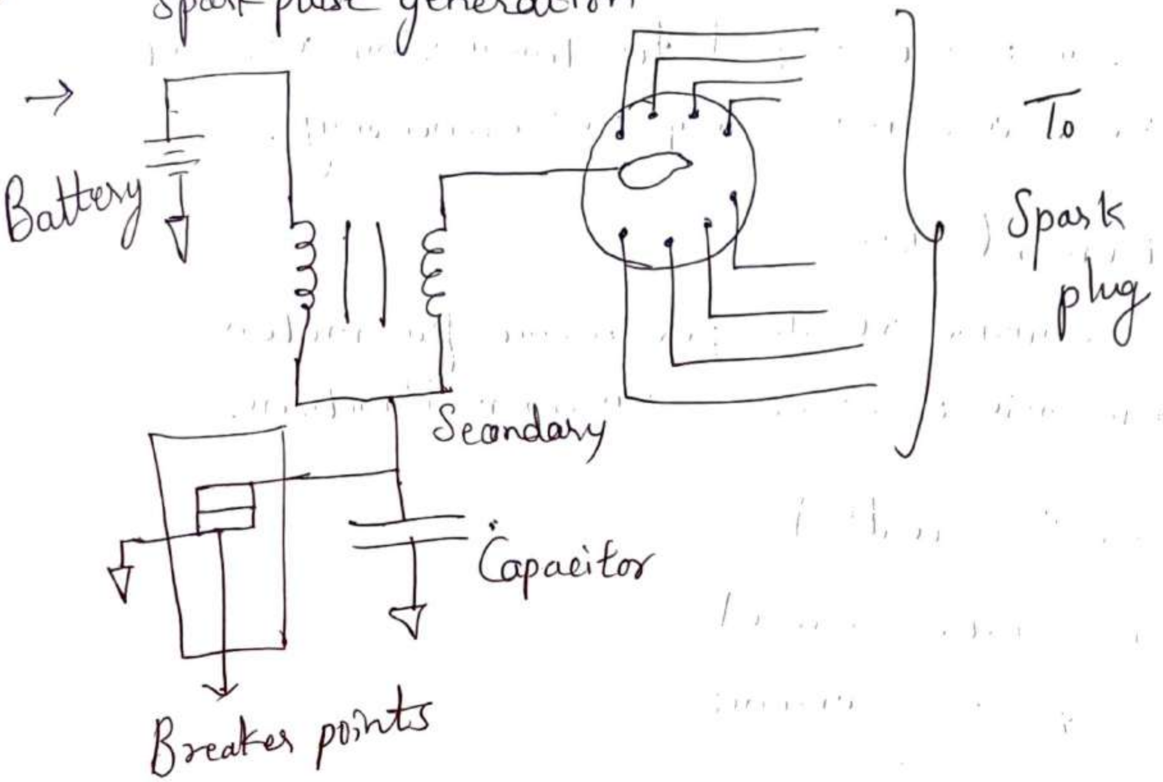
- Power stroke

* High pressure after burning
* Power is generated by engine.
*

- Exhaust stroke

* Piston moves upward
* Exhaust valve is open
* Piston forces burned gases outside.

(i) b. Explain high voltage circuit & distribution for spark pulse generation



* Ignition System generates spark plug.
* This is by high voltage pulse generated by inductive discharge of a special high voltage transformer called ignition coil.
* High voltage is delivered to appropriate spark plug at correct time by distribution circuit
* Breaker points were used earlier.
* Spark plug wires are connected between various spark plug center terminals in distributor cap.

② a. Explain use of electronics in automobile

→ * Electronic engine control for minimizing exhaust emissions and maximizing fuel econonomy.

* Instrumentation
For measusing vehicle performance parameters & diagnosis of on board system malfunctions.

* Drive line Control

* Vehicle motion control

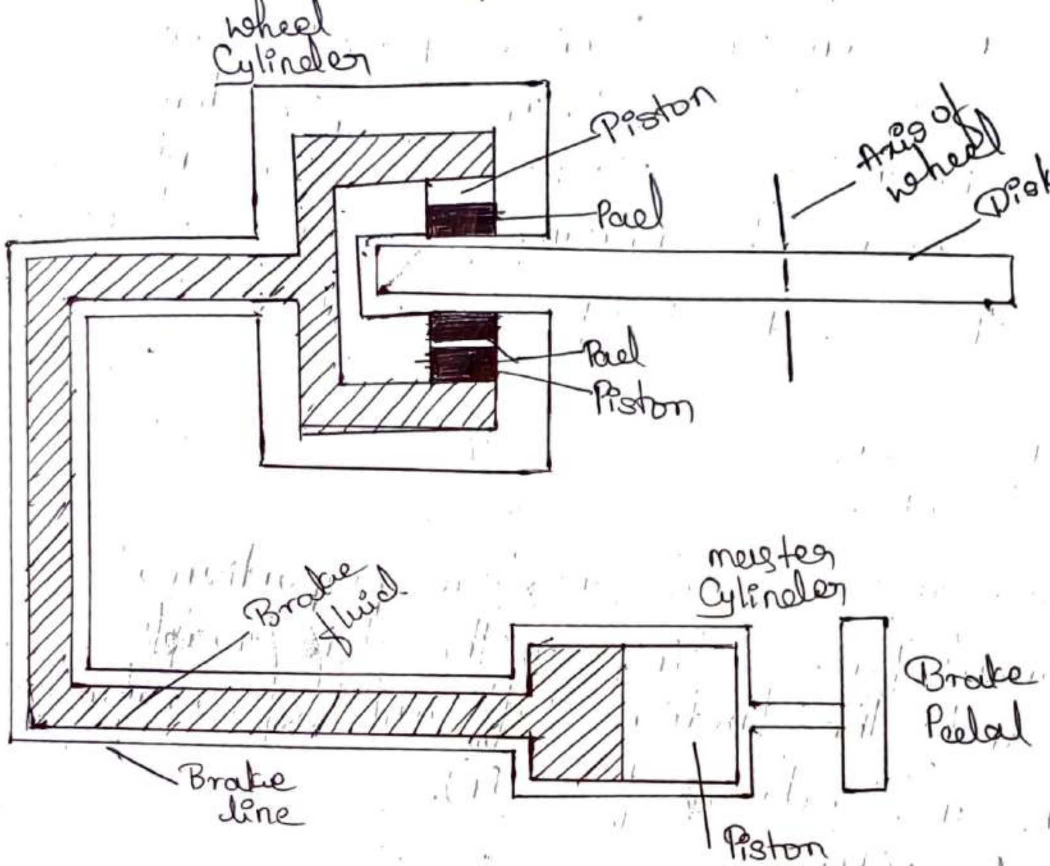
* Safety & convenience

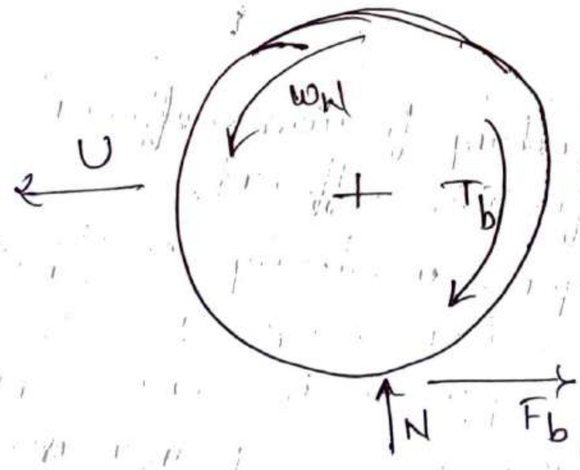
* Entertainment

* Communication

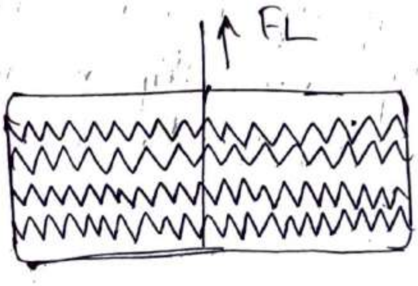
* Navigation

1) b. Explain Brake Configuration and force acting on wheel.





Side view of wheel



Top view of Tire

The wheel angular speed begins to decrease, causing a differance between the vehicle speed U and the tire speed over the road. In effect, the tire slips relative to the road surface. The amount of slips determines the braking force and lateral force. The slip, as a percentage of car speed is given by

$$S = \frac{U - \omega_W r_W}{U}$$

* The braking and lateral forces are proportional to the normal force acting on the tire/road interface and the friction coefficients for braking force (F_b) and lateral force (F_L).

$$F_b = N\mu_b$$
$$F_L = N\mu_L$$

where μ_b is the braking friction coefficient and μ_L is the lateral friction coefficient.

* These coefficients depend markedly on slip, the solid curves are for a dry road and the dashed curves for a wet or icy road. As brake pedal force is increased from zero, slip increases from zero. For increasing slip, μ_b increases to $S = S_0$.
* Further increase in slip actually decreases μ_b, thereby reducing braking effectiveness.

On the other hand, μ_L decreases steadily with increasing a such that for fully locked wheels the lateral force has its lowest value. For wet or icy roads, μ_L at $s=1$ is so low that the lateral force often is insufficient to maintained directional Control of the vehicle.

* However, directional Control can be maintained even in Poor braking Conditions if slip is optimally Controlled. This is essentially the function of the ABS, which Performs an operation equivalent to pumping the brakes.

* In Braking Torque T_b is,

$$T_b = f(P_b)$$

* Although it is not necessary for ABS application

$$T_b \cong k_b P_b$$

where,
k_b is a Constant for the given brakes.

③ a. Explain Electronic Suspension System?

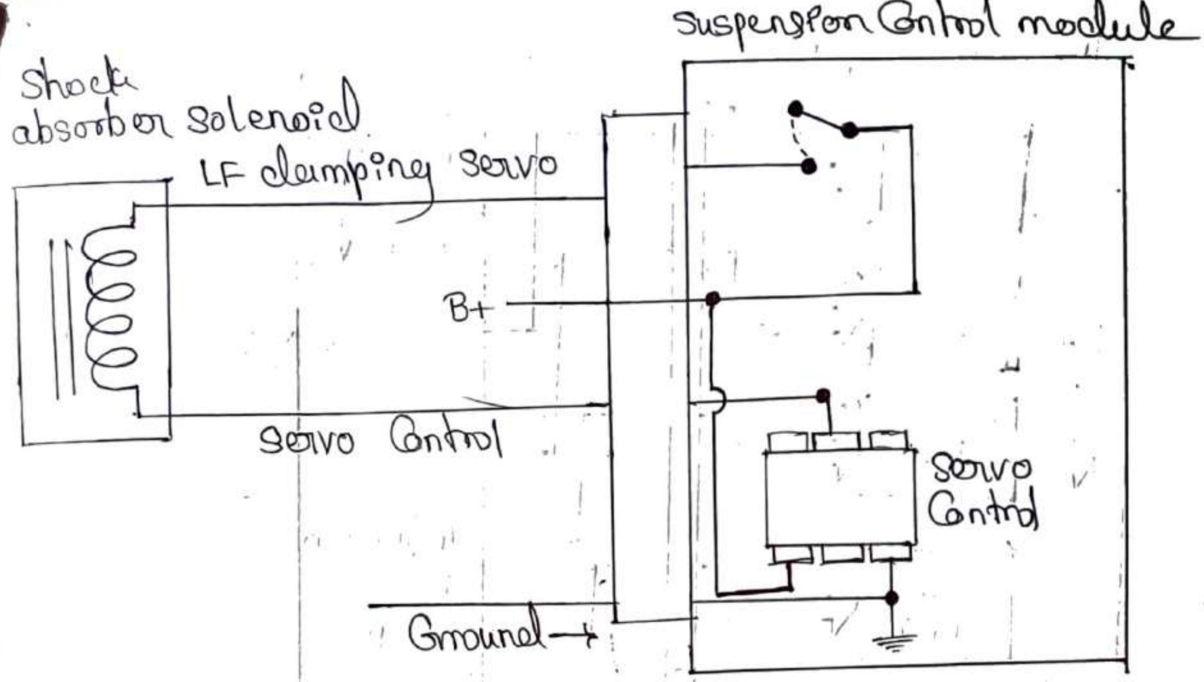
→ * An automotive suspension system consists of springs, shock absorbers, and various linkages isolate the car body motion as much as possible from wheel vertical motion due to rough road input.

* The suspension system for the front wheels of a front wheel drive car. I essence a suspension system is a mass, spring, damping assembly that connects the car body.

* the two primary subjective performance measures from a driver / passanger standpoint are ride and handling. Ride effects refers to the car body in response to road bumps or irregularities. Handling refers to how well the car body responds to dynamic vehicle motion such as cornering or heard braking.

* Damping in the suspension system is provided by the shock absorber portion of the strut assemble. Viscous damping is provided by fluid motion through orifices in a piston portion of the strut.

* The structure and details of a strud are given later in this chapter, but the interested reader can look ahead to this. For the present, attension is forced focused on the influence of strut damping on ride and handling.

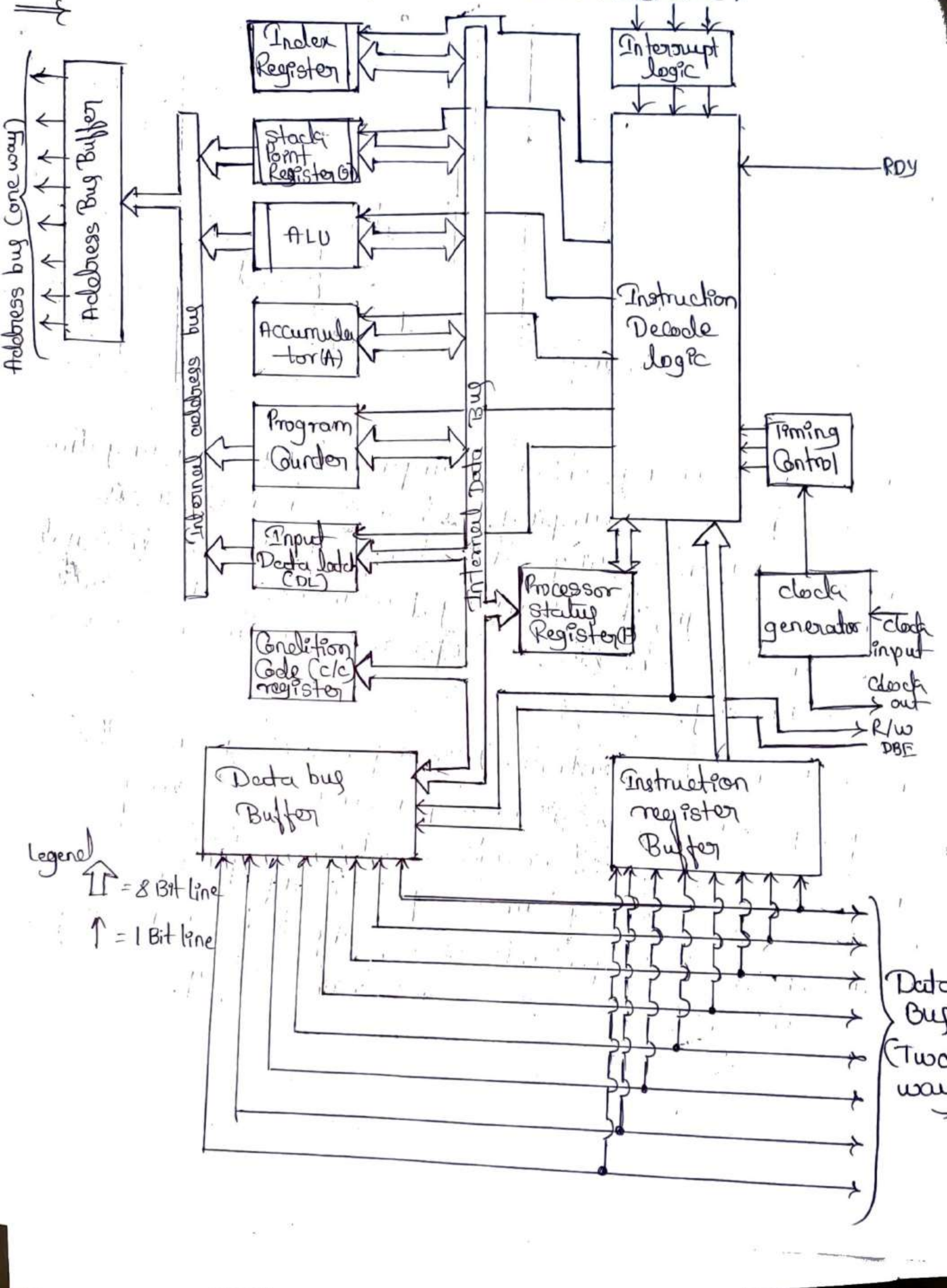


*/ Generally speaking, ride is improved by lowering the shock absorber damping, whereas handling is improved by increasing this damping. In traditional suspension design, the damping parameter is fixed and is chosen to achieve a compromise between ride and handling.

* In electronically Controlled Suspension systems, this damping can be varied depending on driving conditions and road roughness characteristics. That is, the suspension system adapts to inputs to maintain the best possible ride, subject to handling constraints that are associated with safety.

(3) b. Explain the microprocessor architecture?

⇒



The Central Component that Controls and performs all operations in any micro Computer is the microprocessor, which is makeup of many electronic Subsystems all implemented in a Single integrated Circuit.

* This Block diagram is devided into two main portions - a register section and a Control section. The specific operations performed during the Execution of a given step in the program are Controlled by electrical signals from the instruction decoder.
* During the each program step, an instruction in the form of an 8 or more bit binary number is transferred from memory to the instruction register. This instruction is decoded using logic Circuits. The result of this decoding process is a set of electrical Control signals that are sent to the specific Components of the register section that are involved in the instruction bieng Executed.
* The data upon which the operation is performed are similarly transferred from memory to the data bus buffer the data are then transferred to the desired Component in the register section for Execution of the operation.
* This device is a Complex Circuit Capable of performing the arithmatic and logical operations are. There are many potential variations on the architecture shown as well as the number of bits associated with instructions and data.

(4a) Explain the microcomputers in Control systems?

→ * microcomputers are able to handle inputs and outputs that are either digital or converted analog signals. with the proper software, they are capable of making decisions about those signals are can react to them quickly and precisely.

* These features make microcomputers ideal for controlling other digital or analog systems, as discussed in the following sections;

(i) Limit Cycle Control System:

* The limit cycle controller, can be readily implemented with a microcomputer. Recall that the limit cycle controller controls the plant output so that it falls somewhere between an upper and lower limit, preferably so that its average value is equal to the command input. The controller must read in the command input and the plant output and determine via appropriate logic the value of the control signal to be sent to the plant based on those signals alone.

* Using a microcomputers, the upper and lower limits can be determined from the command input by using a lookup table similar to that,

Closed-loop Control System:

* Recall the basic Closed loop Control System is a Continuous time Control system performs the Control law operations on the error signal to generate a Continuous time Control Signal. (u) which is sent to the actuator via hardware.
* Recall that the discrete time system performs the Control law Calculation which is sent to the Control law Calculation by performing operations on the Sampled error between the desired and actual numerical values of the plant variable being Controlled.

(iii) Feedback Control Systems:

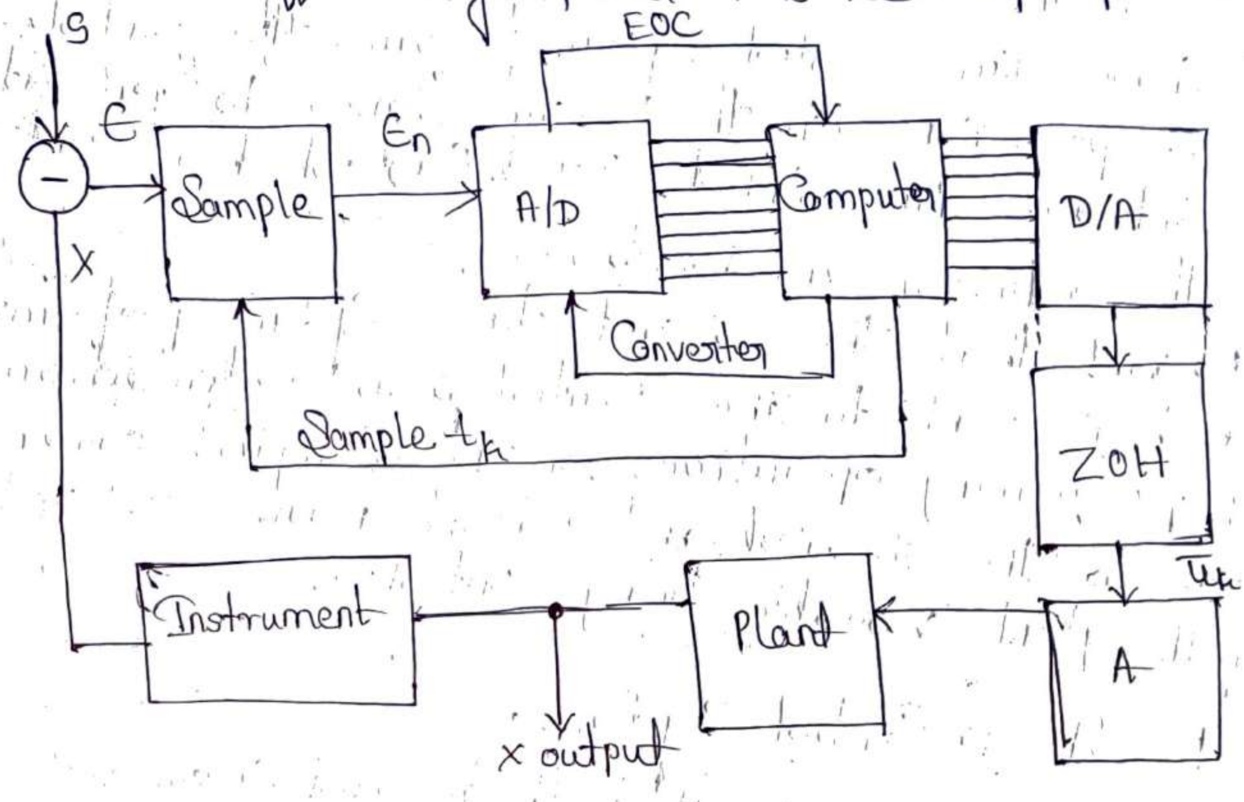
* Recall that the Concept of feedback Control System was introduced.. A feedback Control System Can also be implemented using a digital Computer as well as the limit-Cycle Controller.
* The desired value of for x is the set point s, An error signal ϵ is obtained.

$$\epsilon = s - x$$

* The error signal is Sampled, yielding samples ϵ_n. A representative value of a Control algorithm is the PID Control law by which an output y_n for each input Sample is Calculated by the Computer

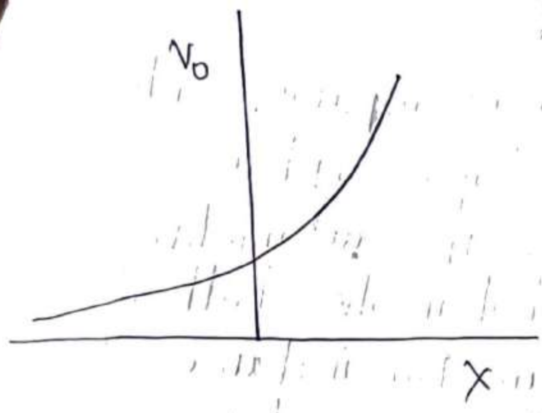
$$y_n = K_P \epsilon_n + \frac{K_I T}{2} \sum_{k=1}^{k} (\epsilon_{n-k} + \epsilon_{n-k-1}) + \frac{K_D (\epsilon_n - \epsilon_{n-1})}{T}$$

where K_p is the proportional gain, K_i is the integral gain, K_D is differential gain, and T is the sample period.



(iv) Table Lookup:

* One of the important functions of microcomputer in automotive application is table lookup. These applications include,
  1. linearization of sensor data
  2. multiplication
  3. Calibration Conversion
* The Concept of table lookup is pair of variables, V_0 & and X, are related by the graph depicted therein. The functional relationship between V_0 and X might, for example, be the output voltage of a nonlinear sensor V_0 for measuring a quantity x.

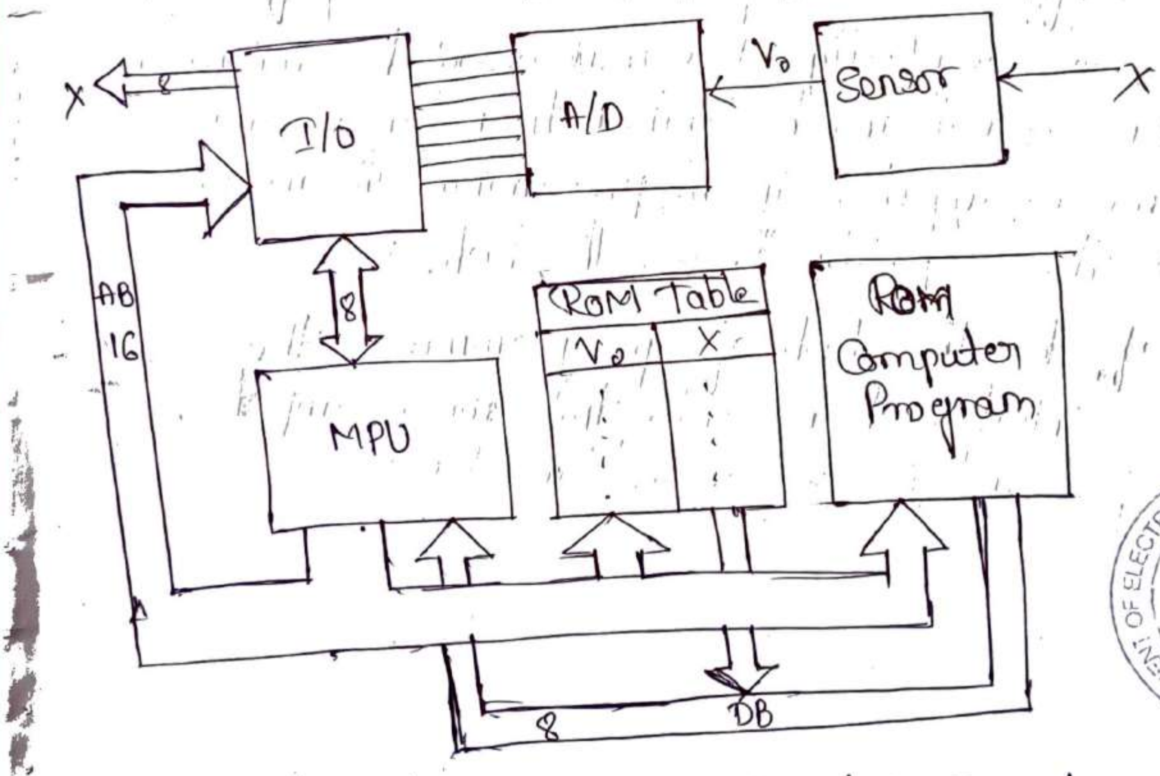


Table

V_0	X
0	-5
1	0
2	4
⋮	⋮

→ Denoting V_1 and V_2 as the nearest values for V_0 and X_1, X_2 as the corresponding tabulated values, the value for x corresponding to V_0 is found by linear interpolation:

$$x = X_1 + (X_2 - X_1)(V_0 - V_1)/(V_2 - V_1)$$



* The relationship $V_0(X)$ is stored in ROM for representative Points along the Curve. These data are stored using V_0 values as addresses, and corresponding values of X as a data.

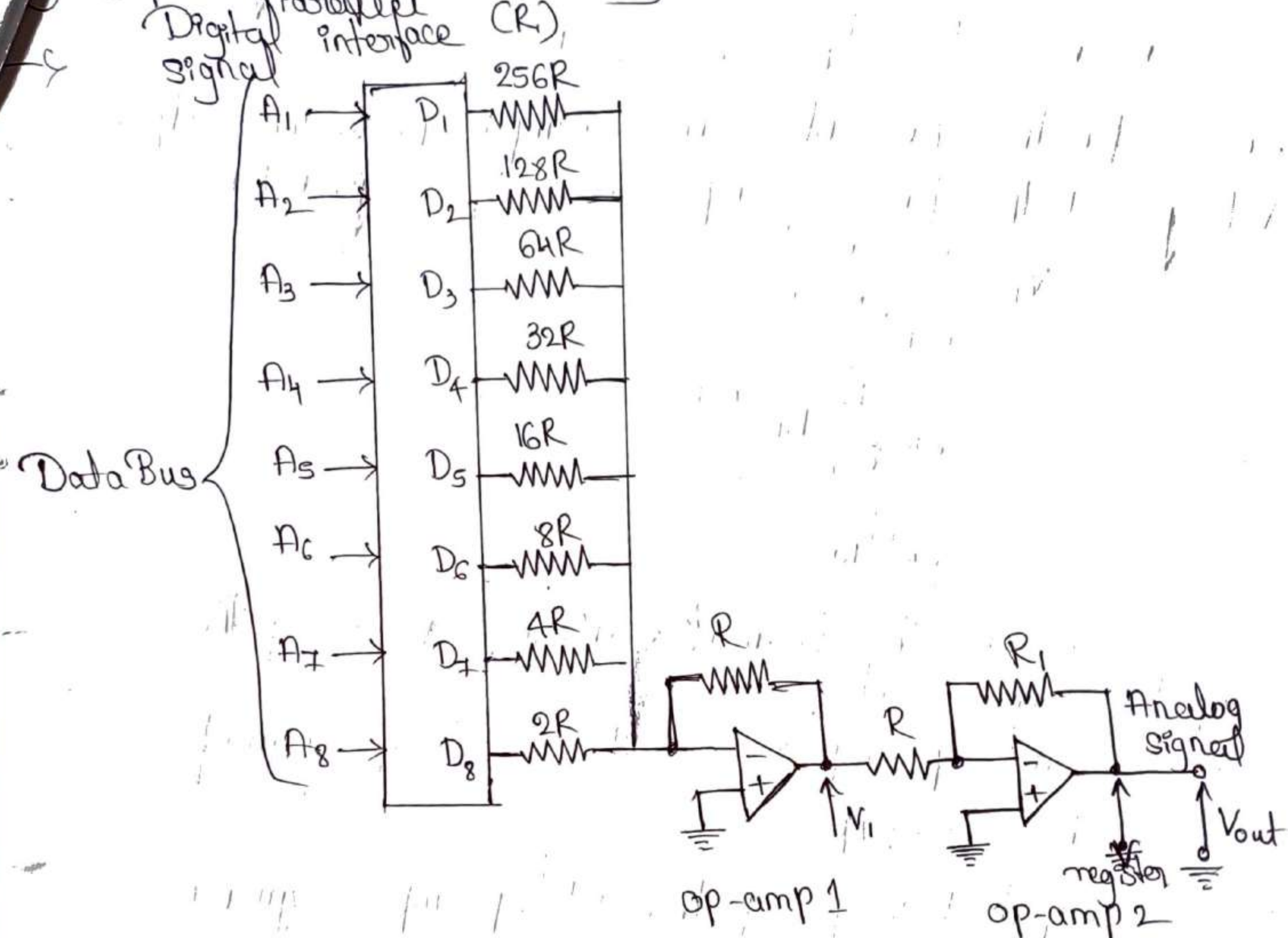
(v) Multivariable and Multiple Task systems:

* A very important feature of microcomputer control logic is the ability to control multiple systems with multiple inputs and outputs. The automotive applications for microcomputer control involve both of these types of multivariable systems. For instance, the automobile engine controller has several inputs and several outputs.

* These types of controllers can be very complicated and are difficult to implement in analog fashion. The increased complexity of a multivariable microcomputer system is not much higher than for a single-variable microcomputer system, presuming the microcomputer has the capacity to do the task.

* It only affects the task of programming the appropriate control scheme into the microcomputer. This type of control is discussed in later chapter.

Explain Digital to analog Converter?



* The parallel input and output interfaces are used to monitor and Control external digital signals. microComputers Can also be used to measure and Control analog signals through the use of special Interfaces.
* The parallel interface includes output Circuitry associated with each data bit latch such that

$$D_n = 5V \text{ if } A_n = 1 \quad n = 1, 2, --- N.$$
$$= 0V \text{ if } A_n = 0$$

where A_n = nth bit of the 8 bit input digital data where A_8 is MSB.

* The source resistance for nth data bit is given by

$$R_s(n) = 2^{N-n+1}R \quad n=1,2,\ldots N$$

where, for the present 8-bit example, N=8. The output voltage of the first op-amp circuit V_1 is given by

$$V_1 = -\sum_{n=1}^{N} \frac{D_n}{2^{N-n+1}}$$

$$= -\frac{5}{2^N}\sum_{n=1}^{N} A_n 2^{n-1}$$

$$= -\frac{5}{2^N} N_{10}$$

where N_{10} is the decimal numerical value of the input digital data.

* The second op-amp has a closed-loop gain of

$$A_{cl} = -R_f/R$$

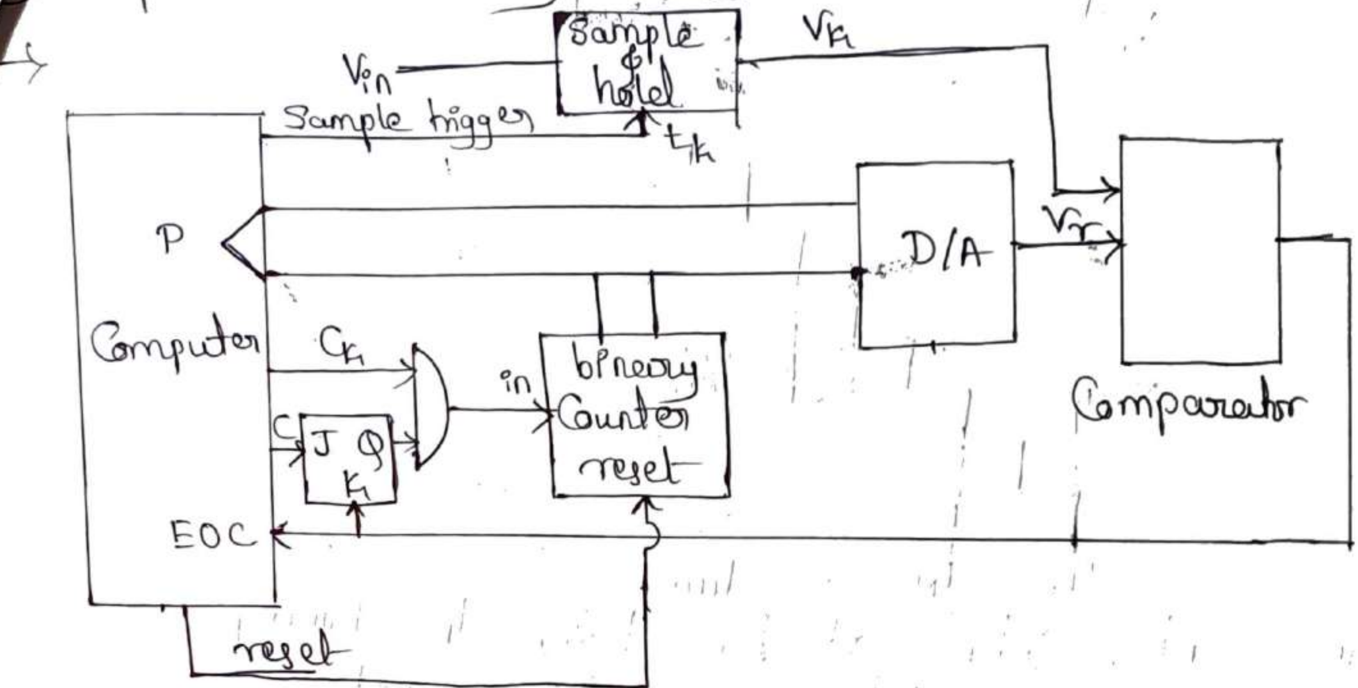
* The output voltage of this 2nd op-amp is given by

$$V_{out} = \frac{5R_f}{2^N R} N_{10}$$

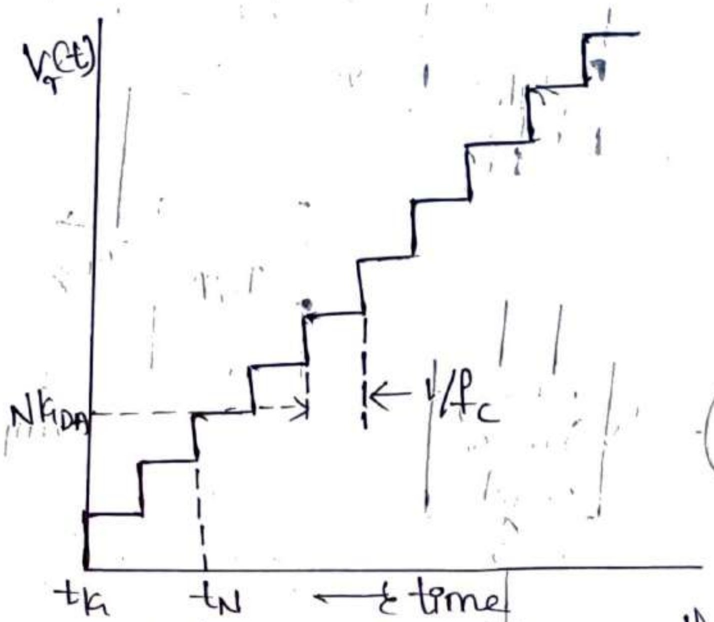
$$= K_{DA} N_{10}$$

where K_{DA} is the scale factor for the D/A converter. The effect of the two amplifier is to scale each bit of the parallel interface by a specially chosen factor and add the resultant voltage together such that the D/A converter output voltage is proportional to the decimal equivalent of the input binary data.

Q. Explain the Analog to Digital Converter?



* In addition, microComputers can measure analog voltages by using a special interface Component called an analog to digital A/D Converter
* Analog to digital Converters Convert an analog voltage input into a digital number output that the microComputer can read.
* At the sample time (tk), the analog to digital Conversion Process begins under Computer Control with several operations. The Computer sends a sample trigger signal to the sample and hold circuit causing it to sample Vin at the sample time tk.
* The Computer also generates a signal that resets the Counter to zero and then sends a signal C to the J-K flip-flop circuit that enables the AND Gate such that the Counter begins Counting clock pulse



* The Counter Contents at time t are the binary equivalent of N where N is the largest integer in the following

$$N = \{ [f_c(t_N - t_K)] \} \quad t_N \le t < t_{N+1}$$

* The ramp voltage $V_r(t)$ for the time interval specified is given by

$$V_r(t) = K_{DA} N$$

* The Comparator output (V_{comp}) is a binary valued voltage, which is given by

$$V_{comp} = V_L \quad V_r < V_K$$
$$= V_H \quad V_r \ge V_K$$

At Coincidence, the ramp voltage is essentially given by

$$V_r(t_c) = V_K$$

* the Computer responds under program Control to read the Counter Contents (N_c) which are the binary equivalent of the number of Clock Pulses N_c Counted from t_K to $t_K + t_c$

A Convenient model for the sensing element resistance (R_{SE}) at temperature (T) is given by

$$R_{SE}(T) = R_0 + K_T \Delta T$$

where, R_0 is the resistance at some reference temperature;

$\Delta T = T - T_{ref}$.

K_T is the resistance / temperature Coefficient.

* For a Conducting sensing element, $K_T > 0$, and for a semiconducting sensing element, $K_T > 0$.
* The output voltage of this amplifier V_0 is connected to the bridge and provides the electrical excitation for the bridge. This voltage is given by

$$V_0 = G(V_1 - V_2)$$

where G is the amplifier voltage gain.

* The differential input voltage ΔV is given by

$$\Delta V = V_1 - V_2$$

$$= V_0 \left[\frac{R_2}{R_1 + R_2} - \frac{R_{SE}}{R_{SE} + R_3} \right]$$

However, it has been shown that $V_0 = G\Delta V$, so the following equation can be shown to be valid

$$\frac{1}{G} = \left[\frac{R_2}{R_1 + R_2} - \frac{R_{SE}}{R_{SE} + R_3} \right]$$

R_{SE} is given approximately by

$$R_{SE}(T) = \frac{R_2 R_3}{R_1}$$

The temperature difference between the sensing element and the ambient air is given approximately by

$$K_T \Delta T = \frac{R_2 R_3}{R_1} \cdot [R_0 + K_T (T_a - T_{ref})]$$

where, T_{ref} is an arbitrary reference temperature

* In one such method, R_3 is made with the same material but possibly with a different structure as the sensing element such that its resistance is given by

$$R_3(T_a) = R_{30} + K_{T_3} (T_a - T_{ref})$$

where, R_{30} is the resistance of R_3 at $T_a = T_{ref}$ and K_{T_3} is the temperature coefficient of R_3.

* The sensing element temperature difference ΔT is,

$$K_T \Delta T = \left(\frac{R_2 R_{30}}{R_1} - R_0\right) + \left(\frac{R_2}{R_1} K_{T_3} - K_T\right) (T_a - T_{ref})$$

If the sensor designed such that

$$\frac{R_2 K_{T_3}}{R_1} = K_T$$

then ΔT is independent of T_a & given by

$$\Delta T = \frac{1}{K_T} \left[\frac{R_2 R_{30}}{R_1} - R_0\right]$$

An approximate model for the dynamic response of ΔT to changes in M_a is given by

$$\Delta T + \frac{\Delta T}{\tau_{SE}} = \alpha_1 P_{SE} - \alpha_2 M_a$$

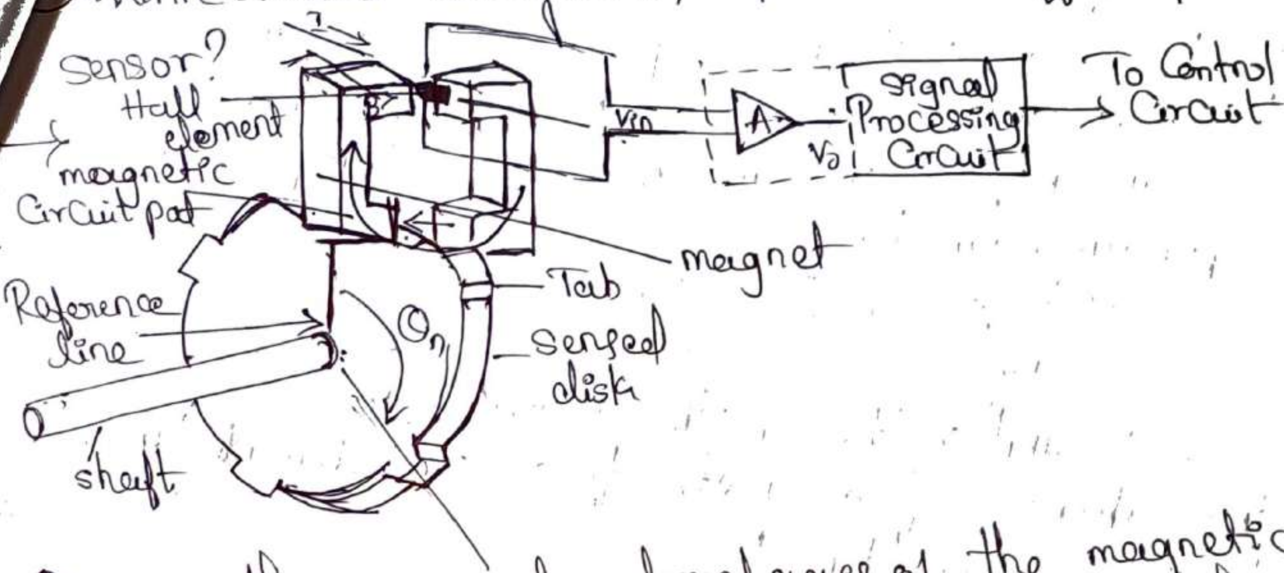
where $P_{SE} = i_2^2 R_{SE}$

$$= \left(\frac{V_0}{R_{SE} + R_3}\right)^2 R_{SE}$$

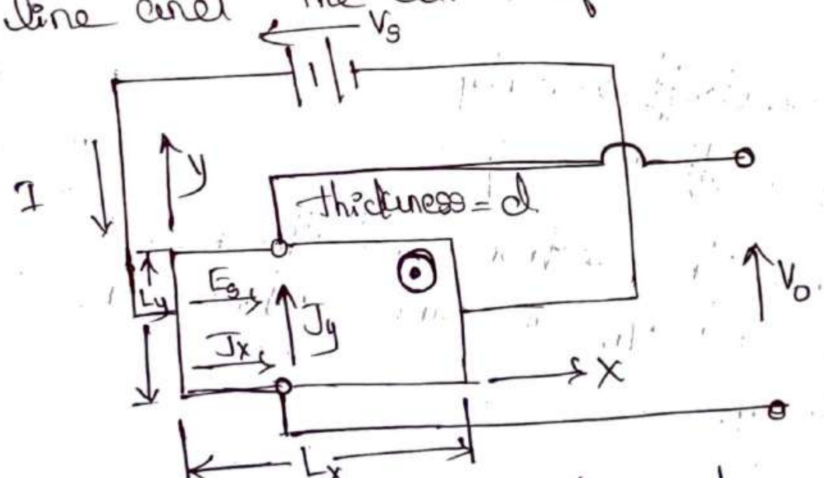
The changes in power dissipation from the zero airflow condition is given by,

$$\alpha_1 [P_{SE}(M_a) - P_{SE}(0)] = \alpha_2 M_a$$

5b. With a neat diagram, Explain Hall effect position sensor?



* One of the main disadvantages of the magnetic reluctance Sensor is its lack of output when the engine is not running. A Crankshaft position sensor can be used to measure either Camshaft position or Crankshaft position. θn is the angle between the reference line and the Center of the nth tab.



A hall element in the form of a semiconductor slab of length L_x, width L_y, and depth d that has an applied Voltage V_s with Current I.

* The electric field intensity $\overline{E_s}$ due to the applied voltage V_s is a function of position in the material, for a relatively long, thin slab of semiconductor it is nearly uniform over much of the sample and given approximately by

$$\overline{E_s} \cong \frac{V_s}{L_x}\hat{x} = E_x\hat{x}$$

where $\hat{x}$ is unit vector in the x direction

* In the absense of magnetic field, the current that would flow given by

$$I = \int_0^{L_y}\int_0^{d} J_x \, dy \, dz$$

where J_x is the current density,

$$J_x = q\left[nV_{ex} + PV_{hx}\right]$$

where,

$V_{ex} = \mu_e E_x$ = electron drift velocity

$V_{hx} = \mu_h E_x$ = hole drift velocity

and where n and p are the electron and the hole concentrations and μ_e and μ_h are the electrons and hole mobilities, respectively.

$$J_y = q\left[PV_{hy} + nV_{ey}\right]$$

The strength of this y directed electric field is,

$$E_y = R_H J_x B_z$$

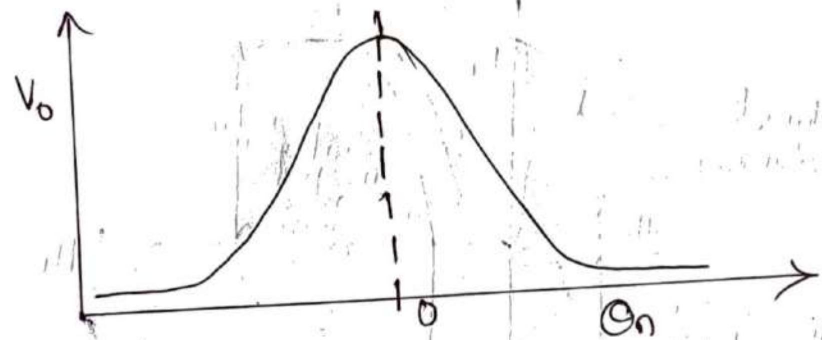
where, R_H is the Hall effect Coefficient.

The terminal voltage of the sensor V_0 is,

$$V_0 = \int_{-L_y/2}^{L_y/2} E_y\, dx$$

$$\cong E_y L_y = R_H J_x B_z L_y$$

Thus, the Hall-effect sensor generates an open circuit voltage that is proportional to the x-directed current density J_x and to the magnetic flux density B_z.



(6)

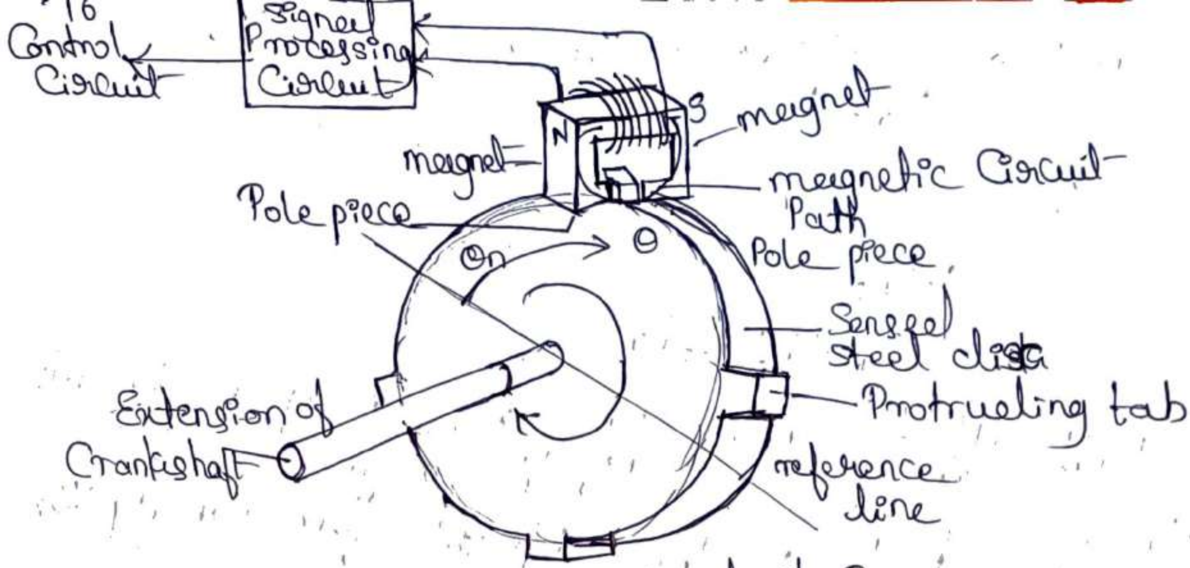
(a) Explain magnetic reluctance position sensor?

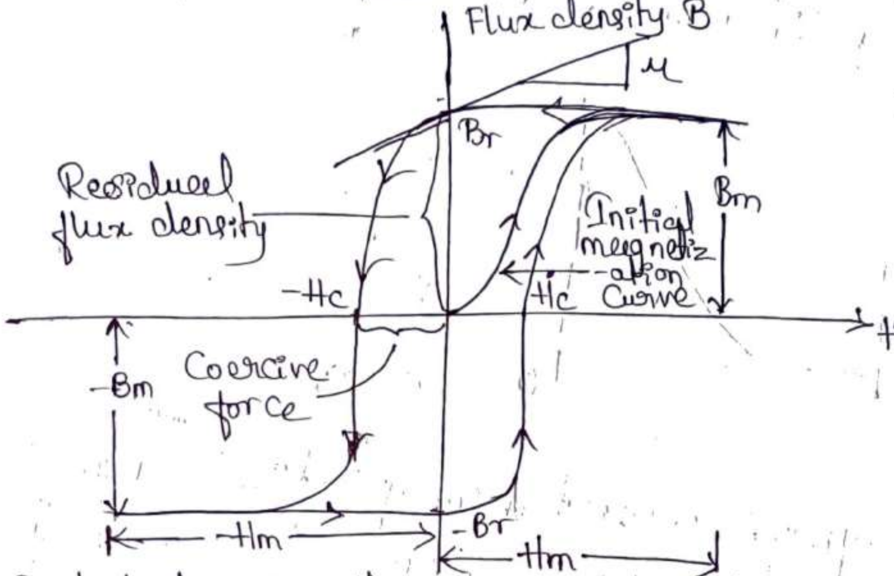
→ * one noncontacting engine sensor configuration that measures crankshaft position directly is illustrated in the below figure.

* This sensor consists of a permanent magnet with a coil of wire wound around it. A steel disk that is mounted on the crankshaft has tabs that pass between the pole pieces of this magnet.

* The crankshaft position Θ at all other times in the engine cycle are given by

$$\Theta - \Theta_n = \int_{t_n}^{t} \omega(t)\,dt \qquad t_n < t < t_{n+1}$$





* The Contribution of the ferromagnetic material to the flux density is Called magnetization M and is given by

$$M = \frac{B}{\mu_0} - H_i$$

where μ_0 is the magnetic permeability of free space

* Normally in automotive sensors, the signals involved correspond to relatively small incremental changes in B and H about a steady value

$$B = B_r + \mu H_i$$

where

$$\mu = \left.\frac{dB}{dH_i}\right|_{H_i=0}$$

= incremental permeability of the ferromagnetic materials.

Incremental permeability is given by

$$\mu = \mu_r \mu_0$$

where μ_0 is the permeability of free space and μ_r is the relative permeability of the material. That equation relates the contour integral of $\bar{H}$ along a closed contour C and is,

$$\oint_C \bar{H} \cdot d\bar{l} = I_T$$

This continuity is expressed by the relation

$$\bar{B}_1 \cdot \hat{n} = \bar{B}_2 \cdot \hat{n}$$

$$\int_C \bar{H} \cdot d\bar{l} \cong H_g g_a + H_m L_m$$

where g_a is the total air gap length along contour C, L_m is the total length along contour C within the material, and C is the closed path along line of constant B.

* The air gap magnetic field intensity H_g is given by

$$H_g \cong -H_m L_m / g_a$$

$$\bar{B}_g \cdot \hat{n}_g = \bar{B}_m \cdot \hat{n}_m$$

The lines of magnetic flux are normal to this interface

$$\bar{B}_g \cdot \hat{n}_g = B_g$$

and $\quad \bar{B}_m \cdot \hat{n}_m = B_m$

or $\quad B_g = B_m$ (at the interface)

$$B_m = \mu_0 (H_m + M_r)$$

$$= B_g$$

$$= \mu_0 H_g$$

where M_r is the remanent magnetization of the pole piece. Thus,

$$H_m = H_g - M_r \qquad M_r >> H_g$$

$$H_g \cong -M_r$$

The flux density is

$$B_g = \mu_0 H_g = \mu_0 \frac{M_r L_m}{g_a}$$

* The terminal voltage V_o is given by the time rate of change of the magnetic flux linking the N turns of the coil:

$$V_o = N\frac{d\phi}{dt}$$

where

$$\phi = \int_{A_c} B\,ds$$

$$= \frac{\mu_0 M_r L_m A_c}{g_a}$$

where $A_c = h_c W_c$

* The flux density magnitude is approximately given by

$$B = \frac{\mu_0 M_r L_m}{g_c}$$

~~where W_c is the width of~~ and g_c is the pole piece gap

$$\phi \approx \frac{\mu_0 M_r L_m h_c W_c}{g_c}$$

W_c is the width of the magnet normal to the page

$$\phi = \frac{\mu_0 M_r L_m h_c W_c}{(g_c - t_1)}$$

$$R = \frac{\mu_0 L_m h_c W_c}{g_a}$$

$$\phi = \tan^{-1}\left(\frac{\omega L_s}{R_s + R_l}\right)$$

On the other hand, an increase in the number of tabs for practical sensor increases the sensor excitation frequency (ω_s) for a given crankshaft angular speed.

$$\phi(\omega_s) = \tan^{-1}\left(\frac{n\omega_s L_s}{R_s + R_l}\right) \quad n = 1, 2, \ldots$$

Q. Explain Electronic Engine Control System?

* An electronic Engine Control System, also known, as an Engine Control unit or Engine Control module, is the Central brain of a modern Car's Engine, managing various functions through electronic Control.
* It monitors Engine performance, fuel injection, emission, and other Critical functions using data form from sensors. The ECU then Controls actuators to optimize engine performance, fuel efficiency, and emissions.
* Fuel injection Controls the amount and timing of fuel delivered to the Engine Cylinders.
* Ignition timing Determines the precis moment when spark plugs fire to ignite the fuel air mixture.
* Air fuel mixture Control maintains the adjusts the ratio of air to fuel to optimize Combustion.
* The ECU receives data from various Sensors, Such as those measuring engine Speed, temperature and air flow. They uses Complex algorithms to analyze the sensor data and determine the optimal Settings for the Engine.
* The ECU sends Control signals to actuators, which then adjust the engine's parameters. Many EECS functions operate in a Closed-loop manner, meaning that the ECU Continuously monitors the Engine's Performance and adjusts the Control signals to maintain optimal Conditions.
* By precisely Controlling the air fuel mixture and ignition timing, EECS Can significantly improved fuel economy.

(a) With neat diagram, Explain Electronic ignition Control System

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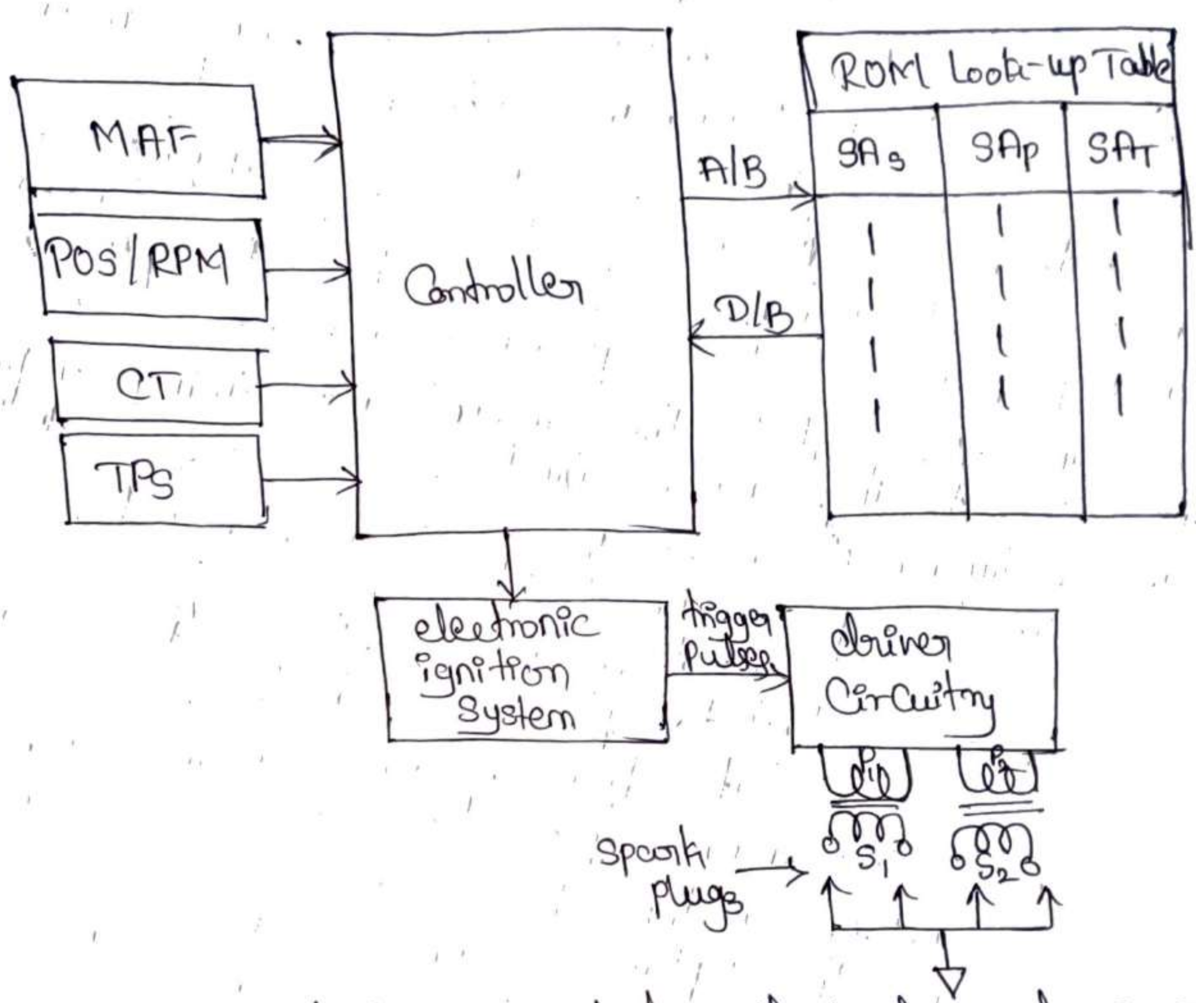
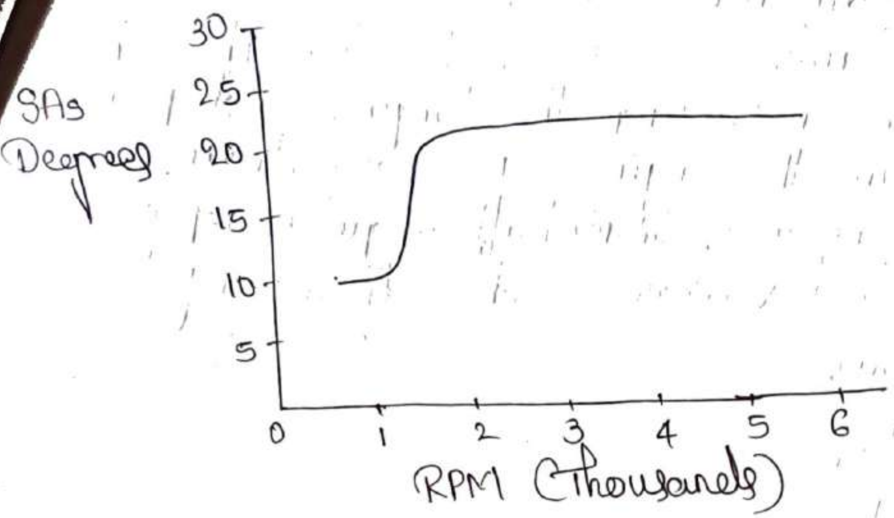


* An Engine must be provided with fuel and air in Correct proportions and the means to ignite this mixture in the form of an electric spark.
* Before the development of Contemporary electronic ignition, the traditional ignition system included spark plugs, a distributor, and a high voltage ignition Coil.
* The distributor would Sequentially Connect the Coil output high voltage to the Correct spark Plug.



* The Coil driver Circuits generate the primary Current in windings P_1 and P_2 of the Coil packs depicted. These primary Currents build up during the so-called dwell period before the spark is to occur.
* The process of spark generating for ignition process purposes was explained. a Configuration would be appropriate for a 4 Cylinder engine. Normally, there would be one Coil pack of for each pair of Cylinders or possibly for each Cylinder.
* In a typical electronic ignition Control System, the total spark advance, SA is made up of several Components that are added together:

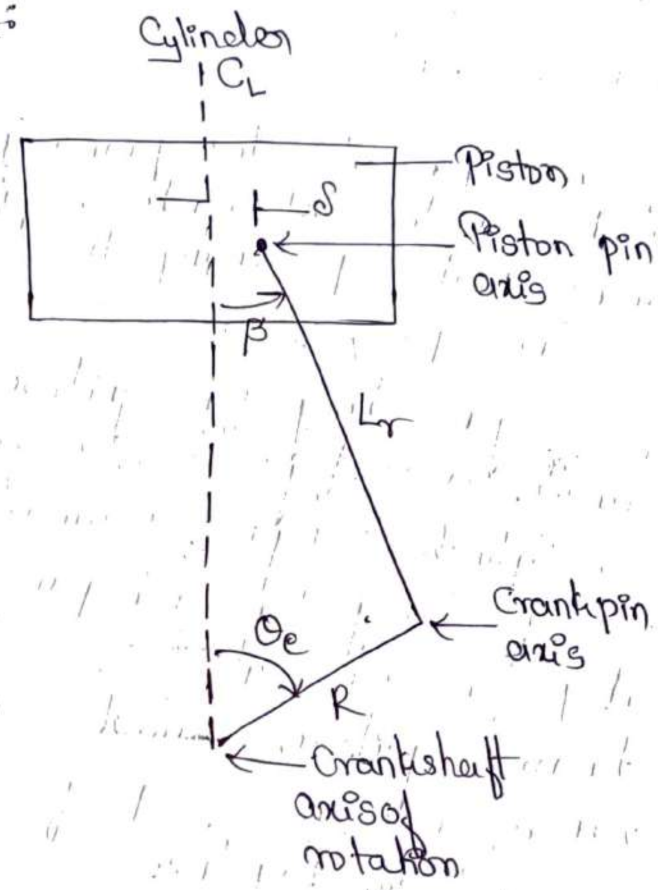
$$SA = SA_S + SA_P + SA_T$$

* The first Component, SA_S, is the basic spark advance, which is a tabulated function of RPM and MAP or MAF.

(7) b. Define Engine performance terms?

→ Several Common terms are used to describe an engine's performance, including the torque and power at various places in the engine and powertrain as well as Cylinder pressure, Crankshaft angular speed, fuel Consumption and various Combinations of these as Explained below.

(i) <u>Torque</u>:



* Engine torque is produced on the Crankshaft by the Cylinder pressure pushing on the piston during the Power stroke. In an IC, engine torque is produces at the Crankshaft as explained below. The torque that is applied to the Crankshaft is Called "indicated torque T_i".

The piston pin offset from the Cylinder C_L is denoted δ in figure. The angle between the Connecting rod Plane of Symmetry and the Cylinder axis is denoted β. Owing to the piston offset, the indicated torque for a piston on the down stroke is given by

$$T_i(\theta_e) = \frac{P_c(\theta_e) AR \sin(\theta_e + \beta)}{\cos\beta} \quad 0 \leq \theta_e < \pi$$

On the up stroke T_i is given by

$$T_i(\theta_e) = \frac{P_c(\theta_e) AR \sin(\theta_e - \beta)}{\cos\beta} \quad \pi \leq \theta_e < 2\pi$$

where A is the piston cross-sectional area. The factors $R[\sin(\theta_e \pm \beta)]/\cos\beta$ represent the lever arm through which torque is applied to the Crankshaft. $\overline{T_i} > 0$

(ii) Power:

One of the most important metrics for engine performance is output power. This power is related to the indicated torque applied to the Crankshaft. The instantaneous Power applied to the Crankshaft by the indicated torque is known as the indicated power ($P_i[\theta_e(t)]$), given by

$$P_i(t) = T_i(t)\, \omega_e(t)$$

where $\omega_e(t) = \frac{d\theta_e}{dt}$ in rad/sec.

$$\overline{P_i}(N) = \frac{1}{4\pi N}\int_0^{4\pi N} P_i(\theta_e)\, d\theta_e \quad N = \text{integer}$$

The brake power P_b is given by

$$P_b = \overline{P_i} - P_{fp}$$

$$T_b = P_b / \omega_e$$

As in the Case of torques, it is Convenient to Consider the indicated mep which is defined as

$$imep = \frac{W_i}{V_D}$$

where, $V_D = V_1 - V_2$ is displacement, V_1 the Cylinder maximum volume & V_2 the Cylinder minimum volume at TDC.

$$fmep = \frac{W_f}{V_d}$$

where W_f is the work done by the friction torque. The most Commonly used mep is the brake mep (bmep), which is defined as

$$bmep = imep - fmep$$

It has the units of pressure and is the value of Constant-Pressure acting over a full engine Cycle to produce the output mechanical work / Cycle.

(iii) Fuel Consumption:

Fuel economy Can be measured while the delivers Power to the dynamometer. BSFC is a measurment of the fuel economy of the engine alone and is,

$$BSFC = \frac{\dot{f}}{P_b}$$

$$V_d = A_p S_c$$

$$e_v = \frac{2M_i}{N V_d P_i}$$

$$V_i = \frac{\dot{M}_i}{P_i}$$

$$= \frac{\dot{M}_a}{P_a}$$

$$P_i = P_a + P_f + P_w$$

$$P_k = \frac{P_k}{RT_i}$$

$$\frac{P_a}{P_i} = \frac{M_a / m_a}{\left[\frac{M_a}{m_a} + \frac{M_f}{m_f} + \frac{M_w}{m_w}\right]}$$

where M_k = mass of Constituent k & m_k = molecular mass of Constituent k;

$k = a, f, w$

Ther air density in the mixture ρ_a is given by

$$\rho_a = \left(\frac{P_i}{RT_i}\right) \Big/ \left[1 + F_i\left(\frac{m_a}{m_f}\right) + \frac{m_a}{m_w} h\right]$$

where $F_i = \frac{M_f}{M_a}$ is the fuel/air mass ratio, h the ratio of mass water vapor to the mass of air, $m_a = 29$, & $m_w = 18$

(iv) Engine overall Efficiency:

One of the most meaningful ways to characterize the Performance of an engine as indicated of these is the efficiency with which the engine Convert the energy available in the fuel to mechanical work.

$$\eta_m = P_m / (CQ_f M_f)$$

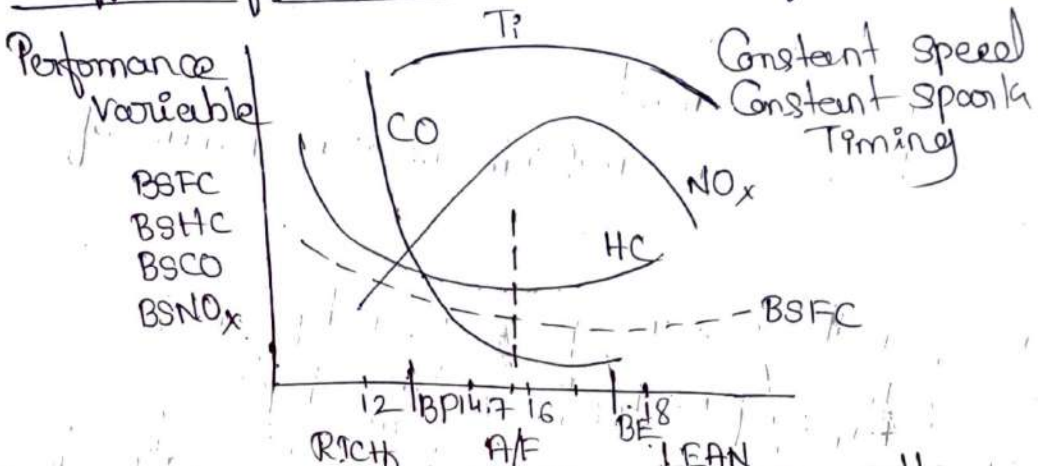
(v) Calibration:

The defination of engine Calibration is the setting of the air/fuel ratio and ignition timing for the engine for any given operating Condition. with the new electronic Control Systems, Calibration is determined by the electronic engine Control System.

(vi) Engine mapping:

The development of any Control System comes from knowledge of the plant, or system to be Controlled In the Case of the automobile engine, this knowledge of the plant Comes Primarily from a process Called engine mapping

(vii) Effect of Air/Fuel Ratio on performance



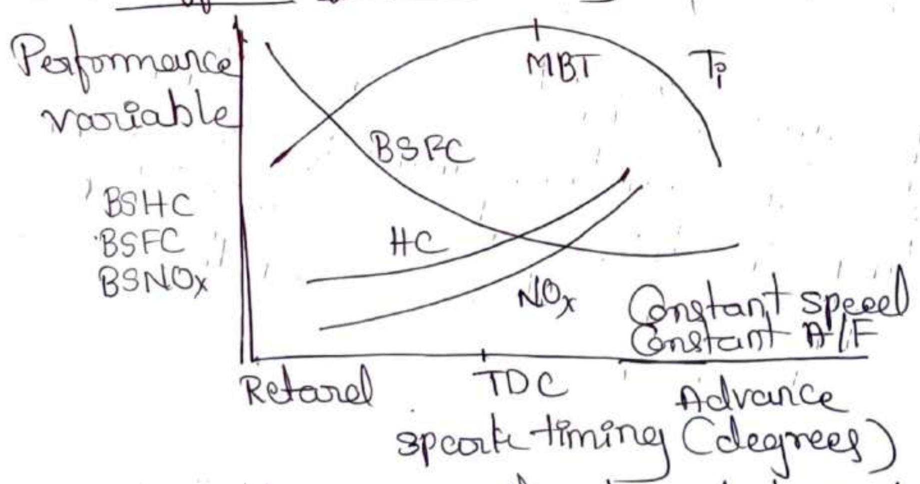
BSHC = brake specific HC Concentration $= \frac{rHC}{P_b}$

BSCO = brake-specific CO Concentration $= \frac{rCO}{P_b}$

BSNOx = brake specific NOx Concentration $= \frac{rNOx}{P_b}$

$$\lambda = \frac{(air/fuel)}{(air/fuel @ stoichimetry)}$$

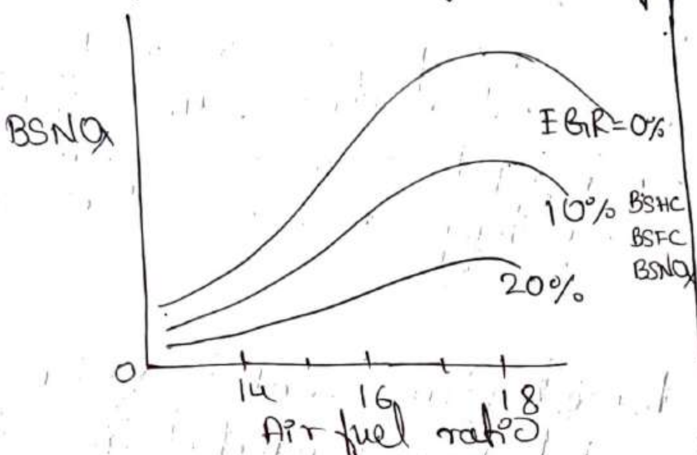
(viii) Effect of spark Timing on performance.

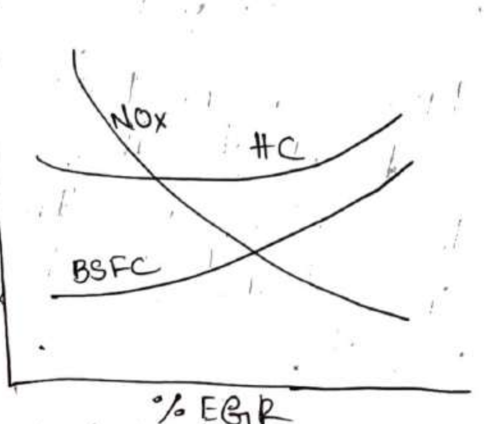


* Spark advance is the time before top dead Center (TDC) when the spark is initiated. It is usually expressed in number of degrees of Crankshaft rotation relative to TDC.

Effect of Exhaust Gas Recirculation on performance

Up to this point in the discussion, only the traditional Calibration parameters of the engine have been Considered.





⑧ a. With neat diagram explain digital Cruise Control System?

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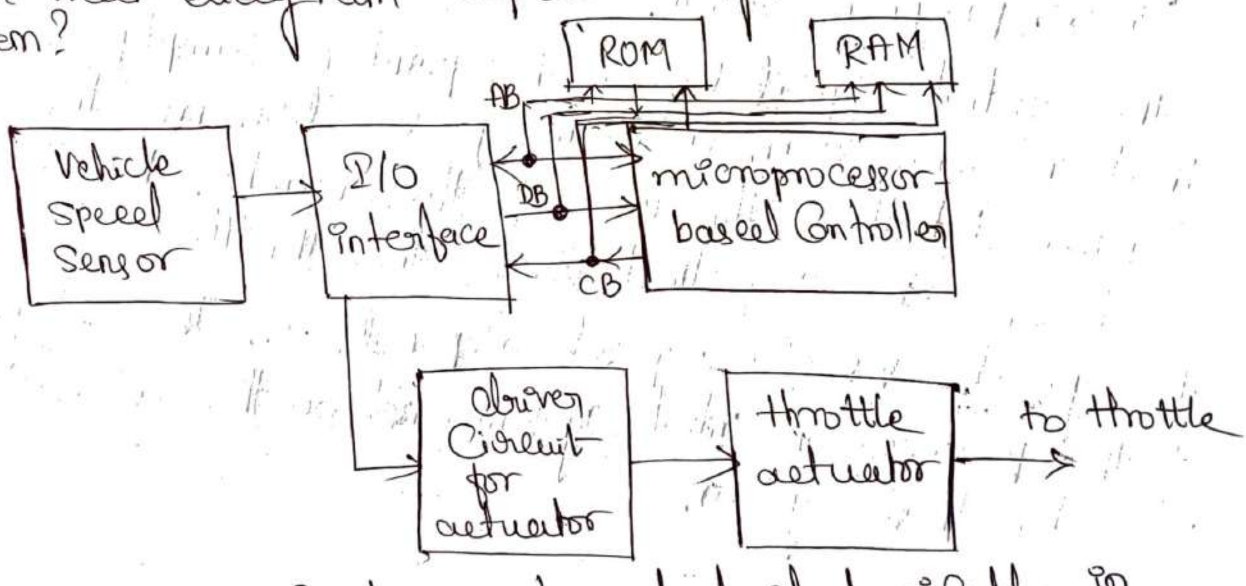


* Cruise Control Can be implemented electronically in various ways, including with a microController, with special purpose digital electronics or with analog electronics. It Can also be implemented with an electromechanical speed governor.
* The ~~phy~~ system has a digital Controller that is often Called a microController since it is implemented with a microprocessor operating Under program Control that is

Part of the design. The actual program that causes the various calculations to be performed is stored in read only memory (ROM).

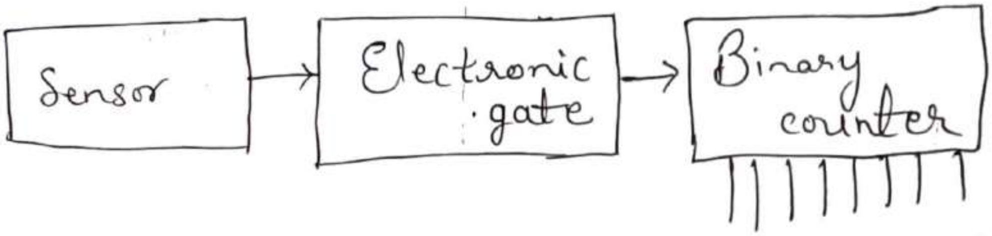
* Typically the ROM also stores parameters that are critical to the correct calculations. In addition, the system uses RAM memory to store the command speed and to store any temporary calculation result.

* A microprocessor-based cruise control system performs all of the required control law computations digitally under program control.

* The control signal u_n at this point is simply a number that is stored in a memory location in the digital controller. The use of this number by the electronic circuitry that drives the throttle actuator to regulate vehicle speed depends on the configuration of the particular control system and on the actuator used by that system.

b. With neat diagram explain throttle actuator?

→



Digital speed measurement

* Throttle actuator is an electromechanical device in response to an electrical input from the controller.
* Moves throttle through some appropriate mechanical linkage.
* Two relatively common throttle actuators operates either from manifold vaccum or with a stepper motor.
* Pneumatic piston arrangement is driven from intake manifold vaccum.

9a. Explain accelerometer based airbag system

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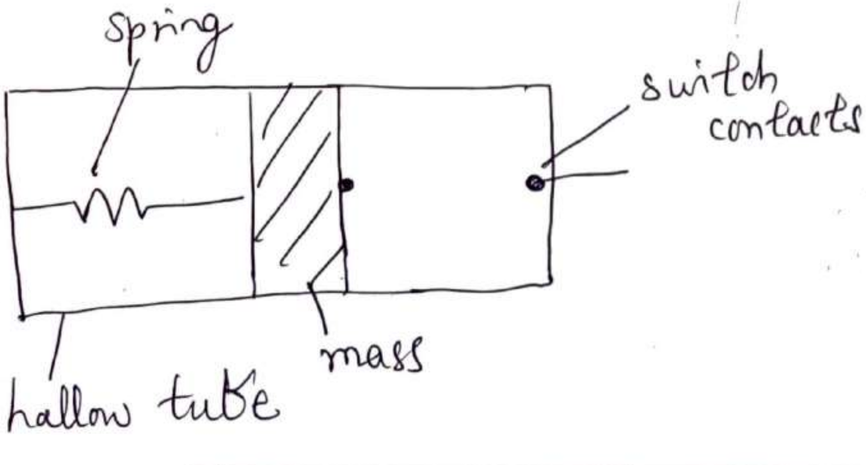
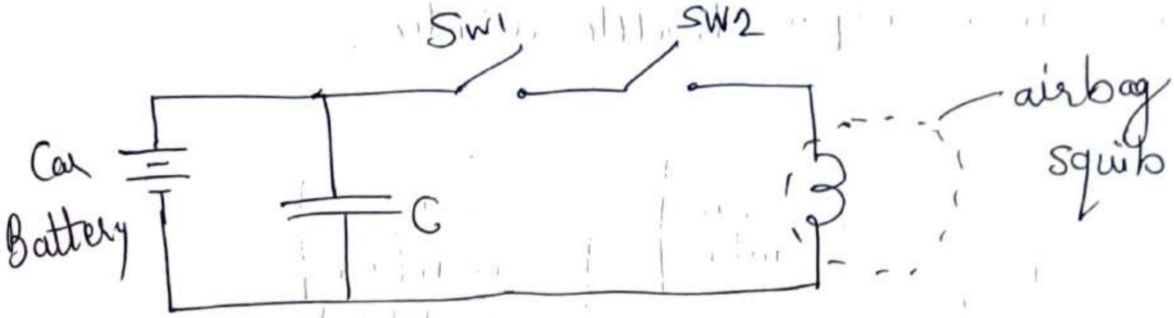
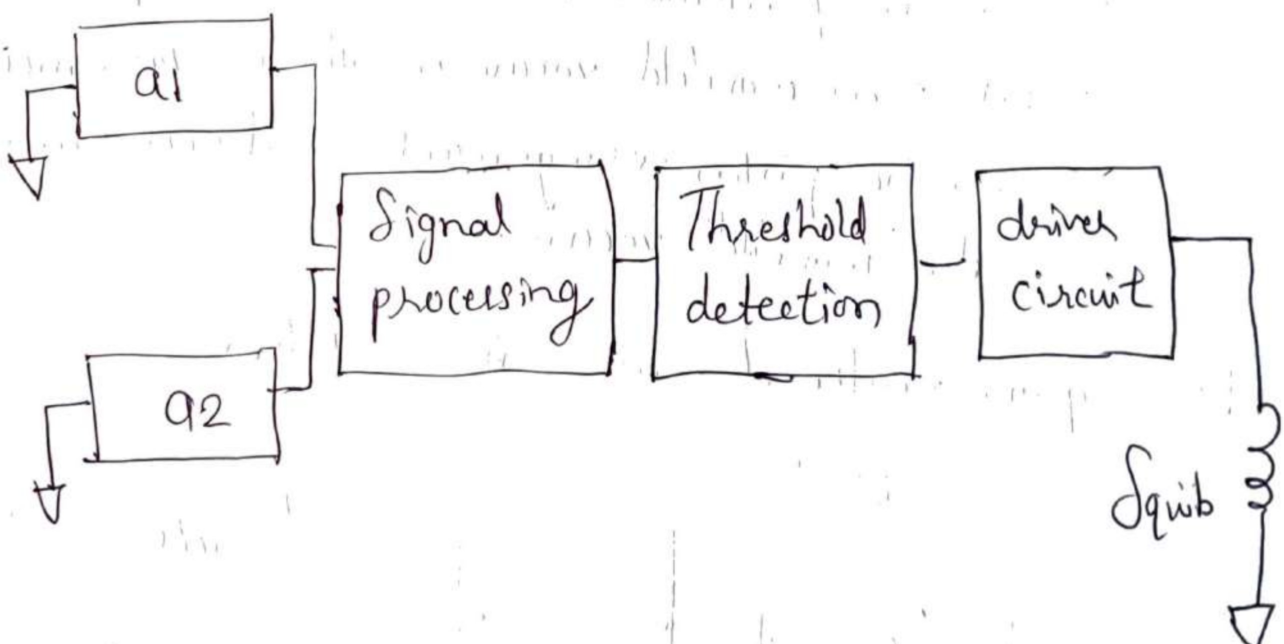




* Air bags work when crash is detected.
* Acts as a cushion to protect the passangers:
* It uses switches SW1 & SW2.
* Mass moves forward during crash & closes switch
* Backup capacitor ensures deployment even if battery is damaged.



6.) Explain collision avoidance Radar warning System?

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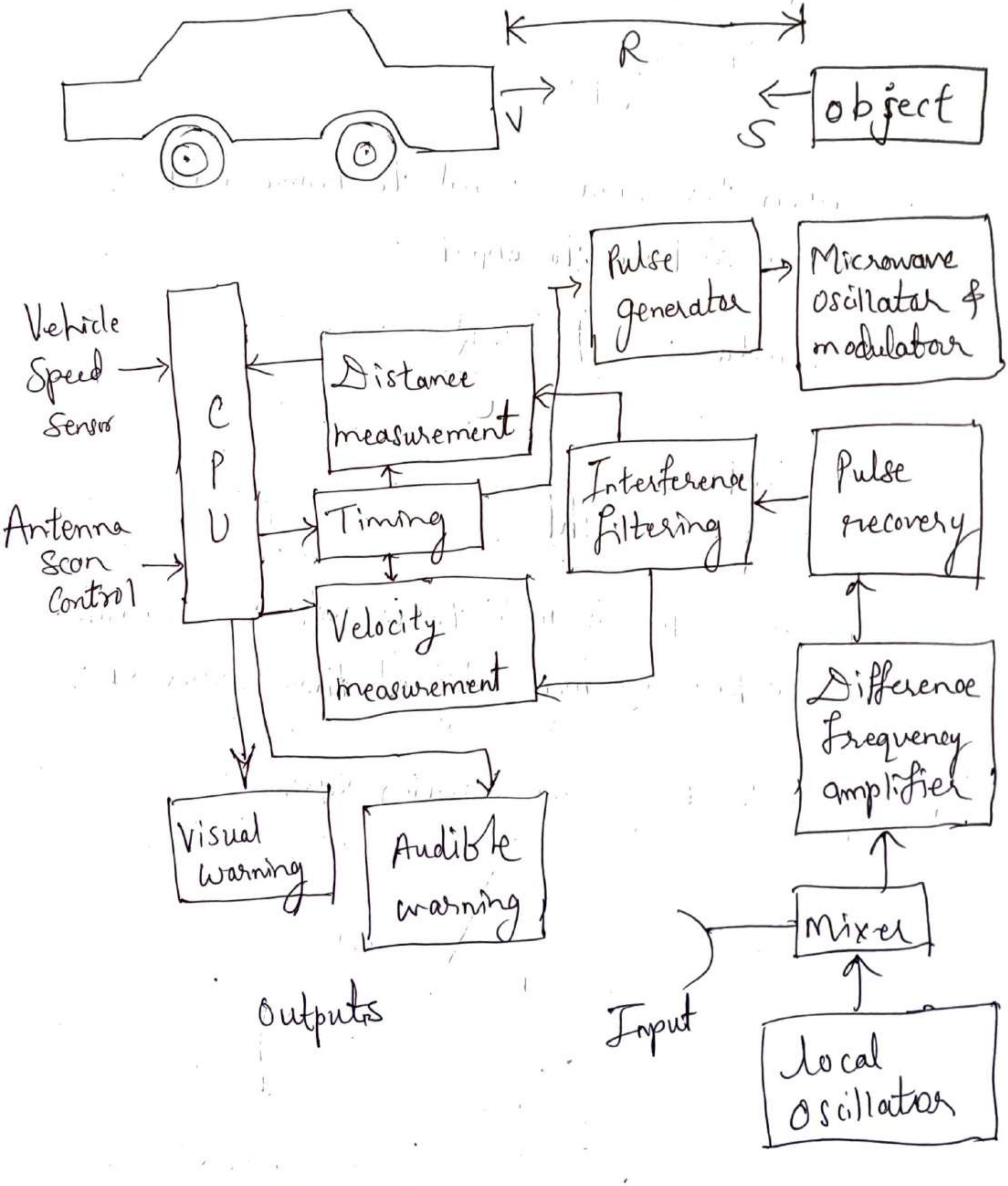


* CPU controls the system to avoid collisions.
* If object is stationary, time is calculated as

$$T = R/(V+\delta)$$

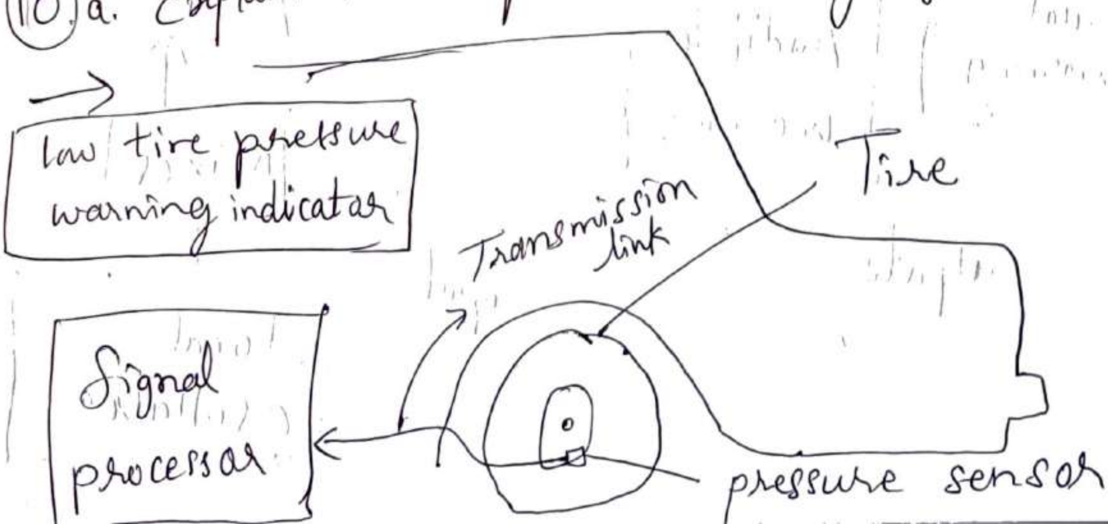
* Time taken for radar signal to bounce back determines distance to object.

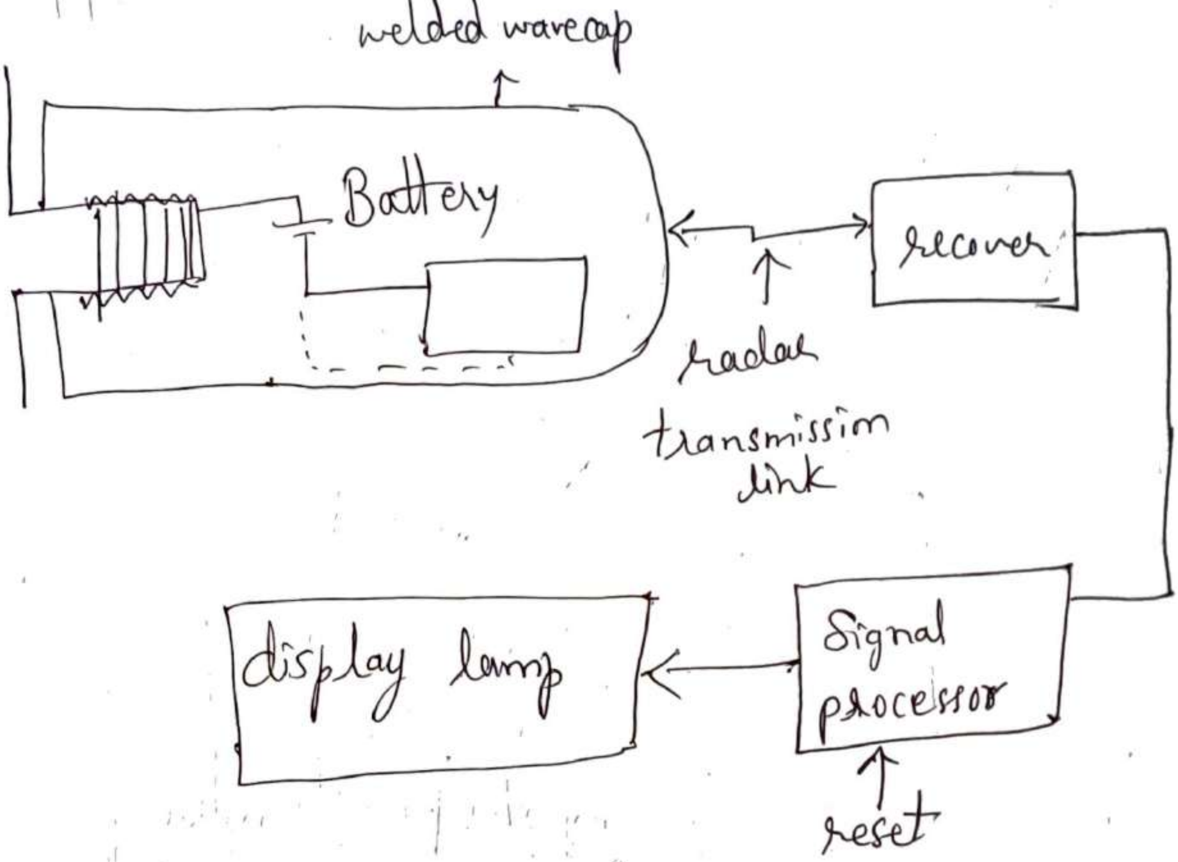
Formula = $t = \frac{2R}{C}$

R = distance
C = speed of light

* System uses steering angle to estimate road curvature.
* Now, systems are more advanced than earlier systems.

(10) a. Explain low tire pressure warning system?





* If low pressure is there in tire, system alerts the driver.
* When pressure is below critical threshold, the sensor triggers a wireless signal & sends it to a receiver.
* Signal processor activates warning light.
* Mini radio transmitter mounted in tire valve cap or inside tire, which transmites data over a short range to the receiver.

(10) b. Explain automotive GPS navigation system - Signpost navigation

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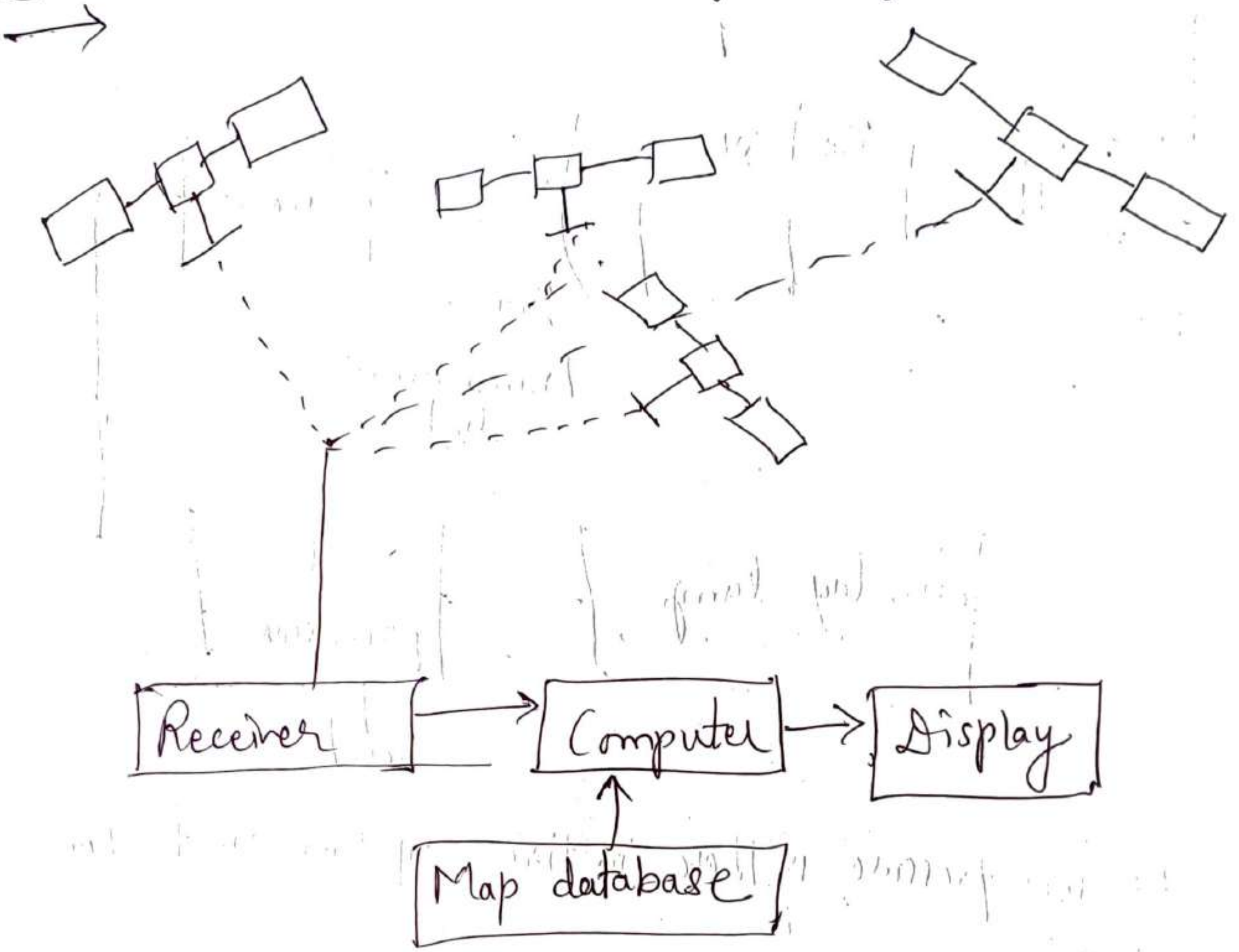

- Signpost navigation

* Uses roadside information station called signposts placed across the road network.
* Each signpost transmits its geographic location continuously
* Drawbacks are No position update b/w signposts, delayed turn instruction, needs dense infrastructure, complex coding.