1. What is Mason's Gain formula?

Mason's gain formula states that the overall gain of the system [transfer function] as follows,

Overall gain, $T = \frac{1}{\triangleleft}\sum_{K} P_K \triangleleft_K$

T = Transfer function of the system

K = Number of forward paths in the signal flow graph

P_K = Forward path gain of the Kth forward path

$\triangleleft_K$ = $\triangleleft$ for the part of the graph which is not touching the kth path.

2. What is a signal flow graph?

A signal flow graph is a diagram that represents a set of simultaneous linear algebraic expressions. By taking laplace transform, the time domain differential equations governing a control system can be transferred to a set of algebraic equations in the s-domain.

3. Compare open loop and closed loop system:

Open loop system	Closed loop system
1. Inaccurate and unreliable 2. Simple and economical 3. Changes in output due to external disturbances are not corrected automatically. 4. They are generally stable	1.Accurate and reliable 2. Complex and costly 3.Changes in output due to external disturbances are corrected automatically. 4. Great efforts are needed to design a stable system.

4. What is called feedback control system? Give an example:

The feedback is a control action in which the output is samples and a proportional signal is given to input for automatic correction of any changes in desired output.

Example: Open loop control system

Closed loop control system

5. Define block diagram and write its basic components:

A block diagram of a system is a pictorial representation of the functions performed by each component of the system and shows the flow of signals.

The basic components are block, branch point, summing point.

6. Compare mechanical translational and rotational systems:

Mechanical translational system	Mechanical rotational system
1. **Translational mechanical systems** move along a straight line. 2.These **systems** mainly consist of three basic elements. Those are mass, spring and dashpot or damper.	**1.Rotational mechanical systems** move about a fixed axis. 2.These **systems** mainly consist of three basic elements. Those are moment of inertia, torsional spring and dashpot.

7. Outline the effect of adding a pole and zero to a open loop system:

The addition of pole to a open loop transfer function of a system will reduce the steady-state error. The closer the pole to the origin lesser will be the steady-state error. Thus steady state performance of the system is improved.

The addition of zero to a open loop transfer function of a system will improve the transient response. The addition of zero reduces the rise time.

8. Define steady state error and list the steady state error constants:

The steady state error is the value of error signal e(t), when t tends to infinity. The steady state error is a measure of system accuracy. These errors arise from the nature of inputs, type of system and from non-linearity of system components.

steady state error constants are: k_p, k_v, k_a.

9. Define damping ratio and classify the system based on damping ratio:

The damping ratio is defined as the ratio of actual damping to critical damping.

Case1: un damped system, ʒ=0

Case2: under damped system, 0< ʒ<1

Case3: critically damped system, ʒ=1

case4: over damped system, ʒ>1

10. Compare P, PI,PID:

P-CONTROLLER:

Output power is directly proportional to control error.

The higher the proportion coefficient, the less the output power at the same control error.

Proportional control can be recommended for fast-response systems with a large transmission coefficient.

PI- CONTROLLER:

Output power equals to the sum of proportion and integration coefficients.

The higher the proportion coefficient, the less the output power at the same control error.

The PI control disadvantage is slow reaction to disturbances.

PID-CONTROLLER:

Output power equals to the sum of three coefficients: proportional, integral and differential.

The higher the proportion coefficient, the less the output power at the same control error.

The PID controller is used in inertial systems with relatively low noise level of the measuring channel.

11.Compare phase lead and phase lag compensator:

Lead and lag compensators are used quite extensively in control. A lead compensator can increase the stability or speed of reponse of a system; a lag compensator can reduce (but not eliminate) the steady-state error. Depending on the effect desired, one or more lead and lag compensators may be used in various combinations.

Lead, lag, and lead/lag compensators are usually designed for a system in transfer function form.

12. Define rise time and peak time:

Rise time:

It is the time taken for response to raise from 0 to 100%, the very first time. For damped system, the rise time is calculated from 0 to 100%. But for over damped system it is the time taken by the response to raise from 10% to 90%. For critically damped system, it is the time taken for response to raise from 5% to 95%.

Peak time:

It is the time taken for the response to reach peak value, the very first time (or) it is the time taken for the response to reach peak overshoot, M_P.

13.List standard test signal in time domain analysis:

There are four types of typical **test signals**:

Impulse Step

Ramp signal

Parabolic

sinusoidal **signal**.

14. What is a compensator? List its types:

A device inserted into the system for the purpose of satisfying the specifications is called compensator.

The different types of compensators are:

1. Lag compensator

2. Lead compensator

3. Lag-lead compensator.

15. Define gain and phase margin:

The gain margin, k_g is defined as the value by which gain of the system has to be increased to drive system to be verge of instability.

$$k_g = \frac{1}{|G(jw)|_{w=w_{pc}}}$$

The phase margin, ϒ= 180 + Φ_{gc}.

16.Define corner frequency:

The magnitude plot can be approximated by asymptotic straight lines. The frequencies corresponding to the meeting point of asymptotes are called corner frequency. The slope of the magnitude plot changes at every corner frequency.

17. What do you mean by type and order of a system:

TYPE:

The type of a system is defined as the number of poles at the origin.

ORDER:

The order of the system is given by the order of the differential equation governing the system. It is also given by the maximum power of s in the denominator polynomial of transfer function. The maximum power of s also gives the number of poles of the system and so the order of the system is given by number of poles of the transfer function.

18. What is BODE plot?

The BODE plot is a frequency response plot of the transfer function of a system.

It consists of two plots namely: Magnitude plot and Phase plot.

19. What is polar plot?

The polar plot of a transfer function G(jw) is a plot of the magnitude of G(jw) versus the phase angle/ argument of G(jw) on polar or rectangular co-ordinates as 'w' is varied from zero to infinity.

20. List the frequency domain specifications:

1. Phase margin

2.Gain margin

3.Resonant peak

4. Bandwidth

21. What will be the stability of the system when the roots of characteristic equation are lying on imaginary axis , left and right of s plane.

22. Define Nyquist stability criterion:

If G(s)H(s)-contour in the G(s)H(s) plane corresponding to Nyquist contour in s-plane encircles the point -1+j0 in the anti-clockwise direction as many times as the number of right half s-plane poles G(S)H(s). Then the closed loop system is stable.

23. How will you find the root locus on real axis:

To find the root locus on real axis, choose a test point on real axis, If the total number of poles and zeros on the real axis to the right of the test point is odd number, then the test point lies on the root locus. If t is even then the test point does not lie on the root locus.

24.Define Routh Hurwitz criterion:

Routh criterion states that the necessary and sufficient condition for stability is that all of the elements in the first column of the Routh array should be positive. If this condition is not met, the system is unstable and the number of sign changes in the elements of the first column of Routh array corresponds to the number of roots of characteristic equation in the right half of the s- plane.

25. Define BIBO stability:

A linear relaxed system is said to have BIBO stability if every bounded (finite) input results in a bounded (finite) output.

The requirement for BIBO stability is, $\int_0^\infty m(t)dt < \infty$, where m(t) is the impulse response of the system.

26. What is relative stability?

Relative stability is the degree of closeness of the system, it and indication of strength or degree of stability.

27.What is dominant pole?

The dominant pole is a pair of complex conjugate pole which decides transient response of the system. In higher order systems the dominant pole are very close to origin and all the other systems are widely seperated and so they have less effect on transient response of the system.

28. Advantages of state variable analysis:

- It can be applied to non linear system.
- It can be applied to tile invariant systems.
- It can be applied to multiple input multiple output systems.
- Its gives idea about the internal state of the system.

29. How do we define state and state vector:

STATE:

The state is the condition of a system at any time instant 't'.

STATE VECTOR:

The state vector is a (n*1) column matrix (or vector) whose elements are state variables of the system,(where n is the order of the system). It is denoted by X(t).

30. What is sample and hold circuit?

In electronics, a **sample and hold** (also known as **sample** and follow) **circuit** is an analog device that **samples** (captures, takes) the voltage of a continuously varying analog signal and holds (locks, freezes) its value at a constant level for a specified minimum period of time.

31. Define observability and controllability of the system:

OBSERVABILITY:

A system is said to be completely observable if every state X(t) can be completely identified by measurements of the output Y(t) over a finite time interval.

CONTROLLABILITY:

A system is said to be completely state controllable, if it is possible to completely transfer the system state from any initial state $X(t_0)$ at any other excited state X(t), in finite specified by a control vector U(t).

32. List the properties of state transition matrix:

$$\Phi(0) = e^{A*0} = I$$
$$\Phi(t) = e^{At} = (e^{-At})^{-1} = [\Phi(-t)]^{-1}$$
$$\Phi(t_1 + t_2) = e^{At_1} e^{At_2} = \Phi(t_1)\Phi(t_2) = \Phi(t_2)\Phi(t_1)$$

33. Write the state space representation equations:

34. State sampling theorem:

Sampling theorem states that a band limited continuous-time signal with highest frequency fm, hertz can be uniquely recovered from its samples provided that the sampling rate Fs is greater than or equal to 2 fm samples per second.

35 Write the electrical analogous equations:

1. MASS:

$$F = Mdx^2 x / dt^2$$

2. DASHPOT:

$F = Bdx/dt$

3. SPRING: $F = kx$