Dynamics of machinery: Two Marks – Question & Answer.: UNIT -I

1. What do you mean by inertia?

The property of matter offering resistance to any change of its state of rest or of uniform motion in a straight line is known as **inertia.**

2. Define inertia force?

The inertia force is an imaginary force, which when acts upon a rigid body, brings it in an equilibrium position.

Inertia force = - Acceleration force = - m. a

3. State D' Alembert's principle?

D' Alembert's principle states that the inertia forces and torques, and the external forces and torques acting on a body together result in statically equilibrium.

4. State the principle of superposition?

The principle of superposition states that for linear systems the individual responses to several disturbances or driving functions can be superposed on each other to obtain the total response of the system.

5. Define: piston effort?

Piston effort is defined as the net or effective force applied on the piston, along the line of stroke. It is also known as effective driving force (or) net load on the gudgeon pin.

6. Define crank effort and crank-pin effort?

* **Crank effort** is the net effort (force) applied at the crank pin perpendicular to the crank, which gives the required turning moment on the crankshaft.

* The component of force acting along the connecting rod (F_Q) perpendicular to the crank is known as **crank-pin effort**.

7. What do you mean by correction couple or error in torque?

The error in torque (T_C) is given by

$$T_C = ml_1(l - L)\alpha$$

This couple must be applied, when the masses are placed arbitrarily to make the system dynamically equivalent

8. What is meant by turning moment diagram or crank effort diagram?

* It is the graphical representation of the turning moment or crank effort for various position of the crank

* In turning moment diagram, the turning moment is taken as the ordinate (Y-axis) and crank angle as abscissa (X-axis).

9. Define inertia torque?

The inertia torque is an imaginary torque, which when applied upon the rigid body, brings it in equilibrium position. It is equal to the acceleration couple in magnitude but opposite in direction.

10. Explain the term maximum fluctuation of energy in flywheel?

The different between the maximum and the minimum energies is known as maximum fluctuation of energy

ΔE = Maximum energy – Minimum energy

11. Define coefficient of fluctuation of energy.

It is the ratio of maximum fluctuation of energy to the work done per cycle.

$$C_E = \frac{\text{Maximum fluctuation of energy}(\Delta \text{E})}{\text{Workdone per cycle}}$$

12. What is meant by maximum fluctuation of speed?

The difference between the maximum and minimum speeds during a cycle is called maximum fluctuation of speed.

13. Define coefficient of fluctuation of speed?

The ratio of the maximum fluctuation of speed to the mean speed is called the coefficient of fluctuation of speed (C_S).

$$C_S = \frac{N_1 - N_2}{N} = \frac{2(N_1 - N_2)}{(N_1 + N_2)}$$

Where N_1 = Maximum speed

N_2 = Minimum speed, and

N = Mean speed = $\frac{N_1 + N_2}{2}$

14. Define coefficient of steadiness?

The reciprocal of the coefficient of fluctuation of speed is known as coefficient of steadiness (m)

$$m = \frac{1}{C_S} = \frac{N}{N_1 - N_2}$$

15. List out few machines in which fly wheel is used?

Fly wheel is used in:

a) Punching machines, b) Shearing machines,

c) Rivetting machines, and d) Crushing machines.

16. Why flywheels are needed in forging and pressing operations?

In both forging and pressing operations, flywheels are required to control the variations in speed during each cycle of an engine.

17. What is cam dynamics?

Cam dynamics is the study of cam follower system with considering the dynamic forces and torques developed in it.

18. Define unbalance and spring surge?

Unbalance: A disc cam produces unbalance because its mass is not symmetrical with the axis of rotation.

Spring surge: Spring surge means vibration of the retaining spring.

19. Define windup. What is the remedy for camshaft windup?

* Twisting effect produced in the camshaft during the raise of heavy load follower is called as windup

* Camshaft windup can be prevented to a large extend by mounting the flywheel as close as possible to the cam.

20. What are the effect and causes of windup?

The effect of wind up will produce follower jump or float or impact.

Causes of wind up are:

- When heavy loads are moved by the follower,
- When the follower moves at high speed, and
- When the shaft is flexible.

UNIT - II

21. Write the importance of balancing?

If the moving part of a machine are not balanced completely then the inertia forces are set up which may cause excessive noise, vibration, wear and tear of the system. So balancing of machine is necessary.

22. Why rotating masses are to be dynamically balanced?

If the rotating masses are not dynamically balanced, the unbalanced dynamic forces will cause worse effects such as wear and tear on bearings and excessive vibrations on machines. It is very common in cam shafts, steam turbine rotors, engine crank shafts, and centrifugal pumps, etc.

23. Unbalanced effects of shafts in high speed machines are to be closely looked into – Why?

The dynamic forces of centrifugal forces or a result of unbalanced masses are a function the angular velocity of rotation.

i.e., $F_C = m\omega^2 r$

$$\because \omega = \frac{2\pi N}{60}$$

24. Write different types of balancing?

a) Balancing of rotating masses

- Static balancing
- Dynamic balancing

b) Balancing of reciprocating masses.

25. State the conditions for complete balance of several masses revolving in different planes of a shaft?

(a) The resultant centrifugal force must be zero, and

(b) The resultant couple must be zero.

26. Whether grinding wheels are balanced or not? If so why?

Yes, the grinding wheels are properly balanced by inserting some low density materials. If not the required surface finish won't be attained and the vibration will cause much noise.

27. Whether your watch needles are properly balanced or not?

Yes, my watch needles are properly balanced by providing some extra projection (mass) in the opposite direction.

28. Why is only a part of the unbalanced force due to reciprocating masses balanced by revolving mass? (Or)

Why complete balancing is not possible in reciprocating engine?

Balancing of reciprocating masses is done by introducing the balancing mass opposite to the crank. The vertical component of the dynamic force of this balancing mass gives rise to "Hammer blow". In order to reduce the Hammer blow, a part of the reciprocating mass is balanced. Hence complete balancing is not possible in reciprocating engines.

29. Can a single cylinder engine be fully balanced? Why?

- No. A single cylinder engine cannot be fully balanced.
- Because the unbalanced forces due to reciprocating masses $(i.e., m\omega^2 r \cos\theta \;\&\; m\omega^2 r \frac{\cos 2\theta}{n})$ remains constant in direction but varies in magnitude.

30. Differentiate between the unbalanced force caused due to rotating and reciprocating masses?

- Complete balancing of revolving mass can be possible. But fraction of reciprocating mass only balanced.
- The unbalanced force due to reciprocating mass varies in magnitude but constant in direction. But in the case of revolving masses, the unbalanced force is constant in magnitude but varies in direction.

31. Why are the cranks of a locomotive, with two cylinders, placed 90° to each other?

In order to facilitate the starting of locomotive in any position (i.e., in order to have uniformity in turning moment) the cranks of a locomotive are generally at 90° to one another.

32. List the effects of partial balancing of locomotives?

- Variation in tractive force along the line of stroke,
- Swaying couple, and
- Hammer blow

33. Define tractive force?

The resultant unbalanced force due to the two cylinders along the line of stroke, is known as tractive force.

34. Define swaying couple?

The unbalanced force acting at a distance between the line of stroke of two cylinders, constitute a couple in the horizontal direction. The couple is known as swaying couple.

35. The swaying couple is maximum or minimum when the angle of inclination of the crank to the line of stroke (θ) is equal to ………. And …………?

Ans : 45° and 225°

36. Define hammer blow with respect to locomotives?

The maximum magnitude of the unbalanced force along the perpendicular to the line of stroke is known as hammer blow.

37. What are the effects of hammer blow and swaying couple?

- The effect of hammer blow is to cause the variation in pressure between the wheel and the rail, such that vehicle vibrates vigorously.
- The effect of swaying couple is to make the leading wheels sway from side to side.

38. What are the condition to be satisfied for complete balance of in- line engine?

- The algebraic sum of the primary and secondary forces must be zero, and
- The algebraic sum of the couples due to primary and secondary forces must be zero.

39. Why radial engines are preferred?

In radial engines the connecting rods are connected to a common crank and hence the plane of rotation of the various cranks is same, therefore there are no unbalanced primary or secondary couples. Hence radial engines are preferred.

40. What are different types of balancing machines?

- Static balancing machines,
- Dynamic balancing machines, and
- Universal balancing machines.

UNIT - III

41. What are the different types of vibrations?

- Free vibrations,
- Forced vibrations, and
- Damped vibration

42. State different methods of finding natural frequency of a system?

- Equilibrium (or Newton's) method,
- Energy method, and
- Rayleigh method.

43. What is meant by free vibration and forced vibrations?

Free or natural vibrations: When no external force acts on the body, after giving it an initial displacement, then the body is said to be under free or natural vibrations.

Forced vibrations: When the body vibrates under the influence of external force, then the body is said to be under forced vibrations.

44. What do you mean by damping and damped vibration?

Damping: The resistance against the vibration is called damping.

Damped vibration: When there is a reduction in amplitude over every cycle of vibration, then the motion is said to be damped vibration.

45. Define resonance?

When the frequency of external force is equal to the natural frequency of a vibrating body, the amplitude of vibration becomes excessively large. This phenomenon is known as resonance.

46. What are the various types of damping?

(a) Viscous damping (b) coulomb or dry friction damping

(c) Solid or structural damping, and (d) slip or interfacial damping.

47. What is the limit beyond which damping is detrimental and why?

When damping factor ξ > 1, the aperiodic motion is resulted. That is, aperiodic motion means the system cannot vibrate due to over damping. Once the system is disturbed, it will take infinite time to come back to equilibrium position.

48. When do you say a vibration system in under-damped?

The equation of motion of a free damped vibration is given by

$$\frac{d^2x}{dt^2}+\frac{c}{m}\frac{dx}{dt}+\frac{s}{m}x=0$$

If $\frac{s}{m} > \left(\frac{c}{2m}\right)^2$, then radical becomes negative. The two roots k_1 and k_2 are known as complex conjugate. Then the vibration system is known as under-damping.

49. What is meant by critical damping?

The system is said to be critically damped when the damping factor $\varsigma = 1$. If the system is critically damped, the mass moves back very quickly to its equilibrium position within no time.

50. Explain the Dunkerley's method used in natural transverse vibration?

The natural frequency of transverse vibration for a shaft carrying a number of point loads and uniformly distributed load is obtained by Dunkerley's formula.

Dunkerley's formula:

$$\frac{1}{f_n^2} = \frac{1}{(f_{n1})^2} + \frac{1}{(f_{n2})^2} + \frac{1}{(f_{n3})^2} + \ldots\ldots\ldots\ldots + \frac{1}{(f_{ns})^2}$$

f_{n1}, f_{n2}, f_{n3}, etc. = Natural frequency of transverse vibration at each point loads, and

f_{ns} = Natural frequency of transverse vibration of the UDL.

51. Define critical or whirling or whipping speed of a shaft?

The speed at which resonance occurs is called critical speed of the shaft. In other words, the speed at which the shaft runs so that the additional deflection of the shaft from the axis of rotation becomes infinite is known as critical speed.

52. What are the factors that affect the critical speed of a shaft?

The critical speed essentially depends on:

- The eccentricity of the C.G of the rotating masses from the axis of rotation of the shaft,
- Diameter of the disc,
- Span of the shaft, and
- Type of supports connections at its ends.

53. Critical speed of shaft is the same as the natural frequency of transverse vibration. Justify?

We know that critical or whirling speed, $\omega_{cr} = \omega_n$

$$\omega_{cr} = \omega_n = \sqrt{\frac{s}{m}} = \sqrt{\frac{g}{\delta}} \text{ Hz}$$

If N_C is the critical speed in rps, then

$$2\pi N_{cr} = \sqrt{\frac{g}{\delta}} \Rightarrow N_{cr} = \frac{1}{2\pi}\sqrt{\frac{g}{\delta}} = \frac{0.4985}{\sqrt{\delta}} rps$$

Hence proved.

54. What are the causes of critical speed? (Or) Why is critical speed encountered?

The critical speed may occur due to one or more of the following reasons:

- Eccentric mountings like gears, flywheels, pulleys, etc.,
- Bending of the shaft due to self-weight,
- Non-uniform distribution of rotor material, etc.

55. Define torsional vibration?

When the particles of a shaft or disc move in a circle about the axis of the shaft, then the vibrations are known as torsional vibrations.

56. Differentiate between transverse and torsional vibration?

- In transverse vibrations, the particles of the shaft move approximately perpendicular to the axis of the shaft. But in torsional vibrations, the particles of the shaft move in a circle about the axis of the shaft.
- Due to transverse vibrations, tensile and compressive stresses are induced.
- Due to torsional vibrations, torsional shear stresses are induced in the shaft.

57. Define torsional equivalent shaft?

A shaft having diameter for different lengths can be theoretically replaced by an equivalent shaft of uniform diameter such that they have the same total angle of twist when equal opposing torques are applied at their ends. Such a theoretically replaced shaft is known as torsion ally equivalent shaft.

58. State natural frequency of torsional vibration of a simple system?

Natural frequency of torsional vibration, $f_n = \frac{1}{2\pi}\sqrt{\frac{CJ}{Il}}$

Where C = Rigidity modulus of shaft,

I = Mass M.I. of rotor,

J = polar M.I of shaft, and

l = Length of node from rotor.

59. What are the conditions to be satisfied for an equivalent system to that of geared system in torsional vibrations?

Two conditions are:

- The kinetic energy of the equivalent system must be equal to the kinetic energy of the original system.

- The strain energy of the equivalent system must be equal to the strain energy of the original system.

60. What is meant by degrees of freedom in a vibrating system?

The number of independent coordinates required to completely define the motion of a system is known as degree of freedom of the system.

UNIT - IV

61. Define damping ratio or damping factor?

It is defined as the ratio of actual damping coefficient (c) to the critical damping coefficient (C_C)

Mathematically, Damping ratio, $\zeta = \frac{c}{c_c} = \frac{c}{2m\omega_n}$

62. Define logarithmic decrement?

Logarithmic decrement is defined as the natural logarithm of the amplitude reduction factor. The amplitude reduction factor is the ratio of any two successive amplitudes on the same side of the mean position.

63. Give the equation for damping factor ζ and damped frequency ω_d ?

(i)Damping factor, $\zeta = \frac{c}{c_c} = \frac{c}{2m\omega_n}$

(ii) Damped frequency, $\omega_d = f_d = \sqrt{1-\zeta^2} \times \omega_n$

Where c = Damping coefficient,

C_C = Critical damping coefficient, and

ω_n = Natural or Undamped frequency.

64. What is meant by harmonic forcing?

The term harmonic refers to a spring-mass system with viscous damping, excited by a sinusoidal harmonic force.

$F = F_0 \sin\omega t$

65. What is the relationship between frequencies of undamped and damped vibrations?

$$\frac{f_d}{f_n} = \frac{\left(\frac{\omega_d}{2\pi}\right)}{\left(\frac{\omega_n}{2\pi}\right)} = \frac{\omega_d}{\omega_n} = \sqrt{1-\zeta^2}$$

66. What is meant by dynamic magnifier or magnification factor? What are the factors on which it depend?

- It is the ratio of maximum displacement of the forced vibration (X_{max}) to the deflection due to the static force F (x_0)

$$D = \frac{x_{\max}}{x_0} = \frac{1}{\sqrt{\left[1-\left(\frac{\omega}{\omega_n}\right)^2\right]^2 + \left[2\zeta\frac{\omega}{\omega_n}\right]^2}} = \frac{1}{\sqrt{\left(1-r^2\right)^2 + \left(2\zeta r\right)^2}}$$

It depends on: (i) the ratio of circular frequencies($\frac{\omega}{\omega_n}$), and

(ii)the damping factor(ζ)

67. Define transmissibility?

When a machine is supported by a spring, the spring transmits the force applied on the machine to the fixed support or foundation. This is called transmissibility.

68. Define transmissibility ratio or isolation factor?

The ratio of force transmitted (F_T) to the force applied (F) is known astransmissibility ratio

$$\varepsilon = \frac{F_T}{F_0} = \frac{\sqrt{1+\left(2\zeta r\right)^2}}{\sqrt{\left(1-r^2\right)^2 + \left(2\zeta r\right)^2}}$$

Where r = Frequency ratio = ($\frac{\omega}{\omega_n}$)

69. Briefly explain elastic suspension?

When machine components are suspended from elastic members, the vibrational force produced by the machine components will not be transmitted to the foundation. This is called elastic suspension.

70. Specify any two industrial application where the transmissibility effects of vibration are important?

(a) All machine tools, and (b) All turbo machines.

71. What is vibration isolation?

The term vibration isolation refers to the prevention or minimisation of vibrations and their transmission due to the unbalanced machines.

72. Specify the importance of vibration isolation?

When an unbalanced machine is installed on the foundation, it produces vibration in the foundation. So, in order to prevent these vibrations or to minimize the transmission of forces to the foundation, vibration isolation is important.

73. What are the methods of isolating the vibration?

- High speed engines/machines mounted on foundation and supports cause vibrations of excessive amplitude because of the unbalanced forces. It can be minimized by providing "spring-damper" , etc.
- The materials used for vibration isolation are rubber, felt cork, etc. These are placed between the foundation and vibrating body.

74. Give Examples of forced vibrations.

- Ringing of electrical bell
- The vibrations of air compressors, internal combustion engines, machine tools and various other machinery.

75. What are the types of external excitation?

- Periodic forces
- Impulsive forces and
- Random forces.

76. Give the governing equation of damped forced vibrations.

$$\frac{d^2x}{dt^2}+\frac{c}{m}\frac{dx}{dt}+\frac{s}{m}x=\left(\frac{F_0}{m}\right)\sin\omega t$$

77. What are isolating materials?

- Rubber
- Felt
- Cork
- Metallic Springs

78. Define vibration isolation.

The process of reducing the vibrations of machines and hence reducing the transmitted force to the foundation using vibration isolating materials is called vibration isolation.

79. What are the types of isolation?

- Isolation of force
- Isolation of motion.

80. Define Amplitude Transmissibility.

Amplitude transmissibility is defined as the ratio of absolute amplitude of the mass ($x_{\max}$) to the base excitation amplitude(y).

<u>UNIT - V</u>

81. What is the function of Governor?

The function of a governor is to maintain the speed of an engine within specified limits whenever there is a variation of load. Governors control the throttle valve and hence the fuel supply to cater the load variation on engines.

82. How governors are classified?

(a). Centrifugal governors.

- Pendulum type: Example: Watt governor.
- Gravity controlled type: Example: Porter and Proell governors.
- Spring controlled type: Example: Hartnell and Hartung governors.

(b). Inertia governors.

83. Differentiate between governor and flywheel?

SL. NO	Governor	Flywheel
1	The function of a governor is to regulate the mean speed of an engine, when there are variations in the load.	The function of a flywheel is to reduce the fluctuations of speed caused by the engine turning moment during each cycle of operation.
2	It is provided or, prime movers such as engines and turbines.	It is provided on engine and fabricating machines viz., rolling mills, punching machines, shear machines, presses, etc.
3	It works intermittently, i.e., only when there is change in load.	It works continuously from cycle to cycle.
4	It has no influence over cyclic speed fluctuation	It has no influence on mean speed of the prime mover

84. What do you mean by governor effort?

The mean force acting on the sleeve for a given percentage change of speed for lift of the sleeve is known as the governor effort.

85. Define power of a governor?

The power of a governor is the work done at the sleeve for a given percentage change of speed. It is the product of the mean value of the effort and the distance through which the sleeve moves.

Power = Mean effort x Lift of sleeve.

86. What is meant by sensitiveness of a governor?

- The sensitiveness is defined as the ratio of the mean speed to the difference between the maximum and minimum speeds.
- A governor is said to be sensitive, when it really responds to a small change of speed.

87. Define coefficient of sensitiveness?

It is the ratio between range of speed and mean speed

coefficient of sensitiveness = $\frac{N_1 - N_2}{N}$

88. What is meant by hunting?

The phenomenon of continuous fluctuation of the engine speed above and below the mean speed is termed as hunting. This occurs in over-sensitive governors.

89. Explain the term stability of governor?

A governor is said to be stable if there is only one radius of rotation for all equilibrium speeds of the balls within the working range. If the equilibrium speed increases the radius of governor ball must also increase.

90. What is meant by isochronous condition in governors?

A governor with zero range of speed is known as an isochronous governor. Actually the isochronism is the stage of infinite sensitivity. i.e., when the equilibrium speed is constant for all radii of rotation of rotation of the balls within the working range, the governor is said to be in isochronism.

91. Can a Porter governor be isochronous?

For a Porter governor, Maximum speed (N_1)and minimum speed N_2 are given by

$$(N_1)^2 = m + \frac{m}{2}(1+q) \times \frac{895}{h_1}$$

$$(N_2)^2 = m + \frac{m}{2}(1+q) \times \frac{895}{h_2}$$

For isochronism, range of speed = ∞

i.e., $N_1 - N_2 = 0 \Rightarrow h_1 = h_2$

which is highly impossible. Hence Porter governor cannot be isochronous.

92. Give the application of gyroscopic principle?

It is used:

- In instrument or troy known as gyroscope,
- In ships in order to minimize the rolling and pitching effects of waves, and
- In aeroplane, monorail cars, gyrocompasses, etc.

93. What is gyroscopic torque?

Whenever a rotating body changes its axis of rotation, a torque is applied on the rotating body. This torque is known as gyroscopic torque.

94. Define steering, pitching and rolling?

- **Steering** is the turning of a complete ship in a curve towards left or right, while it moves forward.

- **Pitching** is the movement of a complete ship up and down in a vertical plane about transverse axis.
- **Rolling** is the movement of a ship in a linear fashion.

95. What is the effect of gyroscopic couple on rolling of ship? Why?

We know that, for the effect of gyroscopic couple to occur, the axis of precession should always be perpendicular to the axis of spin. In case of rolling of a ship, the axis of precession is always parallel to the axis of spin for all positions. Hence there is no effect of the gyroscopic couple acting on the body of the ship during rolling.

96. The left hand and the right hand sides of the ship when viewed from the stern are called _________ and ________ respectively?

Ans: port ; star-board.

97. Discuss the effect of the gyroscopic couple on a two wheeled vehicle when taking a turn?

The gyroscopic couple will act over the vehicle outwards. The tendency of this couple is to overturn the vehicle in outward direction.

98. The engine of an aeroplane rotates in clockwise direction when seen from the tail end and the aeroplane takes a turn to the left. What will be the effect of the gyroscopiccouple on the aeroplane?

The effect of gyroscopic couple will be to raise the nose and dip the tail.

99. Define gyroscopic couple?

If a body having moment of inertia I and rotating about its own axis at ω rad/sec is also caused to turn at $\omega_P$rad/sec about an axis perpendicular to axis of spin, then it experiences a gyroscopic couple of magnitude ($I \omega \; \omega_P$) in an axis which is perpendicular to both the axis of spin and axis of precession.

100. Write the expression for gyroscopic couple?

Gyroscopic couple, $C = I \cdot \omega \cdot \omega_P$

Where I = Moment of inertia of the disc,

ω = Angular velocity of the engine, and

ω_P = Angular velocity of precession.

16 Mark - UNIT-I (FORCE ANALYSIS)

1. For reciprocating engine, derive the expression for
   (i)Velocity and acceleration of the piston
   (ii)Angular velocity and angular acceleration of the connecting rod (16)
2. In a reciprocating engine mechanism, if the crank and connecting rod are 300mm and 1m long respectively and the crank rotates at a constant speed of 200r.p.m.Determine analytically,
   1. The crank angle at which the maximum velocity occurs and
   2. Maximum velocity of piston.
   3. Derive the relevant equations. (16)
3. (i)Deduce the expression for the inertia force in the reciprocating force neglecting the weight of the connecting rod. (8)
   (ii)A vertical petrol engine with cylinder of 150mm diameter and 200mm strokes has a connecting rod of 350mm long. The mass is 1.6kg and the engine speed is 1800 rpm. On the expansion stroke with crank angle 30° fromTDC, the gas pressure is 750KPa.Determine the net thrust on the piston. (8)
4. (i)Define coefficient of fluctuation of speed and coefficient of fluctuation of energy. (4)
   (ii)The radius of gyration of a fly wheel is 1meter and fluctuation of speed is not to exceed 1% of the Mean speed of the flywheel. If the mass of the flywheel is 3340kg and the steam develops 150KW at 135rpm, then find,1.Maximum fluctuation of energy 2. Coefficient of fluctuation of energy (12)
5. The length of crank and connecting rod of a horizontal reciprocating engine are 100mm and 500mm respectively. The crank is rotating at 400rpm.When the crank has turned 30° from the IDC, find analytically
   1.Velocity of piston
   2. Acceleration of piston
   3. Angular velocity of connecting rod
   4. Angular acceleration of connecting rod. (16)
6. The length and connecting rod of a horizontal reciprocating engine are 200mm and 1meter respectively. The crank is rotating at 400rpm.When the crank has turned 30° from the inner dead center, the difference of pressure between cover end and piston rod is 0.4 N/mm2. If the mass of the reciprocating parts is 100Kg and a cylinder bore is 0.4meters.Calculate (i)Inertia force (ii) Force on piston (iii) Piston effort (iv) Thrust on the side of the cylinder walls (v) Thrust in the connecting rod (vi)Crank effort. (16)
7. A horizontal gas engine running at 210rpm has a bore of 220mm and a stroke of 440mm. The connecting rod is 924mm long the reciprocating parts weight 20kg.When the crank has turned through an angle of 30° from IDC, the gas pressure on the cover and the crank sides are 500KN/m2 and 60KN/m2 respectively. Diameter of the piston rod is 40mm.Determine,
   1. Turning moment on the crank shaft
   2.Thrust on bearing
   3. Acceleration of the flywheel which has a mass of 8kg and radius of gyration of 600mm while the power of the engine is 22KW. (16)
8. A single cylinder vertical engine has a bore of 300mm and a stroke of 400mm.The connecting rod is 1000mm long. The mass of the reciprocating parts is 140kg.On the expansion stroke with the crank at 30°from the top dead center, the gas pressure is 0.7MPa.If the runs at 250rpm, determine;
   1. Net force acting on the piston 2.resultant load on the gudgeon pin
   3. Thrust on cylinder walls
   4. The speed above which other things remaining same, gudgeon pin loads would be reversed in direction. (16)
9. A vertical double acting steam engine has a cylinder 300mm diameter and 450mm stroke and runs at 200rpm.The reciprocating parts has a mass of 225kg and the piston rod is 50mm diameter. The connecting rod is 1.2m long. When the crank has turned 125° from IDC the steam pressure above the piston is 30KN/m2.calculate,
   (i)Crank-pin effort
   (ii)The effective turning moment on the crank shaft. (16)
10. The turning moment diagram for a petrol engine is drawn to a scale of 1mm to 6N-9-9m and the Horizontal scale of 1mm to 1°.The turning moment repeat itself after every half revolution of the engine. The area above and below the mean torque line are 305, 710, 50,350,980and 275mm2. The mass of rotating parts is 40kg at a radius of gyration of 140mm.Clculate the coefficient of fluctuation of speed if the mean speed is 1500rpm. (16)
11. The torque delivered by a two stroke engine is represented by T= (1000+300sin2θ-500cos2θ) N-m where _ is the angle turned by the crank from the IDC. The engine speed is 250rpm.The mass of the flywheel is 400kg and radius of gyration 400mm. Determine ,
    (i)the power developed
    (ii)the total percentage fluctuation of speed
    (iii)the angular acceleration of flywheel when the crank has rotated through an angle of 60° from

the IDC.

(iv) the maximum angular acceleration and retardation of the flywheel. (16)

UNIT-II (BALANCING)

1. A shaft is rotating at a uniform angular speed. Four masses M1, M2, and M3and M4 of magnitudes 300kg,450kg, 360kg, 390kg respectively are attached rigidly to the shaft. The masses are rotating in the same plane.The corresponding radii of rotation are 200mm, 150mm, 250mmand 300mm respectively. The angle made bythese masses with horizontal are 0°.45°, 120°and 255°respectively.Find,(i) the magnitude of balancing mass(ii) the position of balancing mass if its radius of rotation is 200mm. (16)
2. Four masses M1, M2, M3, and M4 are 200kg, 300kg, 240kg and 260kg respectively. The corresponding radii ofrotation are 0.2m, 0.15m, 0.25m and 0.3m respectively and the angle between successive masses45°, 75°,and135°.Find the position and magnitude of balance mass required if its radius of rotation is 0.25m. (16)
3. The data for three rotating masses are given below:-
   M1=4kg r_1=75mm θ_1=45 M2=3kg r_2=85mm θ_2=135 M3=2.5kg r_3=50mm θ_3=240 (16)
   Determine the amount of counter mass at a radial distance of 65mm required for their static balance
4. Four masses A, B, C, and D are completely balanced masses C and D makes angles of 90° and 195° respectively with B in the same sense. The rotating masses have the following properties:m_A=25kg r_A=150mm m_B=40kg r_B=200mm m_C=35kg r_C=100mm r_D=180mmPlanes B and C are 250mm apart. Determine (i) the mass A and its angular position(ii) the position of planes A and D. (16)
5. A, B, C and D are four masses carried by a rotating shaft at radii 100mm,125mm,200mm and 150mm respectively. The planes in which the masses revolve are spaced 600mm apart and the masses of B,C and D are10kg,5kg and 4kgrespectively.Find the required mass A and relative angular setting of the four masses so that theshaft be in complete balance. 16)
6. Four masses A, B, C and D revolves at equal radii and equally spaced along a shaft. The mass B is 7kg and the radii of C and D make angle s of 90° and 240 °respectively with the radius of B.Find the magnitude of masses A,C and D and angular position of A . So that the system may be completely balanced. (16)
7. A shaft caries four rotating masses A, B, C and D which are completely balanced. The masses B, C and Dare50kg, 80kg and 70kg respectively. The masses C and D make angles of 90° and 195° respectively with mass B in the same sense. The masses A,B,C and D are concentrated at radius 75mm,100mm,50mm and 90mmrespectively.The plane of rotation of masses B and C are 250mm (16) apart. Determine(i) the magnitude of mass A and its angular position(ii) the position of planes A and D.
8. A four cylinder vertical engine has cranks 150mm long. The plane of rotation of the first, second and fourth cranks are 400mm,200mm and 200mm respectively from that of the third crank and their reciprocating masses are 50kg,60kg and 50kg respectively. Find the mass of the reciprocating parts for the third cylinder and relative angular position of the cranks in order that the engine may be in complete balance. (16)
9. A four cylinder vertical engine has cranks 300mm long. The plane of rotation of the first, third and fourth cranks are 750mm,1050mm and 1650mm respectively from that of the second crank and their reciprocating masses are 10kg,400kg and 250kg respectively. Find the mass of the reciprocating parts for the second cylinder and relative angular position of the cranks in order that the engine may be in complete balance. (16)
10. Derive the following expression of effects of partial balancing in two cylinder locomotive engine

(i) Variation of tractive force (ii) Swaying couple (iii) Hammer blow (16)

UNIT-III (FREE VIBRATION)

1. Derive an expression for the natural frequency of the free longitudinal vibration by
   (i)Equilibrium method (ii) Energy method (iii)Rayleigh's method (16)
2. In a single degree of damped vibration system a suspended mass of 8kg makes 30 oscillations in 18 seconds. T he amplitude decreases in 18 seconds. The amplitude decreases to 0.25 of the initial value after 5 oscillations. Determine (i) the spring stiffness (ii) logarithmic decrement (iii) damping factor (iv) Damping coefficient. (16)
3. Determine equation of motion when a liquid column vibrating in a 'U'tube by
   (i) Newton's method (ii) Energy method and hence find its natural frequency. (16)
4. (i)Deduce the expression for the free longitudinal vibration in terms of spring stiffness, its inertia effect and suspended mass. (8)
   (ii)A spring mass system has spring stiffness 's'N/m and has a mass of 'm'kg. It has the natural frequency of vibration as 12Hz. An extra 2kg mass is coupled to 'm' and natural frequency reduces by 2Hz.Find the value of 's' and 'm'. (8)
5. Avibrating system consists of a mass of 8kg,spring of stiffness 5.6N/m and dashpot of damping coefficient of 40N/m/s. Find,(i)Critical damping coefficient (ii) the damping factor (iii)the natural frequency of damped vibration (iv)the logarithmic decrement(v)the ratio of two consecutive amplitude (vi)the number of cycle after which the original amplitude is reduced to 20 percent.

6. An instrument vibrates with a frequency of 1Hz when there is no damping. When the damping is provided, the frequency of damped vibration was observed to be 0.9Hz.Find, (i) damping factor (ii) logarithmic decrement. (16)
7. Find the equation of notion for the spring mass-dashpot system for the cases when (i) ζ= 2 (ii) ζ = 1 and (iii) ζ = 0.3. The mass 'm' is displaced by a distance of 30mm and released (16)
8. Between a solid mass of 0kg and the floor are kept two slabs of isolates, natural rubber and felt, in series. The natural rubber slab has a stiffness of 3000N/m and equivalent viscous damping coefficient of 100 N-sec/m. The felt has a stiffness of 12000N/m and equivalent viscous damping coefficient of 330N-sec/m. Determine undamped and the damped natural frequencies of the system in vertical direction. (16)
9. (i) A cantilever shaft 50mm diameter and 300mm long has a disc of mass 100kg at its free end. The young's modulus for the shaft material is 200GN/m^2.SDetermine the frequency of longitudinal and transverse vibration of the shaft. (10)
   (ii)Explain the sketches different cases of damped vibrations. (6)
10. The barrel of a large gun recoils against a spring on firing. At the end of the firing, a dashpot is engaged that allows the barrel to return to its original position in minimum time without oscillation. Gun barrel mass is 400kgand initial velocity of recoils 1m.Determine spring stuffiness and critical damping coefficient of dashpot. (16)
11. A steel shaft 100mm in diameter is loaded and support in shaft bearing 0.4m apart. The shaft carries three loads: first mass 12kg at the centre, second mass 10kg at a distance 0.12m from the left bearing and third mass of 7kg at a distance 0.09m from the right bearing. Find the value of the critical speed by using Dunkerley's method. E=2X10^{11}N/m^2 (16)

UNIT-IV (FORCED VIBRATION)

1.A mass of 50kg is supported by an elastic structure of total stiffness 20KN/m. The damping ratio of the system is 0.2.A simple harmonic disturbing force acts on the mass and at any time 't seconds, the force is 60sin10t newtons. Find amplitude of the vibration and phase angle caused by the damping. (16)
2. A mass of 50kg is supported by an elastic structure of total stiffness 20KN/m. The damping ratio of the system is 0.25.A simple harmonic disturbing force acts on the mass and at any time 't seconds, the force is 75cos12tnewtons.Find amplitude of the vibration and phase angle caused by the damping. (16)
3. A mass of 10kg is suspended from one end of a helical spring, the other end being fixed. The stiffness of the spring is10N/mm. The viscous damping causes the amplitude to decreases to one-tenth of the initial value in four complete oscillations. If a periodic force of 150cos50t N is applied at the mass in the vertical direction .Find the amplitude of the forced vibrations? What is its value of resonance? (16)
4. A harmonic exiting force of 25N is acting on a machine part which is having a mass of 2Kg and vibrating in viscous medium. The exciting force causes resonant amplitude of 12.5mm with a period of 0.2sec.(16)
5. A body having a mass of 15kg is suspended from a spring which deflects 12mm under the weight of the mass. Determine the frequency of the free vibrations. What is the viscous damping force needed to make the motion a periodic at a speed of 1mm/s? If, when damped to this extend a disturbing force having a maximum value of 100Nand vibrating at 6Hz is made to act on the body, determine the amplitude of the ultimate motion. (16)
6. A single cylinder vertical petrol engine of total mass of 200kg is mounted upon a steel chassis frame. The vertical static deflection of the frame is 2.4mm due to the weight of the engine .The mass of the reciprocating parts is 18kg and stroke of piston 160mm with S.H.M. If dashpot of damping coefficient of 1N/mm/s used to damped the vibrations, calculate al steady state (i)Amplitude of vibrations at 500rpm engine speed.(ii)The speed of the driving shaft at which resonance will occurs. (16)
7. A vertical single stage air compressor having a mass of 500kg is mounted on spring having stiffness of 1.96X10_5N/m and dashpot with damping factor of 0.2m.The rotating parts are completely balanced and the equivalent reciprocating parts weight 20kg.The stroke is 0.2m.Determine the dynamic amplitude of vertical motion of the excitation force if the compressor is operate at 200rpm. (16)
8. A machine 100kg has a 20kg rotor with 0.5mm eccentricity. The mounting spring have s=85x$10_{3.}$ The operating speed is 600rpm and the unit is constrained to move vertically. Find (i) Dynamic amplitude of machine (ii) the force transmitted to the support. (16)
9.A single cylinder engine has an out of balance force of 500N at an engine speed of 30rpm.The total mass of engine is 150kg and its carried on a set of total stiffness 300N/cm. (i) Find the amplitude of steady motion of the mass and maximum oscillating force transmitted to the foundation. (ii)If a viscous damping is interposed between the mass and the foundation the damping force 1000N at 1m/s of velocity, find the amplitude of force damped oscillation of the mass and its angle of lag with disturbing force.(16)
10. An industrial machine weighting 445kg is supported on a spring with a statical deflection of 0.5cm.If the machine has rotating imbalance of 25kg-cm.Determine the force transmitted at 1200rpm and the dynamic amplitude at the speed. (16)

11. The mass of an electric motor is 120kg and it runs at 1500rpm.The armature mass is 35kg and its centre gravity lies 0.5mm from axis of rotation. The motor is mounted on five springs of negligible damping. So that the force transmitted is one-eleventh of the impressed force. Assume that the mass of the motor is equally distributed among the five springs. Determine (i) the stiffness of the spring (ii) the dynamic force transmitted to the base at the operating speed. (iii) Natural frequency of system. (16)
12. Find the stiffness of each spring when a refrigerator unit having a mass of 30kg is to be support by three springs. The force transmitted to the supporting structure is only 10% of the impressed force. The refrigerator unitoperates at 420rpm. (16)

UNIT-V (GOVERNOR AND GYROSCOPE)

1. A porter governor has equal arms each 250mm long and pivoted on the axis of rotation. Each ball has a mass of 5kg and mass of the central load on the sleeve is 25kg.The radius of rotation of the ball is 150mm when governor is at maximum speed. Find the maximum and minimum speed and range of speed of the governor.(16)
2. The length of the upper and lower arms of a porter governor are 200mm and 250mm respectively. Both the arms are pivoted on the axis of rotation. The central load is 150N, the weight of the each ball is 20N and the friction of the sleeve together with the resistance of the operating gear is equivalent to a force of 30N at the sleeve. If the limiting inclinations of the upper arms to the vertical are 30° and 40° taking friction in to account. Find the range of speed of the governor. (16)
3. Calculate the rage of speed of a porter governor which has equal arms of each 200mm long and pivoted on the axis of rotation .The mass of each ball is 4kg and the central load of the sleeve is 20kg.The radius of rotation of the ball is 100mm when the governor being to lift and 130mm when the governor is at maximum speed. (16)
4. A hartnell governor having a central sleeve spring and two right angled bell crank lever operates between 290rpm and 310rpm for a sleeve lift of 15mm.The sleeve and ball arms are 80mm and 120mm repectively.The levers are pivoted at 120mm from the governoraxis and mass of the ball is 2.5kg.The ball arms are parallel at lowest equilibrium speed. Determine (i) load on the spring at maximum and minimum speeds and (ii) Stiffness of the spring. (16)
5. A governor of hartnell type has equal balls of mass 3kg, set initially at a radius of 200mm.The arms of the bell crank lever are 110mm vertically and 150mm horizontally. Find (i) the initial compressive force on the spring at a radius of 200mm at240rpm and (ii) the stiffness of the spring required to permit a sleeve movement of 4mm on a fluctuation of 7.5 percent in the engine speed. (16)
6. The controlling force in a spring controlled governor is 1500N when radius of rotation is 200mm and 887.5N when radius of rotation is 130mm.The mass of each ball is 8kg.If the controlling force curve is a straight line, then find (i) Controlling force at 150mm radius of rotation (ii) Speed of the governor at 150mm radius.(iii)Increase in initial tension so that governor is isochronous.
   (iv) Isochronous speed. (16)
7. In a spring controlled governor, the controlling force curve is a straight line. When the balls are 400mm apart, the controlling force is 1200N and when 200mm apart, the controlling force is 450N.Determine the speed at which the governor runs when the balls are 250mm apart. When initial tension on the spring would be required for isochronisms and what would be the speed. Take mass of each ball to be 10kg. (16)
8. Calculate the minimum speed of a proell governor, which has equal arms each of 200mm and are provided on the axis of rotation. The mass of each ball is 4kg and the central mass on the sleeve is 20kg.The extension arms of the lower links are each 60mm long and parallel to the axis when the minimum radius of the ball is 100mm.of load. (16)
9. (i) Explain the effect of Gyroscopic couple on a Naval ship during pitching. (8)
   (ii) Explain the effect of Gyroscopic couple on a Aeroplane. (8)
10. Each paddle wheel of a steamer have a mass of 1600kg and a radius of gyration of 1.2meters.The steamer turns to port in a circle of 160meters radius at 24Km/hr. The speed of the paddle is 90rpm.Find the magnitude and effect of the gyroscopic couple acting on the steamer. (16)
11. The rotor of a turbine yatch rotates at 1200rpm clockwise when viewed from stern. The rotor has a mass of 750 kg and radius of gyration of 250mm.Find the maximum gyroscopic couple transmitted to the hull when yacht pitches with a maximum angular velocity of 1 rad/s. What is the effect of this couple? (16)
12. The turbine rotor of a ship has a mass of 20 tonnes and a radius of gyration 0.75.Its speed is 2000rpm.Theship pitches 6° above and below the horizontal position .One complete oscillation takes 18 seconds and themotion is simple harmonic. Determine (i) the maximum couple tending to shear the holding down bolt of theturbine(ii)The maximum angular acceleration of the ship during pitching
   (iii) The direction in which the bow will tend to turn while, if the rotation of the rotor is clockwise when locking fromrear. (16)