SCAD ENGINEERING COLLEGE

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ME 6505 DYNAMICS OF MACHINES

UNIT I – FORCE ANALYSIS AND FLYWHEELS

1. Define D'Alemberts Principle.
2. What is a free body diagram?
3. Define static force analysis.
4. Differentiate between static and dynamic equilibrium.
5. What are the conditions for a body to be in static and dynamic equilibrium?
6. Define applied force.
7. Define constrained force.
8. Which law helps to measure a force quantitatively?
9. When will the two force members is in equilibrium?
10. Give any three advantages of free body diagrams.
11. When will the three force member is in equilibrium?
12. Differentiate between static force analysis and dynamic force analysis.
13. What do you meant by inertia?
14. How will you reduce a dynamic analysis problem into an equivalent problem of static equilibrium?
15. What do you mean by equivalent offset inertia force?
16. State the principle of superposition.
17. Define piston effort
18. Define crank effort.
19. Define angular velocity of precession.

20. Define crank pin effort.

21. Define compound pendulum or torsional pendulum.

22. Give the expression for the equivalent length of the compound pendulum.

23. What are the requirements of an equivalent dynamical system?

24. What do you mean by correction couple?

25. Define error in torque.

26. What are the forces acting on the connecting rod?

27. Draw the turning moment diagram for the following engine.

    a. Single acting stream engine

    b. Double acting stream engine

28. Why single cylinder needs large size flywheel?

29. Draw the turning moment diagram for the following engine.

    a. Four stroke single cylinder engine

    b. Turbine

30. Define inertia torque.

31. Why flywheel is needed in a punching press?

32. Explain surge and windup.

33. Explain free body diagram with one example.

34. What is engine shaking force?

35. Expression for inertia force in reciprocating engine.

36. What is the function of a fly wheel?

37. Define the term maximum fluctuation of energy in flywheels.

38. What is meant by maximum fluctuation of speed?

39. Define coefficient of steadiness.

40. List out few machines in which flywheel are used.

41. Why a smaller flywheel is used in multi cylinder engines?

42. Why the turning moment diagram of a single cylinder four stroke I.C engine transfer from negative to positive during the crank angle 90^0.

43. Define the terms ‘coefficient of fluctuation of energy’ and ‘coefficient of fluctuation of speed’.

44. Define inertia force.

45. Distinguish between flywheel and governor.

46. Sketch the turning moment diagram for a multi-cylinder engine.

47. Define turning moment diagram.

48. What is cam dynamics?

49. What are the forces involved in cam analysis?

50. What is elastic cam analysis?

51. What are the major three problems should be considered during design or analysis of cam follower system?

52. Define unbalance and spring surge.

53. How jump or float of the follower is reduced in cam follower system?

54. What is the condition for zero jump?

55. Define windup.

56. What is the remedy for camshaft?

57. What are the causes and effect of windup?

58. What type of load the ball and taper roller bearing will take?

59. Why a roller follower is preferred to that of a knife edged follower?

60. Define the significance of inertia force analysis.

61. Distinguish between radial cam and cylindrical cam.

62. Distinguish between crank effort and piston effort.

63. In a two force planar member, specify the conditions for static equilibrium.

64. More than 90% of the flywheel effect is from the rim – justify with neat sketch.

65. Mass of the flywheel of a steam engine is 200kg and it has got a radius of gyration of 760mm. the constant starting torque of the engine is 1300N-m. Determine the angular acceleration of the flywheel.

66. What is the principle of virtual work?

67. What are the two principles used in static force analysis?

68. What is meant by equivalent offset inertia force?

69. Mention the various constructions by which inertia forces and torque of the reciprocating steam engine can be determined.

70. What do you meant by equivalent dynamical system?

71. What is the difference between correction couple and correction torque?

72. What is the significance of the sign of correction couple?

73. What is the main advantage of Klien's construction?

74. What is the net work done by an IC engine? Will it positive?

75. Why does the turning moment diagram of a single cylinder four stroke IC engine transfer from negative to positive position during second half of suction and exhaust strokes?

PART – B

1. In a reciprocating engine mechanism, if the crank and connecting rod are 300 mm and 1 m long respectively and the crank rotates at constant speed of 200 rpm. Determine analytically,

    i. The crank angle at which the maximum velocity occurs

    ii. Maximum velocity of the piston.

    iii. Derive the relevant equations.

2. A vertical double acting steam engine has a cylinder 300 mm diameter and 450 mm stroke and runs at 200 rpm. The reciprocating parts have a mass of 225 kg and the piston rod is 50 mm diameter. The reciprocating rod is 1.2 m long. When the crank has turned through 125 degree from the top dead centre the steam pressure above the piston is 30 kN/m^2 and below the piston is 1.5 kN/m^2. Calculate

    i. Crank pin effort.

    ii. The effective turning on the crank shaft.

3. A vertical double acting steam engine develops 75 kW at 250 rpm. The maximum fluctuation of energy is 30% of the work done per stroke. The maximum and minimum speeds are not to vary more than percent either side of the mean speed. Find the mass of the flywheel required, if the radius of gyration is 0.6 m.

4. The length of crank and connecting rod of a vertical reciprocating engine are 300 mm and 1.5 m respectively. The crank is rotating at 200 rpm clockwise. Find analytically, (i) acceleration of piston, (ii)

velocity of piston (iii) angular acceleration of the connecting rod when the crank has turned 40 degree from the top dead centre and the piston is moving downwards.

5. The length of crank and connecting rod of a horizontal reciprocating engine are 200 mm and 1 m respectively. The crank is rotating at 400 rpm. When the crank has turned 30 degree from the inner dead centre, the difference of pressure between the cover end and piston end is 0.4 N/mm^2. If the mass of the reciprocating parts is 100 kg and cylinder bore is 0.4 m, then calculate: (i) inertia (ii) force on piston (iii) piston effort (iv) thrust on the sides of cylinder walls (v) thrust in the connecting rod.

6. A single cylinder, single acting, four stroke cycle gas engine develops 20 kW at 200 rpm. The work done by the gases during the expansion stroke is 3 times the work done on the gases during the compression stroke. The work done on the suction and exhaust strokes may be neglected. If the flywheel has a mass of 1000 kg, and has a radius of gyration of 0.6 m, find the cyclic fluctuation of energy and the coefficient of fluctuation of speed.

7. The turning moment diagram for a multi cylinder engine has been drawn to a scale of 1 mm = 325 Nm vertically and 1 mm = 3^0 horizontally. The areas above and below the mean torque line are -26, +378, -256, +306, -302, +244, -380, +261 and -225 mm2. The engine is running at a mean speed of 800 rpm. The total fluctuation of speed is not to exceed plus or minus 1.6% of the mean speed. If the radius of flywheel is 0.7 m, find the mass of the flywheel.

8. For reciprocating engine, derive the expression for
   I. Velocity and acceleration of the piston
   II. Angular velocity and angular acceleration of the connecting rod

9. Deduce the expression for the inertia force in the reciprocating force neglecting the weight of the connecting rod.

10. The torque delivered by a two stroke engine is represented by T= (1000+300sin2θ-500cos2θ) N-m where θ 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.

UNIT II – BALANCING

PART - A

1. Distinguish between the unbalanced force caused due to rotating and reciprocating masses.
2. Write the importance of balancing.
3. Unbalanced effects of shafts in high speed machines are to be closely looked into – Why?
4. Write the types of balancing.

5. Define static balancing.
6. Define dynamic balancing.
7. State the condition for static balancing.
8. Dynamic balancing implies static balancing. Justify.
9. Why are the cranks of a locomotive, with two cylinders, placed at 90° to each other?
10. What is meant by balancing of rotating masses?
11. Define the term swaying couple.
12. Why single cylinder needs large size flywheel?
13. Mention any two methods to avoid derailment of the locomotive.
14. Compare the magnitude and direction of the unbalanced forces in the case of rotating masses and reciprocating masses.
15. What are the different types of balancing machines?
16. State the conditions for complete balance of several masses revolving in different planes of a shaft.
17. List the effects of partial balancing of locomotives.
18. Can a single cylinder engine be fully balanced? Why?
19. Why rotating masses are to be dynamically balanced?
20. What for the balancing machines are used?
21. What is the need for balancing of rotating masses, particularly in high speed engines?
22. Why is only a part of the unbalanced force due to reciprocating masses balanced by revolving mass?
23. How do you ensure dynamic balancing of rotating masses?
24. Differentiate clearly the static balancing and dynamic balancing.
25. Define dalby's method of balancing masses.
26. Write the phenomenon of transferring forces from one plane to other.
27. Whether grinding wheels are balanced or not? If so why?
28. Whether your watch needles are properly balanced or not?
29. Why is only a part of the unbalanced force due to reciprocating masses balanced by revolving mass?
30. Differentiate between the unbalanced force caused due to rotating and reciprocating masses.
31. Define hammer blow with respect to locomotives.
32. What are the effects of hammer blow and swaying couple?
33. In an outside cylinder uncoupled locomotive the balancing mass for reciprocating parts was found to be 90kg at a radius of 0.75m. Find the speed in km/hr a which the wheel will lift off the rails when the load on each driving wheel is 30kN and the diameter of tread of driving wheels is 1.8m.
34. Define direct and reverse cranks.
35. What are in-line engines?
36. What are the conditions to be satisfied for complete balance of in-line engine?
37. Sketch the primary and secondary crank position of a six cylinder four stroke in-line engine.
38. Why radial engines are preferred?
39. For a V-engine with cylinder axes at right angles and the connecting rods driving a common crank, show that the resultant primary force in the direction of the crank is $m\omega^2r$.

40. List down the planes of considering for uncoupled and coupled locomotives.
41. Mention any two methods to avoid derailment of the locomotive.
42. Compare the magnitude and direction of the unbalanced forces in the case of rotating masses and reciprocating masses.
43. What is partial balancing? Why complete balancing of reciprocating masses is not possible in a single cylinder engine?
44. Explain the term primary balancing and secondary balancing.
45. Define tractive force in a two cylinder locomotive engine and state when its magnitude is maximum and minimum.
46. What is meant by rocking?
47. Why there are projection of hands in opposite direction in watches and clocks?
48. What will happen when reciprocating masses are not balanced?
49. Mention the importance of multi - cylinder engines?
50. What is V – 12 engine? Why it is used in some luxury cars?

PART – B

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 by these 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.

2. Four masses M1, M2, M3, and M4 are 200kg, 300kg, 240kg and 260kg respectively. The corresponding radii of rotation 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.

3. The data for three rotating masses are given below:-

M1=4kg	r1=75mm	θ1=45
M2=3kg	r2=85mm	θ2=135
M3=2.5kg	r3=50mm	θ3=240

Determine the amount of counter mass at a radial distance of 65mm required for their static balance (16)

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=180mm

Planes 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 are 10kg,5kg and 4kgrespectively.Find the required mass A and relative angular setting of the

four masses so that the shaft 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.

7. A shaft caries four rotating masses A, B, C and D which are completely balanced. The masses B, C and Dare 50kg, 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 apart. Determine (i) the magnitude of mass A and its angular position

(ii) the position of planes A and D. (16)

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.

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.

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

PART - A

1. What are the causes and effect of vibration?
2. Define frequency, cycle, period.
3. Define free vibrations.
4. What are the different types of vibrations?
5. State different methods of finding natural frequency of a system.
6. What is meant by free vibration and forced vibration?
7. What is meant by damping and damped vibrations?
8. Define resonance.
9. What is meant by degrees of freedom in a vibrating system?
10. Define steady state vibration.
11. Define transient vibration.
12. What is equivalent spring stiffness?
13. List the various methods of finding the natural frequency of free longitudinal vibrations.
14. What is principle of Rayleigh's method of finding the natural frequency of vibrations?
15. What is the natural frequency of simple spring – mass system?
16. Determine the natural frequency of mass of 10 kg suspended at the bottom of two springs of stiffness 5 N/mm and 8 N/mm in series.
17. What is the effect of inertia on the shaft in longitudinal and transverse vibrations?
18. State the expression for the frequency of simple pendulum.
19. Give the expression for natural frequency of water, which oscillates in a 'U' tube manometer.
20. A car having a mass of 1000 kg deflects its spring 4 cm under its load. Determine the natural frequency of the car in the vertical direction.
21. What are the types of damping?
22. Draw the schematic diagram of a free damped vibration system and write the governing differential equation of the system.
23. Distinguish between critical damping and large damping.
24. Sketch the time Vs displacement plot for under-damped and over-damped systems.
25. What is the limit beyond which damping is determined and why?
26. When do you say a vibrating system in under-damped?
27. What is meant by critical damping?

28. What type of motion is exhibited by a vibrating system when it is critically damped?
29. Explain the Dunkerly's method used in natural transverse vibration?
30. Define critical or whirling or whipping speed of a shaft.
31. What are the factors that affect the critical speed of a shaft?
32. Critical speed of shaft is the same as the natural frequency of transverse vibration. Justify.
33. What are the causes of critical speed?
34. Which system non-vibratory in nature and comes to equilibrium in exponential manner?
35. Give an application of critical damping.
36. What is the difference between viscous damping and coulomb damping?
37. Name the type of motion exhibited by critically damped or over damped vibrating systems.
38. Stiffness of a closely coiled helical spring is 9.2N/mm. Find its natural frequency of longitudinal vibrations if a tensile mass of 17.5 kg is hung from it.
39. A shaft of 100 mm diameter and 1 m long is fixed at one end and other end carries a flywheel of mass 1 tonne. Taking E 200GN/m^2. Find the natural frequency of longitudinal vibrations.
40. Define structural damping.
41. Define interfacial damping.

PART – B

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. The 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) $\zeta = 2$ (ii)$\zeta = 1$ and (iii)$\zeta = 0.3$. The mass 'm'is displaced by a distance of 30mm and released

8. Between a solid mass of 10kg 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/m2.SDetermine the frequency of longitudinal and transverse vibration of the shaft.

(10) (ii)Explain the sketches different cases of damped vibrations.
(16)

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 400kg and 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 Dunker ley's method. $E=2X10^{11}N/m^2$ (16)

UNIT 4 FORCED VIBRATION

PART - A

1. Define Magnification factor.
2. Explain the term 'vibration isolation'.
3. Define damping ratio or damping factor.
4. Give equation for damping factor ζ and damped frequency ωd.
5. What is meant by harmonic forcing?
6. What is the relationship between frequencies of undamped and damped vibration?
7. Define transmissibility.
8. Define transmissibility ratio or isolation factor.
9. What is the role of transmission ratio?
10. Define Dynamic magnifier.
11. What type of motion is exhibited by a vibrating system when it is critically damped?
12. Mention any four materials that arrest vibration.
13. Define node in case of vibration.
14. What is the value of the angular velocity such that natural frequency and time period are equal?
15. A vibrating system consist of a mass of 7 kg and a spring stiffness 50 n/cm and damper of damping coefficient 0.36 N/cm/sec. Find damping factor.
16. What is the difference between frequencies of undamped and damped vibration?

17. Sketch the vector relationship between the dynamic existing force, spring force, damping force, inertia force of a single degree of freedom system subjected to forced vibration.
18. Briefly explain elastic suspension.
19. Specify any two industrial applications where the transmissibility effects of vibration are important.
20. With the help of transmissibility Vs frequency curve, explain the effect of damping on transmissibility.
21. What are the methods of isolating the vibration?
22. Define torsional vibration.
23. Differentiate between transverse and torsional vibration.
24. Write down the expression for natural of free torsional vibration a) without considering the effect of inertia of the constraint and, b) considering the effect of inertia of the constraint.
25. Define node in torsional vibration.
26. Define torsional equivalent shaft.
27. Differentiate force isolation and motion isolation.
28. Write the expression for the frequency of vibration of a two rotor system.
29. The node in the case of torsional vibration of a two rotor system will be situated closer to the rotor having larger mass moment of inertia – Justify.
30. Sketch the different modes of vibration of a three rotor system.
31. Derive equations used to determine the position of node in two rotor system.
32. Derive the equation used to obtain torsionally equivalent shaft of a stepped bar.
33. Explain holzer method.
34. What are the conditions to be satisfied for an equivalent system to that of geared system in torsional vibrations?
35. In a two rotor system, Ia = 60 kg – m^2 and Ib = 40 kg – m^2. If the length of rotor is 50 cm, find the node position.
36. How will you treat the inertia of gears while calculating the frequency of torsional vibrations of geared system?
37. What are the isolating materials?
38. Define force isolation.
39. Define motion isolation.
40. Define fundamental frequency.
41. Define two node frequency.
42. What are assumptions made in free torsional vibrations of a geared system?

PART-B (16 Marks)

1. A mass of 10 kg is suspended from one end of a helical spring, the other end being fixed. The stiffness of the spring is 10 N/mm. The viscous damping causes the amplitude to decrease to one tenth of the initial value in four complete oscillations. If a periodic force of 150 cos 50 t N is applied at the mass in the vertical direction, find the amplitude of the forced vibrations. What is its value at resonance?

2. A machine supported symmetrically on four springs has a mass of 80 kg. The mass of the reciprocating parts is 2.2 kg which move through a vertical stroke of 100 mm with simple harmonic motion. Neglecting damping, determine the combined stiffness of the spring so that the force transmitted to foundation is $1/20^{th}$ of the impresses force. The machine crank shaft rotates at 800 rpm.If under working conditions, the damping reduces the amplitudes of successive vibrations by 30%, find (i) the force transmitted to the foundation at resonance and (ii) the amplitude of vibration at resonance.

3. A mass of 10 kg is suspended from one end of a helical spring, the other end being fixed. The stiffness of the spring is 10 N/mm. The viscous damping causes the amplitude to decrease to one-tenth of the initial value in four complete oscillations. If a periodic force of 150 cos 50t N is applied at the mass in the vertical direction, find the amplitude of the forced vibrations. What is the value of resonance?

4. The mass of an electric motor is 150 kg and it runs at 1500 rpm. The armature mass is 35 kg and its CG lies 0.7 m from the 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) Stiffness of each spring. (ii) Dynamic force transmitted to the base at the operating speed. (iii) Natural frequency of the system.

5. A mass of 500 kg is mounted on supports having a total stiffness of 100 kN/m and which provides viscous damping, the damping ratio being 0.4. The mass is constrained to move vertically and is subjected to a vertical disturbing force of the type $F \cos \omega t$. Determine the frequency at which resonance will occur and the maximum allowable value of F if the amplitude at resonance is restricted to 5 mm.

6. A machine of mass 75 kg is mounted on springs of stiffness 1200 kN/m and with an assumed damping factor of 0.4. A piston within the machine of mass 4 kg has a reciprocating motion with a stroke of 90 mm and a speed of 3000 cycles/min. Assuming the motion to be simple harmonic, Find (i) the amplitude of motion of the machine, (ii) its phase angle with respect to the existing force, (iii) the force transmitted to the foundation, and (iv) the phase angle of transmitted force with respect to the exciting force.

7. 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.

8. 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 unit operates at 420rpm.

9. The mass of an electric motor is 120kg and it runs at 1500rpm.The armature mass is 35kg and its centra 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.

10. 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.

11. A machine 100kg has a 20kg rotor with 0.5mm eccentricity. The mounting spring have s=$85x10^{3}$. 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.

12. A vertical single stage air compressor having a mass of 500kg is mounted on spring having stiffness of $1.96X10^{5}$N/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.

UNIT – V

MECHANISMS FOR CONTROL

1. What is the function of governor?
2. How governors are classified?

3. Differentiate between governor and fly wheel.
4. What is meant by sensitiveness of a governor?
5. What is the effect of friction on the governor?
6. Define coefficient of sensitiveness.
7. What is meant by hunting?
8. What is meant by isochronous conditions governor?
9. Give application of gyroscopic principle.
10. What is gyroscopic torque?
11. What is the effect of gyroscopic couple on rolling of ship? Why?
12. Define gyroscopic couple.
13. Write expression for gyroscopic couple.
14. Define the meaning of stability of a governor.
15. Which part of the automobile is subjected to the gyroscopic couple?
16. What is the principle of working of centrifugal governor?
17. What is equilibrium speed?
18. Explain controlling force.
19. Explain the governor effort.
20. Define power of a governor.
21. Explain the term stability of governor.
22. Explain isochroism.
23. Can a Porter governor be isochronous.
24. What is controlling force diagram.
25. What are the uses of controlling force diagram?
26. Give the applications of gyroscopic couple.
27. Define steering.
28. Define Pitching.
29. Define rolling.
30. Why there is no effect of the gyroscopic couple acting on the body of a ship during rolling?
31. Discuss the effect of the gyroscopic couple on a two wheeled vehicle when taking in turn.
32. A disc is spinning with an angular velocity about the axis of spin. What will be the couple applied to the disc causing precession?
33. Define the term system.
34. Differentiate the terms command and response.
35. What is meant by lag in response?
36. Define a transfer function.

37. If open loop gain is 0.5, then what will be the transfer function for a closed loop control system?
38. Give any two example of open loop control system.
39. Draw the block diagram representing a diesel generator set.
40. Draw the block diagram representing an electric fan heat.
41. What is transducer?
42. Why is a motor cycle bent toward the direction of negotiating curve?
43. Define gyroscopic acceleration.

PART-B (16 Marks)

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.
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.
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.
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.
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.
6. 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.

7. 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.
8. Calclate 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.
9. (i) Explain the effect of Gyroscopic couple on a Naval ship during pitching. (ii) Explain the effect of Gyroscopic couple on a Aeroplane.
10. A porter governor has equal arms each 250 mm long and pivoted on the axis of rotation. Each ball has a mass of 5 kg and the mass of the central load on the sleeve is 25 kg. The radius of rotation of the ball is 150 mm when the governor begins to lift and 200 mm when the governor is at maximum speed. Find the minimum and maximum speeds and range of speed of the governor.
11. In a Porter governor, the mass of the central load is 18 kg and the mass of each ball is 2 kg. The top arms are 250 mm while the bottom arms are each 300 mm long. The friction of the sleeve is 14 N. If the top arms make 45° with the axis of rotation in the equilibrium position, find the range of speed of the governor in that position.