INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad -500 043

MECHANICAL ENGINEERING

TUTORIAL QUESTION BANK

Course Name	**STRESS ANALYSIS AND VIBRATION**
Course Code	**BCC213**
Class	M. Tech II Semester CAD/CAM
Branch	Mechanical
Year	2017 - 2018
Course Coordinator	Dr. K. Viswanath Allamraju, Professor.

OBJECTIVES:

This course introduces the theory of elasticity, contact stress analysis, free and forced vibrations of two and multidegree of freedoms systems, transverse vibrations and continuous systems.

S No	QUESTION BANK	Blooms taxonomy level	Course Outcomes
	UNIT – I **INTRODUCTION OF THEORY OF ELASTICITY**		
Part - A (Short Answer Questions)			
1	Write down the short notes on coordinate system.	Remember	1
2	Explain the theory of elasticity.	Remember	1
3	Write down the short notes on biharmonic equation	Remember	1
4	Express the stress compatibility equation for plane strain case.	Remember	1
5	What are conjugate harmonic functions and analytic functions? Give the property of the analytic functions.	Remember	1
6	Express the stresses acting in a Tapering beam	Remember	1
7	Express the stress components in terms of an Airy stress function.	Remember	1
8	Express the stress compatibility equation for plane stress case.	Remember	1
9	Name basic components in hydraulic systems.	Remember	1
10	Name few applications of hydraulics.	Remember	1
Part - B (Long Answer Questions)			
1	Derive stress displacement relations of a two dimensional state of stress in polar coordinate system.	Remember	1
2	Derive stress displacement relations of a three dimensional state of stress in polar coordinate system.	Remember	1
3	Derive stress strain relations of a three dimensional state of stress in polar coordinate system.	Remember	1
4	Derive compatability equations of a three dimensional state of stress in polar coordinate system.	Remember	1
5	Derive compatability equations of a two dimensional state of stress in polar coordinate system.	Remember	1
6	Derive Airy's stress function of a two dimensional state of stress in polar coordinate system.	Remember	1
7	How Airy's stress function satisfies the biharmonic function in the theory of elasticity?	Remember	1
Part - C (Problem Solving and Critical Thinking Questions)			
1.	A narrow cantilever of rectangular cross section is loaded by a concentrated force at the free end. Determine the stress distribution in the beam.	Understand	1

2.	A cantilever beam of rectangular cross-section 40 mm wide and 60 mm thick is 800 mm in length. It carries a load of 500 N at the free end. Determine the stresses in the cantilever at mid-length.	Remember	1
3.	Show that $(A e^{\alpha y} + B e^{-\alpha y} + Cy e^{\alpha y} + Dy e^{-\alpha y}) \sin \alpha x$ is a stress function in two dimensional stress field.	Remember	1
3.	Show that if V is a plane harmonic function, *i.e.* it satisfies the Laplace equation $\nabla^2 V = 0$, then the functions $xV, yV, (x^2 + y^2)$ satisfy the bilharmonic equation and so can be used as stress functions.	Remember	1
4.	Determine the stress fields that arise from the following stress functions: i. $\phi = Cy2$ ii. $\phi = Ax2 + Bxy + Cy2$	Remember	1
5.	Determine the stress fields that arise from the following stress function: $\phi = Ax3 + Bx2y + Cxy2 + Dy3$	Remember	1
6.	Determine the stress and displacement fields in an infinite medium due to equal and opposite point forces acting at different points along their common line of action.	Remember	1

UNIT-II

STRESS ANALYSIS OF SYMMETRIC BODIES AND CONTACT STRESSES

Part – A (Short Answer Questions)

1	Write a short notes on torsion	Remember	1
2	Explain prismatic bars.	Understand	2
3	Explain contact stress between two rolling bodies.	Remember	1
4	Explain contact stress between two sliding bodies.	Remember	1
5	Explain contact stress between one rolling and one sliding bodies.	Remember	1
6	Define angle of rotation.	Remember	1
7	Give the torsion equation for circular cross-section and explain its terms.	Remember	1
8	Write the Poisson's equation for torsion of prismatic bars of non-circular cross- sections, explaining the various terms.	Remember	1
9	Write the expressions for the angle of twist and the torsional rigidity for a bar of elliptical cross-section, with major and minor axes of 2a and 2b, respectively.	Understand	2
10	For a bar of cross-section of an equilateral triangle of side 'a', what is the relationship between torque, T, and angle of twist per unit length? G is the modulus of rigidity.	Understand	2
11	State and explain the Bredt's formula for torsion of thin walled tubes.	Remember	2
12	Write the simple bending equation for symmetrical cross-sections of a beam.	Remember	2
13	Give the governing differential equation of bending of a cantilever by load P at its free end, when the cantilever has a non-uniform cross-section.	Remember	2

Part - B (Long Answer Questions)

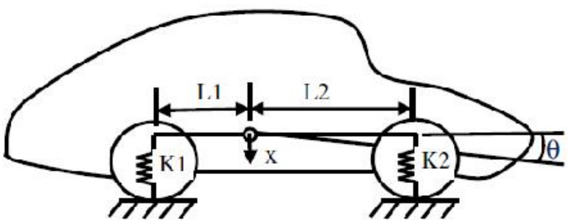
1	Using St. Venant's theory derive the Poisson's equation for torsion of prismatic bars of non-circular cross-sections.	Understand	2
2	Derive the expressions for the angle of twist and the torsional rigidity for a bar of elliptical cross-section, with major and minor axes of 2a and 2b, respectively.	Understand	2
3	Derive the relationship between torque, T, and angle of twist per unit length for a bar of cross-section of an equilateral triangle of side 'a'.	Understand	2
4	Derive the torsion equation of a thin rectangular section..	Understand	2
5	Derive the torsion equation of a hollow cylinder.	Understand	2

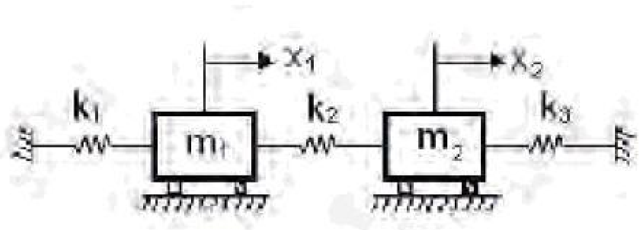
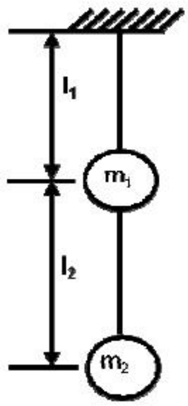
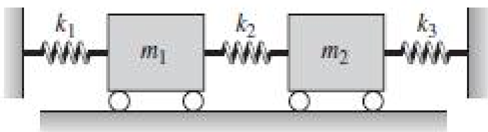
6	Derive the simple bending equation for symmetrical cross-sections of a beam.	Remember	1
7	Derive the governing equation of bending of a cantilever, with a non-uniform cross-section, subjected to load P at its free end.	Understand	2
8	Derive the governing differential equation of bending of a bar of circular cross- section in terms of stress functions	Understand	2
9	Derive the governing differential equation of bending of a bar of an elliptical cross-section in terms of stress functions	Understand	2
10	Derive the governing differential equation of bending of a bar of a rectangular cross-section in terms of stress functions	Understand	2
Part – C (Problem Solving and Critical Thinking)			
1	A square shaft rotating at 250 rpm, transmits torque to a crane which is designed to lift maximum load of 150 kN at a speed of 10m/min. If the efficiency of crane gearing is 65% estimate the size of the shaft for the maximum permissible shear stress of 35MPa. Also calculate the angle of twist of the shaft for a length of 3m. Take G=100 GPa.	Remember	2
2	A 300 mm steel beam with flanges and web 12.5mm thick, flange width 300mm is subjected to a torque of 4 kN m. Find the maximum shear and angle of twist per unit length. G =100 GPa.	Remember	2
3	An elliptical shaft of semi axes a = 0.05 m, b = 0.025m and G = 80 GPa is subjected to a twisting moment of 1200 π Nm. Determine the maximum shearing stress and the angle of twist per unit length.	Understand	2
4	A hollow aluminium section of external dimensions 100 mm x 50 mm and thickness 5 mm is designed for a maximum shear stress of 35 Mpa. Find the maximum permissible twisting moment for this section and the angle of twist under this moment per metre length. G = 28 GPa.	Remember	2
5	A hollow circular torsion member has an outside diameter of 22mm and inside diameter of 18mm, with mean diameter D = 20mm and t/D=0.10. Calculate the torque and angle of twist per unit length if shearing stress at mean diameter is 70MPa. Calculate these values if a cut is made through the wall thickness along the entire length. G = 77.5 GPa.	Understand	2
6	A prismatic bar of length 5m and a rectangular cross-section of 80mm x100mm is fixed at one end as a cantilever. At the free end, 1 kN load acting in the plane of the cross-section but inclined at 30^o to the vertical is applied. Determine the maximum stress in the cantilever beam.	Remember	2
7	A prismatic bar of circular cross-section of radius 25 mm is subjected to a terminal load of 5 kN. Determine the stresses in the bar at the end of the horizontal diameter. Compare the result with the elementary solution. Assume poisson’s ratio = 0.3.	Remember	2
8	A prismatic bar of elliptical cross-section has its semi-minor axes as 40 mm and 20 mm respectively. This bar is subjected to an end load of 2500 N. Determine the stresses in the bar at the end of major and minor axes. Assume poisson’s ratio = 0.28.	Understand	2
9	A prismatic bar of rectangular cross-section 50 mm x 30 mm is subjected to an end load of 4500 N. Determine the stresses at the centre of the bar and the corner. Assume v = 0.3	Remember	2
10	A rectangular beam 120 mm x 100 mm is 3 min length and is simply supported at the ends. It carries a load of 5 kN at mid-span inclined at 45° with the vertical axis and passing through the centroid. Determine the maximum bending stress in the beam.	Understand	2

UNIT-III
FREE AND FORCED VIBRATIONS

Part - A (Short Answer Questions)

1	What is Vibration?	Remember	1
2	Define natural frequency. Why is it important to determine the natural frequency of a vibrating system?	Understand	1
3	Define the following terms: Free, undamped, damped and forced vibrations.	Understand	1
4	Define the following terms: Resonance, phase difference, periodic motion, time period, amplitude and degree of freedom.	Understand	3
5	Distinguish between free and forced vibrations	Understand	2

6	Distinguish between damped and undamped vibrations	Remember	1
7	Distinguish between Rectilinear and torsional system	Remember	2
Part – B (Long Answer Questions)			
1.	Discuss the response of under damped , critically damped and over damped systems using respective response equations and curves.	Understand	4
2.	A machine part of mass 2.5Kg vibrates in a viscous medium. A harmonic exiting force of 30N acts on the part and causes resonant amplitude of 14mm with a period of 0.22 sec. Find the damping coefficient if the frequency of the exciting force is changed to 4Hz. Determine the increase in the amplitude of forced vibration upon removal of the damper.	Understand	4
3.	A damped system has following elements: Mass = 4 kg; k = 1 kN/m; C = 40 N-sec/m. Determine: (a) Damping factor & natural frequency of damped oscillation. (b) Logarithmic decrement and number of cycles after which the original amplitude is reduced to 20.	Understand	4
4.	In a particular case of a large canon, the gun barrel and recoil mechanism have a mass of 500kg with recoil spring stiffness 10,000N/m. The gun recoils 0.4m upon firing. Find i) Critical damping co efficient of the damper. (ii) Initial recoil velocity of the gun.	Understand	4
5.	Derive an expression for the transmissibility and transmitted force for a spring - mass-damper system subjected to external excitation. Draw the vector diagram for the forces.	Understand	4
6.	In the vibration testing of a structure, an impact hammer with a load cell to measure the impact force is used to cause excitation. Assuming m=15kg, k=3000n/m, c=20Ns/m and F=30 N. Find the response of the system.	Understand	4
Part - C (Problem Solving and Critical Thinking Questions)			
1.	Determine the normal mode of vibration of an automobile shown in figure. simulated by a simplified two degree of freedom system with the following numerical values m = 1460 kg, L1 = 1.35m, L2= 2.65 m, K1 = 4.2x105N/m, K2 = 4.55x105 N/m and J=mr2 where r= 1.22 m 	Apply	4
2.	A diesel engine, weighing 3000 N is supported on a pedestal mount. It has been observed that the engine induces vibration into the surrounding area through its pedestal mount at an operating speed of 6000rpm. Determine the parameters of the vibration absorber that will reduce the vibration when mounted on the pedestal. The magnitude of the exciting force is 250 N and the amplitude of the auxiliary mass is to be limited to 2mm.	Apply	4
3.	What is meant by static and dynamic coupling? How can coupling of the equations of motion be eliminated? Derive the governing equations through Lagrange energy approach.	Apply	4

4.	Determine the modes of vibrations for the system shown in figure 	Apply	4
5.	Derive the frequency equation for a double pendulum shown in figure. Determine the natural frequency and mode shapes of the double pendulum when $m_1=m_2=m$, $l_1=l_2=l$. 	Apply	4
6.	Determine the natural frequencies of undamped dynamic vibration absorber	Apply	4
7	Determine the natural frequencies and mode shapes associated with the system shown in Figure for $m1$ = 10 kg, $m2$ = 20 kg, $k1$ = 100 N/m, $k2$ = 100 N/m, and $k3$ = 50 N/m. 	Apply	4

UNIT IV

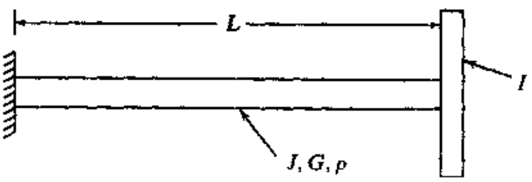
TRANSIENT VIBRATIONS

Part - A (Short Answer Questions)

1	Write short notes on transient vibrations	Understand	5
2.	What is vibration?	Understand	5
3.	Write short notes on laplace transform.	Understand	5
4.	What is characteristic equation?	Understand	5
5.	What is a semi definite system?	Understand	5
6.	Name a few methods for finding the fundamental natural frequency of a multi degree of freedom system	Understand	5
7.	What is the matrix iteration method?	Understand	5
8.	What are different types of influence coefficient methods?	Understand	5
9.	What is an Eigen value problem?	Understand	5
10.	Write the equation of motion of a multi DOF system in matrix form using the flexibility matrix.	Understand	5

Part – B (Long Answer Questions)

1	Briefly explain the transforms of particular functions.	Apply	5
2.	What mathematical concepts to be used in writing the characteristic equations of single degree of freedom systems which undergo transient vibrations.?	Apply	5
3.	Explain briefly unit step function, rectangular pulse and unit impulse functions.	Apply	5
4.	Calculate the equation of motion of undamped free vibration of single degree of freedom systems using Duhamel's integral method.	Apply	5
5.	Calculate the equation of motion of undamped free vibration of single degree of freedom systems using graphical method.	Apply	5
6.	Explain the procedure of transient equation of motion of damped vibration systems.	Apply	5
7.	Describe the mathematical of four wheeler automobile system when it is tested on rectangular impulse mode as an input.	Apply	5
Part - C (Problem Solving and Critical Thinking Questions)			
1.	A force F(t) is suddenly applied to a mass m which is supported by a spring with a constant stiffness 'k'. After a short period of time T, the force is suddenly removed. During the time the force is active, it is a constant, F. Determine the response of the system if t> T. The spring and mass are initially at rest before the force F (t) is applied..	Apply	5
2.	Find the response of a single degree of freedom spring mass system, if the system is initially relaxed and a step function excitation is applied to the mass.	Apply	5
3	A force F(t) is applied with a unit step function to a mass m which is supported by a spring with a constant stiffness 'k'. After a short period of time T, the force is suddenly removed. During the time the force is active, it is a constant, F. Determine the response of the system if t> T. The spring and mass are initially at rest before the force F (t) is applied..	Apply	5
4	A force F(t) is applied with a rectangular function to a mass m which is supported by a spring with a constant stiffness 'k'. After a short period of time T, the force is suddenly removed. During the time the force is active, it is a constant, F. Determine the response of the system if t> T. The spring and mass are initially at rest before the force F (t) is applied..	Apply	5
5	Determine the equation of motion of transcient vibrations of spring mass damped system. Take mass is 10 kg, spring constant is 1000 N/m , damping constant is 100 N. s/m , x(0) = 0.001 m and x dot (0) = 0.10 m/s.	Apply	5
UNIT V **CONTINUOUS SYSTEMS**			
Part - A (Short Answer Questions)			
1	Write a short notes on lumped mass parameter systems	Understand	5
2	Write a short notes on distributed parameter systems.	Understand	5
3	Write a difference between lumped mass and distributed mass parameter sytems.	Understand	5
4	Write a short notes on continuous systems.	Understand	5
5	Write a boundary conditions of continuous systems	Understand	5
6	Write a short notes on wave equation of vibrations	Understand	5
Part – B (Long Answer Questions)			
1	Derive the general solution of the lateral vibrations of a string.	Apply	5

2	Derive the general solution of the longitudinal vibrations of bars.	Apply	5
3	Derive the general solution of the torsional vibration of a uniform shaft.	Apply	5
4	Derive the general solution of transverse vibration of beams.	Apply	5
5	Derive the mode shape equation of the lateral vibrations of a string.	Apply	5
Part - C (Problem Solving and Critical Thinking Questions)			
1	Derive the frequency equation of longitudinal vibrations for a free free beam with zero initial displacement.	Apply	5
2	Derive suitable expression for longitudinal vibrations for a rectangular uniform cross section bar of length l fixed at one end and free at the other end.	Apply	5
3	A moment M is statically applied to the end of a circular shaft, fixed at x = 0 and free at x = 1, causing the angle of twist to vary linearly over the length of the shaft. Determine the resulting free torsional response when the moment is suddenly removed.	Apply	5
4	The circular shaft of Figure below, is fixed at x = 0 and has a thin disk of mass moment of inertia / attached at x = 1. Determine the natural frequencies for this system, identify the orthogonality condition satisfied by the mode shapes, and determine the normalized mode shapes. Shaft has disk of moment of inertia I attached at its free end. 	Apply	5
5	Determine the steady-state response of a circular shaft subject to a uniform torque per unit length T_0 Sin μt applied over its entire length.	Apply	5
6	Propeller blades totaling 1200 kg with a total mass moment of inertia of 155 kg • m2 are attached to a solid circular shaft (p = 5000 kg/m^3, G = 60 x 109 N/m^2, E = 140 x 10g N/m^2) of radius 40 cm and length 20 m. The other end of the shaft is fixed in an ocean liner. Determine (a) The lowest natural frequency for torsional oscillations of the propeller. (b) The lowest natural frequency for longitudinal motion of the propeller.	Apply	5
7	A pipe used to convey fluid is cantilevered from a wall. The steel pipe (p = 7500 kg/m^3, G = 80 x 109 N/m^2, E = 200 x 109 N/m^2) has an inner radius of 20 cm, a thickness of 1 cm, and a length of 4.6 m. For an empty pipe determine (a) The five lowest natural frequencies for torsional oscillation. (b) The five lowest natural frequencies for longitudinal vibration. (c) The five lowest natural frequencies for transverse motion.	Apply	5
8	A steel shaft (p = 7850 kg/m3, G = 85 x 109 N/m2) of inner radius 30 mm and outer radius 50 mm and length 1.0 m is fixed at both ends. Determine the three lowest natural frequencies of the shaft.	Apply	5
9	A 10,000-N • m torque is applied to the midspan of a steel shaft (p = 7850 kg/m3, G = 85 x 109 N/m2) of inner radius 30	Apply	5

	mm and outer radius 50 mm and length 1.0 m is fixed at both ends and suddenly removed. Determine the time-dependent angular displacement of the midspan of the shaft.		
10	Derive frequency equation for a beam with both ends free and having transverse vibrations.	Apply	5

Prepared by **Dr. K.Viswanath Allamraju, Professor, MED**

Head MED