INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)
Dundigal, Hyderabad -500 043

MECHANICAL ENGINEERING

TUTORIAL QUESTION BANK

Course Title	DYNAMICS OF MACHINERY				
Course Code	AME011				
Programme	B.Tech				
Semester	V	ME			
Course Type	Core				
Regulation	**IARE - R16**				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	3	1	4	-	-
Chief Coordinator	Dr. K Viswanath Allamraju, Professor				
Course Faculty	Dr. K Viswanath Allamraju, Professor Prof. V V S H Prasad, Professor				

COURSE OBJECTIVES:

I	Understand the concept of equilibrium of a body subjected to static and dynamic forces.
II	Study the application of Gyroscopes in aero-planes, ships and automobiles.
III	Apply the phenomenon of friction in brakes and clutches for automobile application.
IV	Understand the significance of governors and its application and turning moment diagrams.
V	Determine the fundamental frequency of vibration in mechanical systems and the effect of balancing of masses.

COURSE OUTCOMES (COs):

CO1	Understand the equilibrium of a body subjected to static and dynamic forces of various mechanisms.
CO2	Understand the concept of gyroscopic effect in aero-planes, ships and automobiles for stabilization.
CO3	Explore the concept of friction in various contacts of bodies.
CO4	Understand the significance of energy storage devices by studying the TMD.
CO5	Explore the equations of motion of various degree of freedom systems.

COURSE LEARNING OUTCOMES:

AME011.01	Understand dynamic analysis like gyroscopic forces and moments, rotation of rigid bodies.
AME011.02	Understand the gyroscopic effect on ships, planes and road vehicles.
AME011.03	Understand static force analysis for the design of planar mechanisms.

AME011.04	Understand dynamic force analysis for the design of planar mechanisms
AME011.05	Determine the dynamic behavior principle and operations of clutches, brakes and dynamometers.
AME011.06	Compute frictional losses, torque transmission of mechanical systems such as clutches and brakes.
AME011.07	Compute frictional losses, torque transmission of mechanical systems such as dynamometers.
AME011.08	Understand the design of centrifugal governors for regulation of speed.
AME011.09	Determine the dynamic behavior and principles of operations of flywheels and governors.
AME011.10	Understand dynamic balancing of point masses rotating in a single plane.
AME011.11	Understand dynamic balancing of rotating masses rotating in different planes.
AME011.12	Understand the torque calculations in turning moment diagrams.
AME011.13	Understand dynamic balancing of reciprocating parts in locomotives.
AME011.14	Understand how to determine the natural frequencies of continuous systems starting from the general equation of displacement.
AME011.15	Apply the different methods to solve the equation of motion in damped forced vibrations.
AME011.16	Understand the concepts of free and forced vibrations of single degree freedom systems.
AME011.17	Understand the concepts of vibration modes and natural frequencies and their measurement and estimation for multi-degree-of-freedom systems.
AME011.18	Interpret the behavior of vibrating systems through an understanding of basic principles and the role of mass, stiffness and damping.
AME011.19	Develop the equations of motion for free and forced vibration of simple systems.
AME011.20	Explore the use of modern engineering tools, software and equipment to prepare for competitive exams, higher studies etc.

UNIT – I				
PRECESSION, STATIC AND DYNAMIC FORCE ANALYSIS OF PLANAR MECHANISMS				
PART - A (SHORT ANSWER QUESTIONS)				
S. No	Question	Blooms Taxonomy Level	Course Outcomes	Course Learning Outcomes
1	Define static and dynamic force analysis of planar mechanisms.	Remember	CO1	AME011.01
2	What is the magnitude of gyroscopic couple in an automobile?	Remember	CO1	AME011.01
3	Explain the gyroscopic effect in a rotating disc.	Remember	CO1	AME011.01
4	Define precessional angular velocity of spin vector.	Remember	CO1	AME011.01
5	Give the expression for gyroscopic couple for a spinning disc.	Remember	CO1	AME011.01
6	Define Dynamic force analysis of planar mechanisms.	Remember	CO1	AME011.01
7	Explain static force analysis of planar mechanisms.	Remember	CO1	AME011.01
8	Define plane of precession as applied to an aeroplane.	Remember	CO1	AME011.01
9	What is meant by axis of precession as applied to four wheeler?	Remember	CO1	AME011.02
10	Define plane of spinning of rotor of a ship.	Remember	CO1	AME011.03
11	Define plane of reactive gyroscopic couple for motor cycle.	Remember	CO1	AME011.02
12	Define axis of spinning in the case of a ship.	Remember	CO2	AME011.03
13	Define plane of active gyroscopic couple for a two wheeler.	Remember	CO2	AME011.02
14	What is the magnitude of Gyroscopic couple in motor cycle?	Remember	CO2	AME011.03
15	Define gyroscopic acceleration of a disc in rotation.	Remember	CO2	AME011.02
16	Give the expression for gyroscopic acceleration of a rotating disc.	Understand	CO2	AME011.03
17	Define angle of heel in the case of a two wheeler negotiating curve.	Remember	CO2	AME011.01
18	Explain the effect of gyroscopic couple on an automobile taking left turn.	Remember	CO2	AME011.01
19	Explain the effect of gyroscopic couple on a ship pitching upward.	Understand	CO2	AME011.01
20	With a neat sketch explain gyroscopic effect in a four wheeler.	Understand	CO2	AME011.01
PART - B (LONG ANSWER QUESTIONS)				
1	Derive the relation for the magnitude of gyroscopic couple.	Understand	CO2	AME011.01
2	Explain what is meant by applied torque and reaction torque.	Understand	CO2	AME011.01
3	Discuss the gyroscopic effect on sea vessels.	Understand	CO2	AME011.01
4	Explain the gyroscopic effect on four wheelers.	Understand	CO2	AME011.01
5	Derive the relation for limiting speed of a two wheeler.	Remember	CO2	AME011.01
6	Explain the gyroscopic effects on the motion of an air craft while taking a turn.	Understand	CO2	AME011.02
7	Explain plane of spinning, plane of precession and plane of gyroscopic couple.	Understand	CO2	AME011.03
8	How do the effects of gyroscopic couple and centrifugal force make the rider.	Understand	CO2	AME011.02
9	Explain axis of spinning, axis of precession and axis of gyroscopic couple.	Understand	CO2	AME011.03
10	Explain the gyroscopic effect on a ship during pitching.	Remember	CO2	AME011.02
11	What are applied and constraint forces as applied to mechanisms?	Remember	CO1	AME011.02
12	What are the conditions for a body to be in equilibrium under the action of two forces?	Remember	CO1	AME011.03
13	What are the conditions for a body to be in equilibrium under the action of two forces and a torque?	Understand	CO1	AME011.02
14	How are free body diagrams helpful in finding the various forces acting on different members of the mechanism?	Understand	CO1	AME011.02
15	Explain the principle of superposition as applicable to a system of forces in a mechanism.	Understand	CO2	AME011.03

16	Explain the principle of virtual work with a neat sketch.	Remember	CO2	AME011.02
17	What are the conditions for a body to be in equilibrium under the action of four forces?	Understand	CO1	AME011.03
18	Explain static equilibrium for a planar mechanism.	Remember	CO1	AME011.02
19	Explain dynamic equilibrium of a planar mechanism.	Understand	CO1	AME011.02
20	What are the conditions for a body to be in equilibrium under the action of three forces?	Understand	CO1	AME011.03
PART - C (ANALYTICAL QUESTIONS)				
1	The mass of turbine rotor of a ship is 8 tonnes and has a radius of gyration of 0.6 meters. It rotates at 1800 rpm clockwise when looking from the front. Determine the gyroscopic effect if i) The ship is travelling at 100 km/h and steers to the right in a curve of 70 meters radius. ii) The ship is pitching and the bow descends with maximum velocity. The complete oscillation takes 20seconds.The pitching is simple harmonic and the total angular movement between the extreme positions is 10 degrees. iii) The ship is rolling and at a certain instant has an angular velocity of 0.03 radians/second clockwise when looking from bow.	Remember	CO2	AME011.02
2	The mass of the motor cycle along with the rider is 180 kg. The height of the centre of gravity of total mass is 600mm above the ground when it moves straight. Each wheel 2 has a diameter of 700mm and mass moment of inertia of 2 kgm The engine rotates at a speed of 5 times the road wheel and engine rotating parts have mass moment of inertia of 0.2 kgm . Find the angle of heel if it is travelling at 50 km/h and is taking a turn of 30 meters radius.	Understand	CO2	AME011.03
3	A racing car has a mass of 2500kg.It has a wheel base of 2m, track width of 1m and height of C.G 300mm above ground level and lies midway between the front and rear axles. The engine flywheel rotates at 3000 rpm clockwise when viewed from the front. The moment of inertia of the flywheel is 4kgm and the moment of inertia of each wheel is 3kgm Find the reactions between the wheels and the ground when the car takes a curve of 15m towards right at 30 km/hr, taking into consideration the gyroscopic and centrifugal effects. Each wheel radius is 400mm.The ratio of engine speed to back axle speed is 3:1.	Remember	CO2	AME011.02
4	An aero-plane makes a complete half circle of 50 m radius towards left in a time of 20 seconds when flying at 200kmph. The rotary engine and the propeller of the plane has a mass of 400kg and a radius of gyration of 0.3 m. The engine rotor rotates at 2400 rpm clockwise when seen from the rear. Find the gyroscopic couple on the air craft and state its effect on the aero-plane.	Remember	CO2	AME011.03
5	A uniform disc having a mass of 8 kg and radius of gyration 150 mm is mounted on one end of a horizontal arm of length 200 mm. The other end rotates freely in a bearing. The disc is given a clockwise spin of 240 rpm. Determine the motion of the disc if its arm remains horizontal.	Remember	CO2	AME011.02
6	Determine the required input torque on the crank of a slider crank mechanism for static equilibrium when the applied piston load is 1500N. The length of the crank and connecting rod are 40 mm and 100 mm respectively and the crank has turned through 45^0 from the inner dead center.	Remember	CO2	AME011.02
7	In a four link mechanism ABCD, the link AB revolves with an angular velocity of 10 radians/second and angular acceleration of20 radians/s^2 at the instant when it makes an angle of 45˚ with AD the fixed link. The lengths of the links are AB=CD=800mm, BC=1000mm and AD=1500mm. The mass of the links is 4kg/m length. Determine the torque required to overcome the inertia forces, neglecting the gravitational effects. Assume the links to be of uniform cross-section.	Remember	CO1	AME011.03

8	In a four bar mechanism, the link 3 and 4 are subjected to forces of 100N at an angle of 60˚ and 50N at an angle of 45˚. The dimensions of the links are O_2O_4= 800 mm = 800 mm, O_2B=500 mm, BC=450 mm, O_4C= 300mm, BD=200 mm and O_4E=150mm. Calculate the shaft torque on link2 for static equilibrium of the mechanism along with the constraint forces.	Remember	CO1	AME011.04
9	A vertical petrol engine 150 mm diameter and 200 mm stroke has a connecting rod 350 mm long. The mass of the piston is 1.6 kg and the engine speed is 1800 rpm. On the expansion stroke with crank angle 30˚ from top dead center, the gas pressure is 750 kN/m^2. Determine the net thrust on the piston.	Remember	CO1	AME011.05
10	For the static equilibrium of a quick return mechanism of crank and slotted lever, determine the required input torque for a force of 5000N acting from left to right on the slider. The dimensions of various links are crank AB=120mm, fixed link AC =175 mm, connecting link DE=250mm and slotted link CD= 300 mm. The crank makes 60 ˚with the vertical.	Remember	CO1	AME011.04
UNIT-II				
CLUTCHES, BRAKES AND DYNAMOMETERS				
PART - A (SHORT ANSWER QUESTIONS)				
S. No	**Question**	**Blooms Taxonomy Level**	**Course Outcomes**	**Course Learning Outcomes**
1	Define a clutch used in an automobile.	Understand	CO3	AME011.04
2	Explain the function of brakes in a crane lifting loads.	Understand	CO3	AME011.05
3	Classify different dynamometers based on absorption of friction.	Remember	CO3	AME011.04
4	Describe with a neat sketch absorption type dynamometer.	Remember	CO3	AME011.05
5	Define centrifugal clutch as applicable to a two wheeler.	Remember	CO3	AME011.04
6	Define cone clutch as applied to a two wheeler.	Remember	CO3	AME011.05
7	Describe a transmission type dynamometer.	Remember	CO3	AME011.04
8	Describe an internal expanding brake with a neat sketch.	Remember	CO3	AME011.05
9	Deduce expression for the friction torque for a flat collar bearing considering uniform wear.	Remember	CO3	AME011.04
10	Deduce expression for the friction torque for a flat collar bearing considering uniform pressure.	Understand	CO3	AME011.06
11	Deduce expression for the friction torque for a conical collar bearing considering uniform wear.	Remember	CO3	AME011.07
12	Deduce expression for the friction torque for conical collar bearing considering uniform pressure.	Remember	CO3	AME011.06
13	Describe the working of a single plate clutch and give its applications.	Remember	CO3	AME011.07
14	Explain the working of a multi plate clutch with a neat sketch.	Understand	CO3	AME011.06
15	Deduce expression for the friction torque for a centrifugal clutch.	Remember	CO3	AME011.07
16	What is the difference between brake and clutch?	Understand	CO3	AME011.06
17	Describe briefly the various types of brakes.	Understand	CO3	AME011.07
18	Deduce the relation for ratio of tensions in a band brake.	Understand	CO3	AME011.06
19	Derive the relation for friction torque in an internal expanding shoe brake.	Understand	CO3	AME011.07
20	Explain absorption type dynamometer with a neat sketch.	Understand	CO3	AME011.06
PART - B (LONG ANSWER QUESTIONS)				
S. No	**Question**	**Blooms Taxonomy Level**	**Course Outcomes**	**Course Learning Outcomes**

1	Deduce expression for the friction torque for a flat collar bearing considering uniform wear.	Remember	CO3	AME011.06
2	Deduce expression for the friction torque for a flat collar bearing considering uniform pressure.	Understand	CO3	AME011.07
3	Deduce expression for the friction torque for a conical collar bearing considering uniform wear.	Understand	CO3	AME011.06
4	Deduce expression for the friction torque for a conical collar bearing considering uniform pressure.	Understand	CO3	AME011.07
5	Describe the working of a single plate clutch in an automobile.	Understand	CO3	AME011.06
6	Explain the working of a multi plate clutch with a neat sketch.	Understand	CO3	AME011.07
7	Deduce expression for the friction torque for a centrifugal clutch.	Understand	CO3	AME011.06
8	What is the difference between brake and clutch?	Remember	CO3	AME011.07
9	Describe briefly the various types of brakes.	Understand	CO3	AME011.06
10	What is self locking and self energized brake?	Understand	CO3	AME011.07
11	Deduce the relation for ratio of tensions in a band brake.	Remember	CO3	AME011.06
12	Derive the relation for friction torque in an internal expanding shoe brake.	Understand	CO3	AME011.07
13	Explain any one type of absorption dynamometer.	Understand	CO3	AME011.06
14	Explain any one type of transmission dynamometer	Remember	CO3	AME011.07
15	Explain transmission type dynamometer with a neat sketch.	Understand	CO3	AME011.06
16	Explain double band brake with a neat sketch.	Understand	CO3	AME011.06
17	Explain shoe brake with a neat sketch. Deduce the relation for ratio of tight side and slack side tensions.	Understand	CO3	AME011.07
18	Explain internal expanding band brake with a neat sketch.	Remember	CO3	AME011.06
19	Discuss the effectiveness of a band brake under various conditions.	Understand	CO3	AME011.06
20	What are various types of brakes? Describe briefly.	Understand	CO3	AME011.07

PART - C (ANALYTICAL QUESTIONS)

S. No	Question	Blooms Taxonomy Level	Course Outcomes	Course Learning Outcomes
1	Determine the axial force required to engage a cone clutch transmitting 20kW of power at 750 rpm. Average friction diameter of the cone is 400mm and average pressure intensity 60 kN/m^2. Semi cone angle is 100 and coefficient of friction is 0.25.Also find the width of the friction cone.	Understand	CO3	AME011.06
2	A band brake acts on 3/4th of a circumference of a brake drum of 450 mm diameter which is keyed to a shaft. The band brake provides a braking torque of 225 Nm. One end of the lever is attached to a fulcrum pin of the lever and the other end is attached to a pin 100 mm from the fulcrum. If the operating force is applied at 500 mm from the fulcrum and coefficient of friction is 0.25, find the operating force when the drum rotates in Clock-wise direction and anti- clockwise direction.	Understand	CO3	AME011.07
3	In a vertical belt transmission dynamometer, the diameter of the driving pulley rotating at 1500 rpm is 80 mm. The centre distance of the intermediate pulley from the fulcrum is also 80 mm each. The weighing pan on the lever is at a distance of 250 mm. find the power transmitted when a mass of 20kg is required on the pan including its own mass.	Understand	CO3	AME011.06
4	The following data refer to a rope brake dynamometer in a laboratory experiment. Diameter of the flywheel=1m, Diameter of the rope=10 mm, Dead weight on the brake=50 kg, Speed of the engine =180 rpm, Spring	Understand	CO3	AME011.07

	balance reading=120 N, Find the power of the engine.			
5	A conical pivot supports a load of 20kN, cone angle is 120^0 and intensity of pressure normal to the cone is $0.3N/mm^2$. The outer diameter is twice the inner diameter. Find the outer and inner radii of bearing surface if the shaft rotates at 200 rpm and μ= 0.1. Find the power absorbed in friction assuming uniform wear.	Understand	CO3	AME011.06
6	A bicycle and rider , travelling at 12 kmph on a level road have a mass of 105 kg. A brake is applied to the rear wheel which is 800 mm in diameter. The pressure on the brake is 80 N and the coefficient of friction is 0.06. Find the distance covered by the bicycle and number of turns of its wheel before coming to rest.	Understand	CO3	AME011.06
7	A simple band brake is applied to a drum of 560 mm diameter which rotates at 240 rpm. The angle of contact of the band is 270 degree. One end of the band is fastened to a fixed pin and the other end to the brake lever, 140 mm from the fixed pin. The brake lever is 800 mm long and is spaced perpendicular to the diameter that bisects the angle of contact. Assuming the coefficient of friction is 0.3, determine the necessary pull at the end of the lever to stop the drum if 40 kW of power is being absorbed. Also find the width of the band if its thickness is 3 mm and the maximum tensile stress is 40 N/mm^2.	Understand	CO3	AME011.07
8	A band and block brake has 14 blocks. Each block subtends an angle of 14 degree at the center of the rotating drum. The diameter of the drum is 750 mm and the thickness of the blocks is 65 mm. The two ends of the band are fixed to the pins on the lever at distances of 50 mm and 210 mm from the fulcrum on the opposite sides. Determine the least force required to be applied at the lever at a distance of 600 mm from the fulcrum if the power absorbed by the blocks is 180 kW at 175 rpm. Coefficient of friction between the blocks and the drum is 0.35.	Understand	CO3	AME011.06
9	A simple band brake is applied to a drum of 500 mm diameter which rotates at 200 rpm. The angle of contact of the band is 260 degree. One end of the band is fastened to a fixed pin and the other end to the brake lever, 130 mm from the fixed pin. The brake lever is 700 mm long and is spaced perpendicular to the diameter that bisects the angle of contact. Assuming the coefficient of friction is 0.3, determine the necessary pull at the end of the lever to stop the drum if 30 kW of power is being absorbed. Also find the width of the band if its thickness is 4 mm and the maximum tensile stress is 40 N/mm^2.	Understand	CO3	AME011.06
10	A band and block brake has 14 blocks. Each block subtends an angle of 14 degree at the center of the rotating drum. The diameter of the drum is 700 mm and the thickness of the blocks is 60 mm. The two ends of the band are fixed to the pins on the lever at distances of 50 mm and 210 mm from the fulcrum on the opposite sides. Determine the least force required to be applied at the lever at a distance of 600 mm from the fulcrum if the power absorbed by the blocks is 180 kW at 175 rpm. Coefficient of friction between the blocks and the drum is 0.35.	Understand	CO3	AME011.06

UNIT-III

TURNING MOMENT AND GOVERNORS

PART - A (SHORT ANSWER QUESTIONS)

S. No	Question	Blooms Taxonomy Level	Course Outcomes	Course Learning Outcomes
1	Define turning moment diagram with a neat sketch of an engine.	Remember	CO4	AME011.06
2	What is a spring loaded governor and give its application.	Remember	CO4	AME011.06
3	What are the various types of governors used for regulating speed?	Understand	CO4	AME011.06
4	Define fluctuation of energy for a multi-cylinder engine.	Understand	CO4	AME011.06
5	Define coefficient of fluctuation of speed for an engine.	Understand	CO4	AME011.06
6	What is the function of a fly wheel in a rock crusher?	Understand	CO4	AME011.06
7	Explain the function of a governor.	Understand	CO4	AME011.06
8	What is the equilibrium speed of a Porter governor?	Remember	CO4	AME011.06
9	How does a governor differ from that of flywheel?	Understand	CO4	AME011.06
10	Explain the function of flywheel in a punching press.	Understand	CO4	AME011.06
11	What is the function of a Watt governor?	Remember	CO4	AME011.06
12	Define isochronism of a Porter governor.	Remember	CO4	AME011.06
13	Define effort and power of a Proell governor.	Understand	CO4	AME011.06
14	Explain a Hartnell governor with a neat sketch.	Understand	CO4	AME011.06
15	Describe Hartung governor with a neat sketch?	Remember	CO4	AME011.06
16	Explain the function of a Porter governor?	Remember	CO4	AME011.06
17	What is a Proell governor? Explain with a neat sketch.	Remember	CO4	AME011.06
18	Derive the equation for calculating the equilibrium speed of a Porter governor	Understand	CO4	AME011.06
19	Explain the term hunting in the case of governors.	Remember	CO4	AME011.06
20	Explain the terms stability and insensitiveness in governors.	Remember	CO4	AME011.06

PART - B (LONG ANSWER QUESTIONS)

S. No	Question	Blooms Taxonomy Level	Course Outcomes	Course Learning Outcomes
1	State and explain D'Alembert's principle.	Understand	CO4	AME011.06
2	What is meant by piston effort and crank effort?	Understand	CO4	AME011.06
3	What are turning moment diagrams? Briefly explain	Understand	CO4	AME011.06
4	Define the terms coefficient of fluctuation of energy and coefficient of fluctuation of speed.	Remember	CO4	AME011.06
5	What is the function of a flywheel in a punching press?	Understand	CO4	AME011.06
6	Derive the relation for the coefficient of fluctuation of speed in terms of maximum fluctuation of energy and the kinetic energy of the flywheel at mean speed.	Understand	CO4	AME011.06
7	Describe the graphical method of determining the inertia of the connecting rod of a reciprocating engine.	Understand	CO4	AME011.06
8	What is meant by dynamically equivalent system?	Understand	CO4	AME011.06
9	Derive an expression for the angular acceleration of the connecting rod of a reciprocating engine.	Understand	CO4	AME011.06
10	What is meant by equivalent offset inertia force?	Understand	CO4	AME011.06
11	Differentiate between the functions of a governor and flywheel.	Understand	CO4	AME011.09
12	What are centrifugal governors? How do they differ from inertia governors?	Understand	CO4	AME011.10
13	Describe the function of a Watt governor.	Remember	CO4	AME011.11
14	How does a Porter governor differ from Watt governor?	Understand	CO4	AME011.09
15	What is the effect of friction in a Porter governor?	Understand	CO4	AME011.09
16	Describe the function of a Proell governor with a neat sketch.	Remember	CO4	AME011.11
17	What is a spring controlled governor?	Remember	CO4	AME011.09
18	Describe the function of a Hartnell governor.	Remember	CO4	AME011.10

19	Explain the function of a Hartung governor with a neat sketch.	Remember	CO4	AME011.11
20	Derive the expressions for the effort and power of a Porter governor.	Remember	CO4	AME011.09
PART - C (ANALYTICAL QUESTIONS)				
S. No	**Question**	**Blooms Taxonomy Level**	**Course Outcomes**	**Course Learning Outcomes**
1	A machine shaft running at 200 rpm requires a torque increasing uniformly from 1200 Nm to 3600 Nm during180^0 of rotation. It is steady at 3600 Nm for subsequent one revolution and decreases uniformly to its original value of 1200 Nm in subsequent one revolution and is again steady at 1200 Nm for the next two revolutions. This completes the cycle. The motor has a constant torque which has a rotor of mass 450 kg and 250mm radius of gyration. In addition, if it has a flywheel of mass 2000kg and 600 mm radius of gyration fitted to the shaft. Determine the power required to drive the motor and percentage fluctuation in speed.	Understand	CO4	AME011.06
2	The effective turning moment exerted by a two stroke engine at crank shaft is T= 8000+ 1000sin2θ- 2000cos2θ where θ is the inclination of the crank to inner dead center. The mass of the flywheel is 500kg and radius of gyration is 750 mm. The engine speed is 300 rpm. Determine the power developed, the total percentage fluctuation of speed and maximum angular retardation.	Remember	CO4	AME011.06
3	The turning moment diagram for a multi cylinder engine has been drawn to a scale of 1mm to 500 Nm of torque and 1mm to 60 of crank displacement The intercepted areas between the output torque curve and the mean resistance line taken in order from one end of the engine are -30, +410, -280+320, -330, +250, -360, +280, -260 mm2 when the engine runs at 800 rpm. The engine has a stroke of 300mm and the fluctuation of speed is not to exceed 2% of mean speed. Determine suitable diameter and cross section of the flywheel rim for a limiting value of safe centrifugal stress of 7 Mega Pascal. The material density is $720kg/m^3$. Width of the rim is 5 times the thickness.	Remember	CO4	AME011.06
4	The turning moment diagram for a multi cylinder engine has been drawn to a scale of 1cm= 5000Nm torque and 1cm= 600 respectively. The intercepted areas between output torque curve and mean resistance taken in order from one end are -0.3, +4.1, -2.8, +3.2, -3.3, +2.5, -3.6, +2.8, -2.6 square cm when the engine is running at 800rpm. The engine has a stroke of 300 mm and the fluctuation of speed is not to exceed 2% of mean speed. Determine a suitable diameter of cross section of the flywheel rim for limiting value of the shaft centrifugal stress of 280 X 103 N/m^2. The material density may be assumed as $7.2\ g/cm^3$. Assume the thickness of the rim to be ¼ th of the width.	Understand	CO4	AME011.06
5	A single cylinder single acting four stroke gas engine develop 20kW at 300 rpm. The work done by the gases during the expansion stroke is three times the work done on the gases during the compression stroke, the work done during the suction and exhaust strokes is negligible. If the total fluctuation of speed is not to exceed ± 2 percent of the mean speed and the turning moment diagram during compression and expansion is assumed to be triangular in shape, find the moment of inertia of the flywheel.	Remember	CO4	AME011.06
6	Each arm of a porter governor is 300 mm long and is pivoted on the axis of rotation. Each ball has a mass of 6 kg and the sleeve weighs 18kg. The radius of rotation of	Remember	CO4	AME011.06

	the ball is 200 mm when the governor begins to lift and250 mm when the speed is maximum. Determine the maximum and minimum speeds and the range of speed of the governor.			
7	The weight of each ball of a Proell governor is 90N. The central load is1500N and the arms are 250mm long. The arms are open and pivoted at a distance of 50 mm from the axis of rotation. The extension of the lower arms to which each ball is attached is 125 mm long and the radius of rotation of the balls is 250mm. When the arms are inclined at 40^0 to the axis of rotation, find i) the equilibrium speed for the above configuration and the coefficient of insensitiveness if friction is equivalent to a force of 20N at the sleeve.	Remember	CO4	AME011.06
8	A Hartnell governor having a central sleeve spring and two right angle bell crank levers moves between 290 rpm and 310 rpm for a sleeve lift of 15 mm. The sleeve arms and the ball arms are 80 mm and 120 mm respectively. The levers are pivoted at 120 mm from the governor axis and the mass of each ball is 2.5 kg. Determine the loads on the spring at the lowest and highest equilibrium speeds and the stiffness of the spring.	Remember	CO4	AME011.06
9	Calculate the minimum speed of a Porter governor, which has equal arms each 200mm long and are pivoted on the axis of rotation. The mass of each ball is 5 kg and the minimum radius of rotation for the ball is 100mm.	Remember	CO4	AME011.06
10	In a spring controlled governor of the Hartung type, the length of the ball and sleeve arms are 80mm and 120mm respectively. The total travel of the sleeve is 25 mm. In the mid position, each spring is compressed by 50mm and the radius of rotation of the mass center is 140mm. Each ball has a mass of 4 kg and the spring has a stiffness of 10kN/m. The equivalent mass at the sleeve is 16kg. Neglecting the moment due to the revolving masses, when the arms are inclined, determine the ratio of range of speed to the mean speed of the governor. Also find the speed in mid position.	Remember	CO4	AME011.06
UNIT-IV				
BALANCING OF ROTATORY AND RECIPROCATING MASSES				
PART - A (SHORT ANSWER QUESTIONS)				
S. No	**Question**	**Blooms Taxonomy Level**	**Course Outcomes**	**Course Learning Outcomes**
1	Explain balancing of a single rotating mass?	Understand	CO5	AME011.09
2	What is static balancing of a rotating mass?	Understand	CO5	AME011.10
3	What is dynamic balancing in the case of rotation in a single plane?	Understand	CO5	AME011.11
4	Explain balancing of rotating masses in different planes.	Understand	CO5	AME011.09
5	What is balancing of reciprocating masses?	Understand	CO5	AME011.10
6	Explain locomotive balancing with a neat sketch.	Understand	CO5	AME011.11
7	Define tractive force in locomotive balancing.	Remember	CO5	AME011.09
8	Explain the effect of swaying couple in locomotives.	Remember	CO5	AME011.10
9	Define hammer blow in the case of locomotives.	Remember	CO5	AME011.11
10	What is a multi cylinder engine?	Remember	CO5	AME011.09
11	Explain balancing of a V engine?	Remember	CO5	AME011.10
12	What is primary balancing of reciprocating masses?	Remember	CO5	AME011.11
13	What is secondary balancing of rotating masses?	Remember	CO5	AME011.09
14	How are unbalanced forces balanced?	Remember	CO5	AME011.11
15	What are unbalanced couples in the case of radial engines?	Understand	CO5	AME011.12
16	Explain balancing of radial engine?	Remember	CO5	AME011.13
17	What are in-line engines?	Remember	CO5	AME011.11
18	State the conditions for static balancing.	Remember	CO5	AME011.12
19	State the conditions for dynamic balancing.	Remember	CO5	AME011.13
20	What are coupled locomotives?	Remember	CO5	AME011.11

PART - B (LONG ANSWER QUESTIONS)				
S. No	**Question**	**Blooms Taxonomy Level**	**Course Outcomes**	**Course Learning Outcomes**
1	What is meant by static and dynamic unbalance in machinery?	Understand	CO5	AME011.09
2	Why is balancing necessary in rotors of high speed engines?	Remember	CO5	AME011.10
3	How are rotating masses balanced? Explain with a neat sketch.	Remember	CO5	AME011.11
4	What is balancing of reciprocating masses? Explain with a neat sketch.	Remember	CO5	AME011.09
5	Derive the expression for variation in tractive force in locomotive balancing.	Understand	CO5	AME011.10
6	Derive the expression for swaying couple in locomotive balancing.	Understand	CO5	AME011.11
7	Derive the expression for hammer blow in locomotive balancing.	Understand	CO4	AME011.11
8	What is meant by primary balancing in reciprocating engines?	Understand	CO5	AME011.12
9	What is meant by secondary balancing in reciprocating engine?	Understand	CO5	AME011.13
10	Determine the unbalanced forces and couples in case of two cylinder engines.	Remember	CO5	AME011.11
11	Determine the magnitudes of unbalanced forces in V-engines	Understand	CO5	AME011.12
12	Determine the magnitudes of unbalanced forces in radial engines	Remember	CO5	AME011.13
13	Determine the magnitudes of unbalanced forces in in-line engines.	Understand	CO5	AME011.11
14	Determine the magnitudes of unbalanced forces in multi-cylinder engines.	Understand	CO5	AME011.12
15	Explain the method of direct and reverse cranks to determine the unbalance in radial engines.	Understand	CO5	AME011.13
16	How is the effect of hammer blow reduced in coupled locomotives	Understand	CO5	AME011.11
17	Explain the method of balancing different masses revolving in the same plane.	Understand	CO5	AME011.11
18	How are different masses rotating in different planes balanced?	Understand	CO5	AME011.12
19	Explain how a single revolving mass is balanced by two masses revolving in different planes.	Remember	CO5	AME011.13
20	What are the conditions for balancing several masses revolving in the same plane?	Understand	CO5	AME011.11

PART - C (ANALYTICAL QUESTIONS)				
S. No	**Question**	**Blooms Taxonomy Level**	**Course Outcomes**	**Course Learning Outcomes**
1	The cranks of a three cylinder locomotive are set at 120^0. The stroke is 120 mm, the length of the connecting rod is 240 mm, the mass of the reciprocating parts per cylinder is 1 Kg and the speed of the crank shaft is 2400 rpm. Determine the magnitude of primary and secondary balancing.	Remember	CO5	AME011.09
2	A rigid rotor has its unbalance in one plane and can be considered to consist of three masses m1 = 5 kg at an angle of 30^0 from mass m_1 in anti clockwise direction, m2 = 3 kg at an angle of 165^0 counter clockwise from m1 and m3 = 8 kg at angle 85^0 clockwise from m_1. The radii r1 = 200mm, r2 = 80mm and r3 = 140 mm. Determine the balancing mass required at a radius of 100 mm. Specify the location of this mass with respect to m1.	Remember	CO5	AME011.10
3	An air compressor has four vertical cylinders 1,2,3 and 4 inline and the driving cranks at 90^0 intervals reach their	Remember	CO5	AME011.11

	uppermost positions in this order. The cranks are of 150 mm radius, the connecting rods 500 mm long and the cylinder centre lines 400 mm apart. The mass of the reciprocating parts of each cylinder is 22.5 kg and the speed of rotation is400 rpm. Show that there are no out of balance primary and secondary forces. Determine the corresponding couples indicating their positions for maximum values. The central plane of the machine may be taken as reference plane.			
4	The pistons of 60^0 twin V-Engine have strokes of 120 mm. The connecting rods driving a common crank and are of length 200 mm. The mass of the reciprocating parts per cylinder is 1.5 kg and the speed of the crankshaft is2500 rpm. Determine the magnitude of primary and secondary unbalanced forces.	Remember	CO5	AME011.12
5	A single cylinder horizontal engine runs at 120 rpm. The length of stroke is 400mm. The mass of the revolving parts assumed concentrated at the crank pin, is 100kg and mass of reciprocating parts is 150kg. Determine the magnitude of the balancing mass required to be placed opposite to the crank at a radius of 150mm which is equivalent to all the revolving masses and 2/3 of the reciprocating masses. If the crank turns 30^0 from the inner dead center, find the magnitude of the unbalanced force due to the balancing mass.	Remember	CO5	AME011.13
6	An inside cylinder locomotive has its cylinder center lines 0.7 m apart and has a stroke of 0.6 m. The rotating masses per cylinder are equivalent to150kg at the crank pin and the reciprocating masses per cylinder are 180kg. The wheel center lines are 1.5m apart. The cranks are at right angles. The whole of rotating parts and 2/3 of reciprocating masses are to be balanced by masses placed at a radius of 0.6m. Find the magnitude and direction of the balancing masses.	Understand	CO5	AME011.11
7	Four masses P, Q, R and S are completely balanced. Masses R and S make angles of 90^0 and 210^0 respectively with Q in the same sense. The planes containing Q and R are 300 mm apart. Masses P, Q, R and S are supposed to be concentrated at radii of 360mm, 480mm, 240mm and 300mm respectively. The masses Q, R and S are 15kg, 25kg and 20kg respectively. Determine The mass P and its angular position, The planes in which the masses P and S are placed.	Understand	CO5	AME011.13
8	The three cylinders of an air compressor have their axes120^0 to one another and their connecting rods are coupled to a single crank. The stroke is 100mm and the length of each connecting rod is 150mm. The mass of the reciprocating parts per cylinder is 1.5 kg. Find the maximum primary and secondary forces acting on the frame of the compressor when running at 3000 rpm.	Understand	CO5	AME011.14
9	A V- twin engine has the cylinder axes at right angles and the connecting rods operate a common crank. The reciprocating masses per cylinder are11.5kg and the crank radius is 75mm. The length of connecting rod is 0.3m Show that the engine may be balanced for primary forces. If the engine speed is 500rpm, what is the maximum secondary unbalanced force?	Remember	CO5	AME011.15
10	The three cylinders of an air compressor have their axes120^0 to one another and their connecting rods are coupled to a single crank. The stroke is 150mm and the length of each connecting rod is 160mm. The mass of the reciprocating parts per cylinder is 3 kg. Find the maximum primary and secondary forces acting on the frame of the compressor when running at 2000 rpm.	Remember	CO5	AME011.15
UNIT-V				

MECHANICAL VIBRATIONS				
PART - A (SHORT ANSWER QUESTIONS)				
S. No	**Question**	**Blooms Taxonomy Level**	**Course Outcomes**	**Course Learning Outcomes**
1	What is meant by longitudinal vibration?	Understand	CO5	AME011.11
2	What are the causes of vibration?	Understand	CO5	AME011.12
3	State the effects of vibration?	Understand	CO5	AME011.11
4	Define free vibration of mass attached to a spring.	Understand	CO5	AME011.12
5	Define forced vibration of a spring mass system.	Remember	CO5	AME011.13
6	Define damped vibration in spring mass damper system.	Remember	CO5	AME011.11
7	Define longitudinal vibration of mass attached to a vertical spring.	Remember	CO5	AME011.12
8	Define transverse vibration of mass attached to a vertical spring.	Understand	CO5	AME011.13
9	Define torsional vibration of a single rotor system.	Understand	CO5	AME011.11
10	Define critical Speed of shaft supported horizontally.	Understand	CO5	AME011.12
11	Explain the term under damping of a vibrating system.	Understand	CO5	AME011.13
12	What is meant by the term critical damping?	Understand	CO5	AME011.11
13	Explain the term over damping of vibrating system.	Understand	CO5	AME011.11
14	What is meant by transmissibility?	Remember	CO5	AME011.12
15	Define Damping Factor of a vibrating system.	Remember	CO5	AME011.13
16	Explain logarithmic decrement.	Remember	CO5	AME011.11
17	What is a torsionally equivalent shaft?	Remember	CO5	AME011.12
18	What is meant by magnification factor?	Remember	CO5	AME011.13
19	Explain Dunkerley’s method of vibrating system.	Understand	CO5	AME011.11
20	What is Raleigh’s method as applied to a spring mass system?	Understand	CO5	AME011.12
PART - B (LONG ANSWER QUESTIONS)				
S. No	**Question**	**Blooms Taxonomy Level**	**Course Outcomes**	**Course Learning Outcomes**
1	What are the causes of vibrations and mention their effect?	Remember	CO5	AME011.11
2	Explain the effects of vibrations in simple vibrating system.	Remember	CO5	AME011.12
3	Define free and forced vibrations of a vibrating system.	Remember	CO5	AME011.13
4	Define damped vibrations of vibrating system.	Understand	CO5	AME011.11
5	Describe with neat sketch the longitudinal free vibrations.	Understand	CO5	AME011.12
6	Describe with neat sketch the transverse free vibrations.	Understand	CO5	AME011.13
7	Derive an expression for the natural frequency of free longitudinal vibrations	Understand	CO5	AME011.11
8	Derive an expression for the natural frequency of free transverse vibrations	Understand	CO5	AME011.12
9	Derive an expression for the natural frequency of free transverse vibrations for a simply supported shaft carrying uniformly distributed mass of m kg per meter length.	Remember	CO5	AME011.13
10	Deduce an expression for the natural frequency of free transverse vibrations for a beam fixed at both ends and carrying uniformly distributed mass of m kg per meter length.	Understand	CO5	AME011.11
11	Establish an expression for the natural frequency of free transverse vibration for a simply supported beam carrying a number of point loads by energy method.	Understand	CO5	AME011.11
12	Establish an expression for the natural frequency of free transverse vibration for a simply supported beam carrying a number of point loads by Dunkerley’s method	Understand	CO5	AME011.12
13	Explain the term whirling speed or critical speed of shaft.	Understand	CO5	AME011.13
14	Prove that the whirling speed of a rotating shaft is the same as the frequency of natural transverse vibration.	Understand	CO5	AME011.11
15	Explain the terms under damping, critical damping and over damping.	Remember	CO5	AME011.12

16	Explain the term logarithmic decrement as applied to damped vibrations.	Remember	CO5	AME011.11
17	What is transmissibility in the case of a vibrating system?	Remember	CO5	AME011.12
18	Establish an expression for the amplitude of forced vibrations.	Understand	CO5	AME011.13
19	Derive the differential equation for the motion of an oscillating system subjected to viscous damping without a periodic excitation force.	Understand	CO5	AME011.11
20	Derive the equation for natural frequency of free torsional vibration of three rotor system.	Understand	CO5	AME011.12
PART - C (ANALYTICAL QUESTIONS)				
S. No	**Question**	**Blooms Taxonomy Level**	**Course Outcomes**	**Course Learning Outcomes**
1	A shaft 50 mm diameter and 3 m long is simply supported at its ends and carries three loads of 1000 N, 1500N and 750N at 1m, 2m and 2.5m from the left support. Modulus of elasticity is 200 GN/m2. Find the frequency of transverse vibrations.	Understand	CO5	AME011.13
2	A cantilever shaft of 50 mm diameter and 300 mm long has a disc of mass100 kg at its free end. The Young's modulus of the shaft material is 200 GN/m^2. Determine the frequency of longitudinal and transverse vibrations of the shaft.	Remember	CO5	AME011.14
3	A vibrating system consists of a mass of 50 kg, a spring of stiffness 30kN/m and a damper. The damping provided is only 20% of the critical value. Determine the damping factor, critical damping coefficient and logarithmic decrement.	Remember	CO5	AME011.15
4	Calculate the whirling speed of a shaft 20 mm diameter and 0.6 m long, carrying a mass of 1 kg at its mid point. Density of the shaft material is 40 Mg/m3 and E = 200 GN/m2. Assume freely supported shaft.	Understand	CO5	AME011.13
5	A 1.5 m long shaft AB has flywheels at its ends A and B. The mass of the flywheel at the end A is 600kg and its radius of gyration is 400mm. The corresponding values for the flywheel at the end B are300kg and 300 mm. The diameter of the shaft for the first 400mm starting from the end A is 50mm, 60 mm diameter for the next portion of 500 mm length and the remaining portion of 600mm length is unknown. Determine the diameter of the shaft for the portion B so that the node of the torsional vibration of the system will be at the center of 500 mm long segment. Also determine the frequency of vibration.	Remember	CO5	AME011.14
6	A stepped shaft of 0.05 m in diameter for the first 0.6 m length, 0.08 m diameter for the next 1.8 m and 0.03 m diameter for the remaining 0.25 m length. While the 0.05 m diameter end is fixed, the 0.03 m diameter end of the shaft carries a rotor of mass moment of inertia 14.7 kg-m2. If the modulus of elasticity of the shaft material is 0.83 x 1011 N/m2, find the natural frequency of torsional oscillations, neglecting the inertia effect of the shaft.	Remember	CO5	AME011.1 5
7	A shaft 100 mm diameter and 1000 mm long is fixed at one end and the other end carries a flywheel of mass 90 kg. The radius of gyration of the flywheel is 500mm. Find the frequency of torsional vibration, if the modulus of rigidity for the shaft material is 80GN/m^2.	Remember	CO5	AME011.13
8	A single cylinder engine of total mass 200kg is to be mounted on an elastic support which permits vibratory movement in vertical direction only. The mass of the piston is 3.5 kg and has a vertical simple harmonic motion with a stroke of 150mm. It is desired that the maximum vibratory force transmitted through the elastic support to the foundation shall be 600N when the engine speed is 800	Remember	CO5	AME011.14

	rpm. Find the necessary stiffness of the elastic support and the amplitude of vibration at 800 rpm.			
9	An instrument vibrates with a natural frequency of 1 Hz. when there is no damping. When the damping is provided, the frequency of damped vibration was observed to be 0.9 Hz. Find the damping factor and logarithmic decrement.	Remember	CO5	AME011.15
10	A body of mass 20kg is suspended from a spring which deflects 15mm under this load. Calculate the frequency of free vibrations and verify that a viscous damping force of 1000N at a speed of 1 m/s is just sufficient to make the motion aperiodic.	Remember	CO5	AME011.13

Prepared by:
Dr. K Viswanath Allamraju, Professor
Prof. V V S H Prasad, Professor

HOD, ME