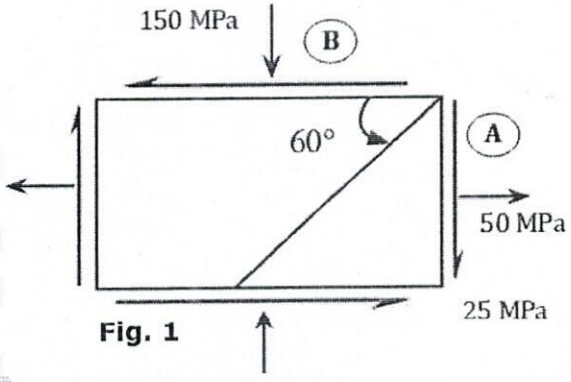
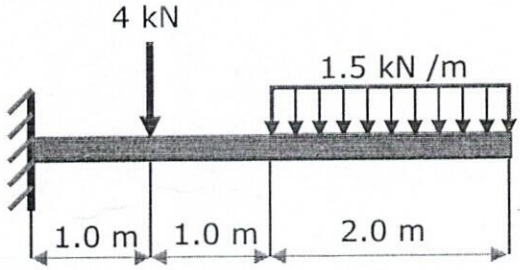
NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR
Even Semester Mid-term Examination, 2023-24

Course Code: MEC301
Course Name: Solid Mechanics

Full Marks: 25
Time: 90 Mins

Instructions: Answer all the questions. Assume suitable data whenever necessary.

Question No.	Body of the Question	Marks	Mapped CO
1	(A) Define the following terms and write their unit in SI system (i) Stress at a point (ii) Young's modulus (iii) Modulus of rigidity (iv) Poisson's ratio (v) Bulk modulus	2.5	CO1
	(B) A steel bar of 15 mm diameter is subjected to an axial load of 30 kN. If the change in diameter is found to be 0.004 mm. Determine the Poisson's ratio, and the magnitudes of the modulus of elasticity (E) and the bulk modulus (K). Assume the magnitude of modulus of rigidity $G = 80$ GPa.	4	
2	At a certain point in a strained material, there exists a state of stress condition as shown in **Fig. 1**. Determine the a) Normal and shear stresses on the inclined plane AB b) Principal stresses and associated planes c) Maximum in-plane shearing stress and its orientation.  **Fig. 1**	6	CO1
3	Calculate and Draw the shear force and bending moment diagrams across the length of the cantilever beam as shown in the **Fig. 2.**  **Fig. 2:** A cantilever beam	6	CO2

Course Outcomes
CO1: Knowledge on the analysis of stress, strains, elasticity properties of materials, strain energy principles.
CO2: Exposure towards members subjected to shear force, bending moments, flexure loads, torsional loads.

4	A simply supported beam of width 100 mm, height 200 mm and length 4 m is carrying a uniformly distributed load of intensity 10 kN/m. Determine the maximum bending stress (in MPa) in the beam. Derive the flexure formulae. **OR** A cantilever beam is made of wood with cross-sectional dimensions: width 120 mm and height 200 mm. Calculate the shear stresses due to the 8kN load acting at the free end at points located 25 mm, 50 mm, 75 mm, and 100 mm from the top surface of the beam. From these results, plot a graph showing the distribution of shear stresses from top to bottom of the beam.	6.5	CO2

NITDGP/BTECH/Reg/Odd/2023-24

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

Odd Semester Mid-Term Examination, 2023-24

Course Code: MEC 302 Full Marks: 25

Course Name: THEORY OF MACHINES AND MECHANISMS Time: 90 Minutes

Instructions: Answer all the questions.

Materials to be supplied: Graph paper shall be supplied, if required.

Question No.	Body of the Question	Marks	Mapped CO
1	Answer any four of the following questions briefly; (a) "All machines are mechanisms but all mechanisms are not machines"- Justify (b) Describe the different kinematic pairs according to nature of relative motion. (c) Describe the principle of crank-slotted lever quick return mechanism. (d) Derive the expression of acceleration of slider of an I C engine. (e) Explain the principle of the compound gear train. (f) Drive the expression of thrust on connecting rod in term of piston effort.	2x4=8	CO1
2.	(a) Describe the methodology to create a dynamically equivalent connecting rod of an IC engine. What's the necessity of it? (b) The radius of crank of a horizontal engine is 300 mm. The mass of the reciprocating parts is 200 kg. The difference between the driving and the back pressures is 0.4 N/mm2 when the crank has travelled 60° from I.D.C. The length of connecting rod is 1.2 m and the cylinder bore is 0.5 m. The engine runs at 240 rpm. Neglecting the effect of the piston rod, find (a) piston effort, (b) thrust in the connecting rod, and (c) turning moment on the crankshaft.	4+6=10	CO1

Course Outcomes

CO1: Knowledge of dynamics of elementary mechanisms and machines

CO2: One of the fundamental subject for machine design

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NITDGP/BTECH/Reg/Odd/2023-24

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

Odd Semester Mid-Term Examination, 2023-24

Course Code: MEC 302 Full Marks: 25

Course Name: THEORY OF MACHINES AND MECHANISMS Time: 90 Minutes

3.	(a) Distinguish between planar mechanism and spatial mechanism. (b) What is the purpose of kinematic synthesis? Explain with suitable example. (c) What is transmission angle? What is the optimal value of the transmission angle of a 4R linkage?	1x3=3	CO1
4.	In a 4R planar mechanism, the dimensions of the links are given as: Length of the crank=5 cm; length of the coupler=6.6 cm; length of the follower=5.6 cm; length of the fixed link=10 cm and $\theta_1=0°$. The crank rotates at uniform angular velocity of 2 rad/s in anti-clockwise direction. Determine the angular displacement and angular velocity of the follower when the crank angular position is 60°.	4	CO1

Course Outcomes

CO1: Knowledge of dynamics of elementary mechanisms and machines

CO2: One of the fundamental subject for machine desi

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

Mid Term Examination, 2023-24

Course Code: MEC 303
Course Name: Fluid Mechanics

Full Marks: 25
Time: 90 Minutes

Instructions: Answer all the questions. (SCR-1 to 4, RNB- 5 to 7 and JaD-8 to 10)
Materials to be supplied: Graph paper shall be supplied, if required.

Group-A (SCR)			
Q no.	Body of the Question	Marks	Mapped CO
1	3D general continuity equation in Cartesian Coordinate system from the first principle is $\frac{\partial \rho}{\partial t} + \vec{\nabla} \bullet \rho \vec{V} = 0$. Derive continuity equation (i) considering Incompressible flow and (ii) considering steady flow.	1+1	CO2
2	The x-component of velocity in a steady, incompressible flow field in xy plane is $u = x^2 - 2xy$, where x and y are measured in meters. Find the simplest y - component of velocity for this flow field .	1	CO2
3	For an incompressible flow in $r\theta$ plane, the $r-$ component of velocity is given as, $V_r = \frac{-A\cos^2\theta}{r^2}$. Find the simplest $\theta-$component of velocity.	1	CO2
4	A fluid flows down a plane inclined to horizontal by θ . The x axis is positive along the flow direction and y axis is perpendicular to the inclined plane and is positive in upward direction. The laminar film thickness , h along the positive axis. The following assumptions are made to model the flow field using Continuity and Navier- Stokes equations: (a) Steady flow. (b) Incompressible flow constant $i.e.\ \rho =$ constant . (c) No flow or variation of properties in the z direction; $w = 0$ and $\frac{\partial(.)}{\partial z} = 0$. (d) Fully developed flow, so no properties vary in the x direction; *i.e.* $\frac{\partial(.)}{\partial x} = 0$. Answer the following: (i) Deduce the governing equation of the flow field. (ii) Find the velocity profile. (iii) Estimate the shear stress distribution.	2+1.5+1	CO2
Group-B (RNB)			
5	Define Knudsen number. What do you mean by No-Slip Boundary Condition of viscous Fluids? What is the significance of Mach Number?	3	CO1
6	A cylinder of 0.12 m radius rotates concentrically inside a fixed hollow cylinder of 0.13 m radius. Both the cylinders are 0.3m long. Determine the viscosity of the liquid which fills the space between the cylinders if a torque of 0.88 Nm is	2.5	CO1

Course Outcomes
CO1: : To understand the fundamental concepts of fluid mechanics
CO2: To formulate the fundamental equations in mathematical form to solve the fluid mechanics problems
CO3: To apply the conservation equations to analyse both viscous and inviscid flow.

	required to maintain an angular velocity of 2π rad/s.		
7.	Prove that due to surface tension a curved liquid interface in equilibrium results in a greater pressure at the concave side of the surface than that at its convex side.	3	CO1
	Group-C (JaD)		
8	Using simple scaling analysis, show that the term $\frac{\partial^2 u}{\partial x^2}$ (in the x-momentum equation) is not significant in comparison to the term $\frac{\partial^2 u}{\partial y^2}$ within a hydrodynamic boundary layer for high Reynolds number flows.	3	CO1
9	If a graph is plotted with logarithm of Reynolds number $\left(\log(\mathrm{Re})\right)$ as its x-axis and logarithm of skin-friction coefficient $\left(\log(C_f)\right)$ as its y-axis, what will be the slope of the plot?	2	CO2
10	An incompressible fluid flows over a flat plate with a constant approach velocity at its leading edge. At a certain distance from the leading edge, the Reynolds number is 10^5 and the boundary layer thickness is 2 mm. If the velocity of the incoming fluid is decreased by a factor of 16, what will be the new boundary layer thickness at the location having the same distance from the leading edge?	3	CO2

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

Odd Semester Mid-Term Examination, 2023-24

Course Code: MEC 304 Full Marks: 25

Course Name: ENGINEERING THERMODYNAMICS Time: 90 Minutes

Instructions: Answer all the questions.
Assume suitable data if needed. Symbols used carry their usual meanings.

Question No.	Body of the Question	Marks	Mapped CO
1	a) Define in words: (i) closed system (ii) open system Also, mention at least two examples of each.	1	CO1
	b) What are the different forms of work transfer between a system and its surroundings? Is paddle wheel work is a reversible work of irreversible work? Explain.	3	CO1
	c) A gas of mass 1.5 kg undergoes a quasi-static expansion which follows a relationship $p = a+bV$, where a and b are constants. The initial and final pressure are 1000 kPa and 200 kPa, respectively and the corresponding volumes are 0.20 m^3 and 1.20 m^3. The specific internal energy of the gas is given by $u = 1.5\ pv - 85$ kJ/kg, where p is in kPa and v in m^3/kg. Calculate the net heat transfer and the maximum internal energy of the gas attained during expansion.	5	CO2
2	a) Define air standard efficiency and explain its importance.	1	CO3
	b) Derive the expression of air standard efficiency and mean effective pressure for Otto cycle.	4	CO3
	c) An engine of 250 mm bore and 275 mm stroke works on Otto cycle. The clearance volume is 0.00169 m^3. The initial pressure and temperature are 1 bar and 25°C. If the maximum pressure is limited to 22 bar, find the air standard efficiency and mean effective pressure of the cycle.	3	CO3
3	a) Draw the phase equilibrium diagram on Pressure-Temperature and Temperature- specific entropy for a substance which shrinks in volume on melting at a temperature variation between (-) 50°C and 150°C.	2	CO4
	b) Write short note on h-s diagram of steam.	1	CO4
	c) Draw the Carnot cycle on p-v and T-s planes and derive its efficiency. Why Carnot cycle is not a practical cycle?	2	CO4
	d) Steam enters a surface condenser at 32◦C at the rate of 3000 kg/hr. The dryness fraction of steam is 0.9. Determine the rate at which cooling water is to be supplied to the condenser if the rise in temperature of cooling water is 10◦C. Take specific heat of water as 4.187 kJ/kg.K. Given: @ 32◦C: $h_f = 134$ kJ/kg, $h_{fg} = 2425.8$ kJ/kg.	3	CO4

Course Outcomes
CO1: Knowledge of thermodynamical system
CO2: Mastering laws of thermodynamics
CO3: Study of air standard thermodynamic cycles
CO4: Properties of pure substance
CO5: Thermodynamic relations

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

Odd Semester Mid-Term Examination, 2023-24

Course Code: MEC501 Full Marks: 25

Course Name: Machining and Machine Tools Time: 1½ Hours

All questions are compulsory :: Notations carry their usual meanings.

Q. No.	Question	Marks	Mapped CO
1.	a) Show orthogonal rake angle and principal clearance angle of a single point cutting tool with a neat sketch. b) Describe the mechanism of chip formation. Also, discuss Piispanen's model of card analogy with a neat sketch in this context. c) What are the various forces in machining? Illustrate them with neat sketch(es).	2 4½+2 4	CO1
2.	a) Define machine tools. b) With a neat sketch, explain the working principle of apron mechanism in a lathe. Also find apron constant for the described mechanism.	1 5½	CO2
3.	a) Explain feed and depth of cut with neat sketch for shaping operation. b) Explain the effect of feed with suitable diagram for the surface finish on the flat surface generated in shaping operation.	2 4	CO2

Course Outcomes:
CO1: Knowledge of fundamental machining processes and the underlying sciences of machining and the related processes.
CO2: Various machine tools, their operations and the mechanisms in machine tools.

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

Odd Semester Mid-Term Examination, 2023-24

Course Code: MEC502 Full Marks: 25

Course Name: I C Engine and Gas Turbines Time: 90 Minutes

Instructions: Answer all the questions.
Materials to be supplied: None.

Q. No.	Body of the Question	Marks	Mapped CO
	Part –A Answer Q. No 1 and any one among Q. Nos. 2 and 3		
1	(a) Explain Octane number and its significance. (b) How do you identify Cetane number of an unknown CI engine fuel? (c) Explain self-ignition and ignition delay in context of IC engine.	2+2+3	CO1, CO2
2	(a) A racing car burns nitro-methane (CH_3NO_2) with air at an equivalence ratio of 1.25. Except for unburned fuel, all nitrogen ends up as N_2, all Carbon ends up as CO_2, and all Hydrogen ends up as H_2O. Write the balanced chemical equation. Calculate: (i) Percent stoichiometric air [%] and (ii) Air-fuel ratio.	5	CO1, CO2
3	(a) Comment on the octane numbers of alcohol fuels. How it can be used in diesel engine? (b) Write 3 disadvantages of alcohol fuels and 3 advantages of hydrogen as fuel.	2+3	CO5
	Part –B Answer all		
4	(a) A large diesel engine runs on four stroke cycle at 2000 rpm. The engine has a displacement of 25 liters and a brake mean effective pressure of 0.6 MN/m^2. It consumes 0.018 kg/s of fuel (calorific value = 42000 kJ/kg). Determine the brake power and brake thermal efficiency. (b) Discuss briefly the basic parameters by which performance of an engine is evaluated. (c) Describe briefly how the I.P. of a multi-cylinder SI engine is measured?	2+3+3	CO1
5	(a) In a test of a 4-cylinder, 4-stroke engine 75 mm bore and 100 mm stroke, the following results were obtained at full throttle at a particular constant speed with fixed setting of fuel supply of 6 kg/h, BP with all cylinder working = 15.6 kW BP with cylinder no. 1 cut out = 11.1 kW BP with cylinder no. 2 cut out = 11.03 kW BP with cylinder no. 3 cut out = 10.88 kW BP with cylinder no. 4 cut out = 10.66 kW If the calorific value of the fuel is 83 600 kJ/ kg and clearance volume is 0.0001 m^3, calculate: (i) Mechanical efficiency, (ii) Indicated thermal efficiency and (iii) air standard efficiency. (b) Describe the Willan's line method used for measurement of frictional power of an engine.	3+2	CO2

Course Outcomes
CO1: Concept of internal combustion engines
CO2: Mechanism of internal combustion engines
CO3: Pollution from internal combustion engines
CO4: Mechanism of gas turbines
CO5: Outlines of alternative fuels

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

Even Semester Mid-term Examination, 2023-24

Course Code: MEC503
Course Name: Machine Design

Full Marks: 25
Time: 90 Mins

Instructions: Answer all the questions. Assume suitable data whenever necessary.

Question No.	Body of the Question	Marks	Mapped CO
1	In design of friction clutch, uniform wear theory is used. Why?	2	CO2
2	Design a suitable clutch for a speed gear-box of a milling machine to transmit 15 kW at 1440 rpm. Due to space limitation the outer diameter is limited to 120 mm, **Hints:** Use a multi disk clutch with μ=0.2 and p_{max} = 0.35 N/ mm^2 with a maximum operating temperature as 260° C.	4	CO2
3	What is the constructional difference between simple band brakes and Differential band brakes, give sketches. Which one of the above can be used as back-stop brake?	3.5	CO2
4	In reference of the above sketches deduce conditions of self-locking.	3	CO2
5	A fan is to be connected to a 4.5 kW 1440 rpm motor, mounted vertically above it, by means of a flat belt. The diameter of the motor pulley is 240 mm and the fan is to rotate at about 480 rpm. A layout of the drive shows an angle of lap of the belt on the motor pulley as 165 degrees. A rubber belt is to be used, of which two types of thickness are available: 5mm and 8mm and one of them is to be selected. The expected average coefficient of friction between belt and the pulley is 0.3. Assuming a service factor of 1.2 and an allowable stress in the belt of 2.4 MPa, determine the width of the belt required. The density of the belt material is 1.2 gram per cubic centimetre.	7	CO2
6	(a) Explain the following terminologies of a straight tooth spur gear drive with a neat sketch: (i) Addendum circle (ii) Pitch circle diameter (iii) Pressure angle (b) The number of teeth in a spur gear is 28. The gear has a module of 2 mm and it rotates at 250 r.p.m. Calculate its circular pitch and pitch line velocity	3 + 2.5 = 5.5	CO5

Course Outcomes
CO1 Detail analysis of members under fatigue loads
CO2 Design procedures for some machine elements used in mechanical drives
CO3 Exposed to the importance of engineering tolerances and its use
CO4 Introduction to different types of bearings and lubrications
CO5 To understand the basics of gear mechanics

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

Odd Semester Mid-Term Examination, 2023-24

Course Code: MEC 504 Full Marks: 25

Course Name: DYNAMICS OF MACHINERY Time: 90 Minutes

	A flywheel of mass 10 kg has a radius of gyration of 0.3 m. It is given a spin of 1000 rpm clockwise looking from the right about its axis which is horizontal. The flywheel is suspended at a point 20 cm from the plane of rotation of the flywheel. Determine the motion of the flywheel due to the gyroscopic effect.		
4	A motor cycle with its rider has a mass of 200 kg. The centre of gravity of the motor cycle and rider combined being 0.8 m above the ground level when the motor cycle is upright. Each wheel of the motor cycle is of 0.8 m diameter and has a moment of inertia of 0.8 kg-m^2. The engine rotates at six times the speed of the road wheels and is in same sense. The moment of inertia of the rotating parts of the engine is 0.18 kg. m^2. (i) Determine the angle of heel necessary when the motor cycle takes a turn of 30 m radius at a speed of 60 km/hr. (ii) If the road and tyre friction allow for angle of heel not to exceed 45^0 and the motor cycle takes a turn of 30 m, what is the maximum road velocity of the motor cycle? **Or** Each wheel of the of a four wheeled rear engine automobile has a moment of inertia of 2.4 kg m^2 and an effective diameter of 0.6 m. The moment of inertia of the rotating parts of the engine is 1.2 kg. m^2. The gear ratio of engine to the back wheel is 3 to 1. The engine axis is parallel to the rear axle and the crank shaft rotates in the same sense as the road wheels. The mass of the vehicle is 2200 kg and the centre of mass of the vehicle is 0.5 m above the road level. The track width of the vehicle is 1.2 m. Determine the limiting speed of the vehicle around a curve with 100 m radius so that all the four wheels maintains contact with the road surface.	10	CO1

Course Outcomes
CO1: Knowledge of gyroscopic motion of dynamic mechanical system
CO2: Knowledge of balancing of rotating and reciprocating machines
CO3: Knowledge of longitudinal, torsional and transverse vibration of mechanical system

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

Odd Semester Mid-Term Examination, 2023-24

Course Code: MEC 504 Full Marks: 25

Course Name: DYNAMICS OF MACHINERY Time: 90 Minutes

	A flywheel of mass 10 kg has a radius of gyration of 0.3 m. It is given a spin of 1000 rpm clockwise looking from the right about its axis which is horizontal. The flywheel is suspended at a point 20 cm from the plane of rotation of the flywheel. Determine the motion of the flywheel due to the gyroscopic effect.		
4	A motor cycle with its rider has a mass of 200 kg. The centre of gravity of the motor cycle and rider combined being 0.8 m above the ground level when the motor cycle is upright. Each wheel of the motor cycle is of 0.8 m diameter and has a moment of inertia of 0.8 kg-m^2. The engine rotates at six times the speed of the road wheels and is in same sense. The moment of inertia of the rotating parts of the engine is 0.18 kg. m^2. (i) Determine the angle of heel necessary when the motor cycle takes a turn of 30 m radius at a speed of 60 km/hr. (ii) If the road and tyre friction allow for angle of heel not to exceed 45^0 and the motor cycle takes a turn of 30 m, what is the maximum road velocity of the motor cycle? **Or** Each wheel of the of a four wheeled rear engine automobile has a moment of inertia of 2.4 kg m^2 and an effective diameter of 0.6 m. The moment of inertia of the rotating parts of the engine is 1.2 kg. m^2. The gear ratio of engine to the back wheel is 3 to 1. The engine axis is parallel to the rear axle and the crank shaft rotates in the same sense as the road wheels. The mass of the vehicle is 2200 kg and the centre of mass of the vehicle is 0.5 m above the road level. The track width of the vehicle is 1.2 m. Determine the limiting speed of the vehicle around a curve with 100 m radius so that all the four wheels maintains contact with the road surface.	10	CO1

Course Outcomes
CO1: Knowledge of gyroscopic motion of dynamic mechanical system
CO2: Knowledge of balancing of rotating and reciprocating machines
CO3: Knowledge of longitudinal, torsional and transverse vibration of mechanical system