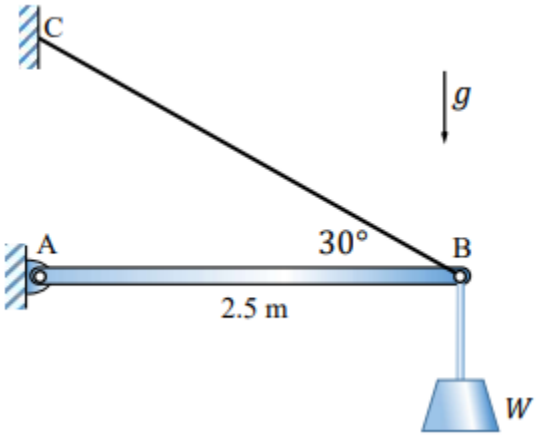
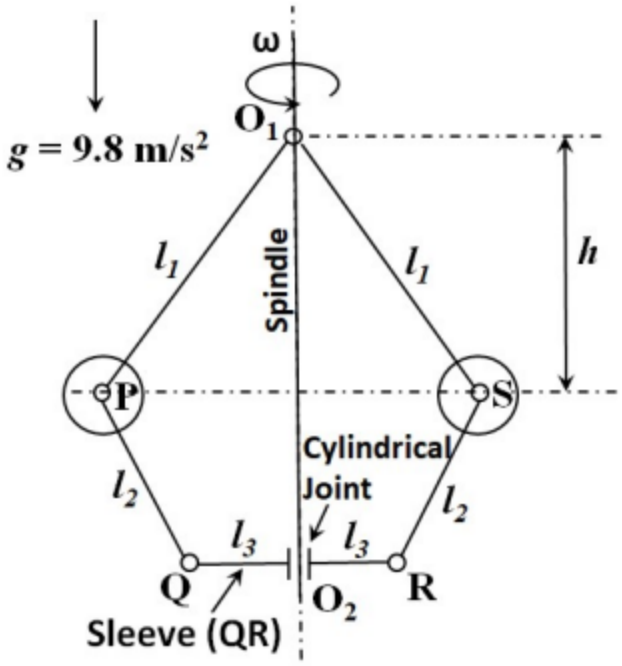
Q1) The Fourier series expansion of x^3 in the interval $-1 \leq x < 1$ with periodic continuation has
(A) only sine terms
(B) only cosine terms
(C) both sine and cosine terms
(D) only sine terms and a non-zero constant

Q2) A uniform light slender beam AB of section modulus EI is pinned by a frictionless joint A to the ground and supported by a light inextensible cable CB to hang a weight W as shown. If the maximum value of W to avoid buckling of the beam AB is obtained as $\beta\pi^2 EI$, where π is the ratio of circumference to diameter of a circle, then the value of β is



(A) 0.0924 m-2
(B) 0.0713 m-2
(C) 0.1261 m-2
(D) 0.1417 m-2

Q3) The figure shows a schematic of a simple Watt governor mechanism with the spindle O_1O_2 rotating at an angular velocity ω about a vertical axis. The balls at P and S have equal mass. Assume that there is no friction anywhere and all other components are massless and rigid. The vertical distance between the horizontal plane of rotation of the balls and the pivot O1 is denoted by h. The value of h = 400 mm at a certain ω. If ω is doubled, the value of h will be _____ mm.



(A) 50
(B) 100
(C) 150
(D) 200

Q4) A square threaded screw is used to lift a load W by applying a force F. Efficiency of square threaded screw is expressed as
(A) The ratio of work done by W per revolution to work done by F per revolution
(B) W/F
(C) F/W
(D) The ratio of work done by F per revolution to work done by W per revolution

Q5) A CNC worktable is driven in a linear direction by a lead screw connected directly to a stepper motor. The pitch of the lead screw is 5 mm. The stepper motor completes one full revolution upon receiving 600 pulses. If the worktable speed is 5 m/minute and there is no missed pulse, then the pulse rate being received by the stepper motor is
(A) 20 kHz
(B) 10 kHz
(C) 3 kHz
(D) 15 kHz

Q6) In a linear programming problem, if a resource is not fully utilised, the shadow

price of that resource is
(A) positive
(B) negative
(C) zero
(D) infinity

Q7) Which one of the following is NOT a form of inventory?
(A) Raw materials
(B) Work-in-process materials
(C) Finished goods
(D) CNC Milling Machines

Q8) The Clausius inequality holds good for
(A) any process
(B) any cycle
(C) only reversible process
(D) only reversible cycle

Q9) In the following two-dimensional momentum equation for natural convection over a surface immersed in a quiescent fluid at temperature T_∞ (g is the gravitational acceleration, β is the volumetric thermal expansion coefficient, $\boldsymbol{\nu}$ is the kinematic viscosity, u and v are the velocities in x and y directions, respectively, and T is the temperature)

$$u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} = g\beta(T - T_\infty) + \boldsymbol{\nu}\frac{\partial^2 u}{\partial y^2}$$

the term $g\beta(T - T_\infty)$ represents
(A) Ratio of inertial force to viscous force.
(B) Ratio of buoyancy force to viscous force.
(C) Viscous force per unit mass.
(D) Buoyancy force per unit mass.

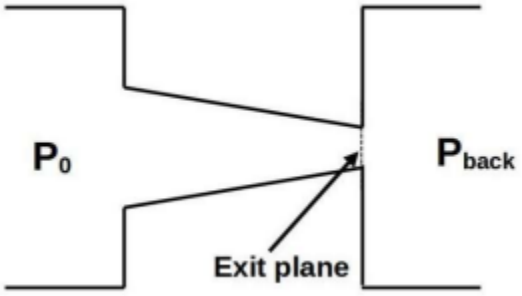
Q10) Assuming the material considered in each statement is homogeneous, isotropic, linear elastic, and the deformations are in the elastic range, which one or more of the following statement(s) is/are TRUE?
(A) A body subjected to hydrostatic pressure has no shear stress.
(B) If a long solid steel rod is subjected to tensile load, then its volume increases.
(C) Maximum shear stress theory is suitable for failure analysis of brittle materials.
(D) If a portion of a beam has zero shear force, then the corresponding portion of the elastic curve of the beam is always straight.

Q11) Which of the following heat treatment processes is/are used for surface hardening of steels?
(A) Carburizing
(B) Cyaniding
(C) Annealing
(D) Carbonitriding

Q12) Which of the following additive manufacturing technique(s) can use a wire as a feedstock material?
(A) Stereolithography
(B) Fused deposition modelling
(C) Selective laser sintering
(D) Directed energy deposition processes

Q13) Which of the following methods can improve the fatigue strength of a circular mild steel (MS) shaft?
(A) Enhancing surface finish
(B) Shot peening of the shaft
(C) Increasing relative humidity
(D) Reducing relative humidity

Q14) The figure shows a purely convergent nozzle with a steady, inviscid compressible flow of an ideal gas with constant thermophysical properties operating under choked condition. The exit plane shown in the figure is located within the nozzle. If the inlet pressure (P_0) is increased while keeping the back pressure (P_{back}) unchanged, which of the following statements is/are true?



(A) Mass flow rate through the nozzle will remain unchanged.
(B) Mach number at the exit plane of the nozzle will remain unchanged at unity.
(C) Mass flow rate through the nozzle will increase.
(D) Mach number at the exit plane of the nozzle will become more than unity.

Q15) Match the following metal forming processes with their associated stresses in the workpiece.

Metal Forming Process	Type Of Stress
1. Coining	P. Tensile
2. Wire Drawing	Q. Shear
3. Blanking	R. Tensile and compressive
4. Deep Drawing	S. Compressive

(A) 1-S, 2-P, 3-Q, 4-R
(B) 1-S, 2-P, 3-R, 4-Q
(C) 1-P, 2-Q, 3-S, 4-R
(D) 1-P, 2-R, 3-Q, 4-S

Q16) During normalising process of steel, the specimen is heated
(A) between the upper and lower critical temperature and cooled in still air.
(B) above the upper critical temperature and cooled in furnace.
(C) above the upper critical temperature and cooled in still air.
(D) between the upper and lower critical temperature and cooled in the furnace.

Q17) In abrasive jet machining, as the distance between the nozzle tip and the work surface increases, the material removal rate
(A) increases continuously.
(B) decreases continuously.
(C) decreases, becomes stable and then increases.
(D) increases, becomes stable and then decreases

Q18) The following are the data for two crossed helical gears used for speed reduction:
Gear I : Pitch circle diameter in the plane of rotation 80 mm and helix angle 30º
Gear II : Pitch circle diameter in the plane of rotation 120 mm and helix angle 22.5º
If the input speed is 1440 rpm, the output speed in rpm is
(A) 1200
(B) 900
(C) 875
(D) 720

Q19) A thin walled spherical shell is subjected to an internal pressure. If the radius of the shell is increased by 1% and the thickness is reduced by 1%, with the internal pressure remaining the same, the percentage change in the circumferential (hoop) stress is
(A) 0
(B) 1
(C) 1.08
(D) 2.02

Q20) Which one of the following is NOT a decision taken during the aggregate production planning stage?
(A) Scheduling of machines
(B) Amount of labour to be committed
(C) Rate at which production should happen
(D) Inventory to be carried forward

Q21) A solid cylinder of diameter 100 mm and height 50 mm is forged between two frictionless flat dies to a height of 25 mm. The percentage change in diameter is
(A) 0
(B) 2.07
(C) 20.7
(D) 41.4

Q22) Which one of the following configurations has the highest fin effectiveness?
(A) Thin, closely spaced fins
(B) Thin, widely spaced fins
(C) Thick, widely spaced fins
(D) Thick, closely spaced fins

Q23) A circular solid disc of uniform thickness 20 mm, radius 200 mm and mass 20 kg, is used as a flywheel. If it rotates at 600 rpm, the kinetic energy of the flywheel, in Joules is
(A) 395
(B) 790
(C) 1580
(D) 3160

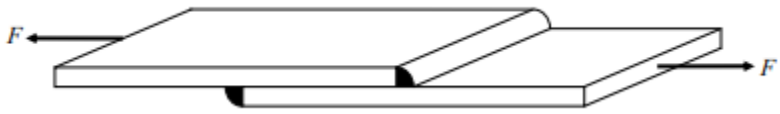
Q24) For a long slender column of uniform cross section, the ratio of critical buckling load for the case with both ends clamped to the case with both ends hinged is
(A) 1

(B) 2
(C) 4
(D) 8

Q25) In a single pass drilling operation, a through hole of 15 mm diameter is to be drilled in a steel plate of 50 mm thickness. Drill spindle speed is 500 rpm, feed is 0.2 mm/rev and drill point angle is 118°. Assuming 2 mm clearance at approach and exit, the total drill time (in seconds) is
(A) 35.1
(B) 32.4
(C) 31.2
(D) 30.1

Q26) An incompressible fluid flows over a flat plate with zero pressure gradient. The boundary layer thickness is 1 mm at a location where the Reynolds number is 1000. If the velocity of the fluid alone is increased by a factor of 4, then the boundary layer thickness at the same location, in mm will be
(A) 4
(B) 2
(C) 0.5
(D) 0.25

Q27) A fillet welded joint is subjected to transverse loading F as shown in the figure. Both legs of the fillets are of 10 mm size and the weld length is 30 mm. If the allowable shear stress of the weld is 94 MPa, considering the minimum throat area of the weld, the maximum allowable transverse load in kN is



(A) 14.44
(B) 17.92
(C) 19.93
(D) 22.16

Linked Answer Question

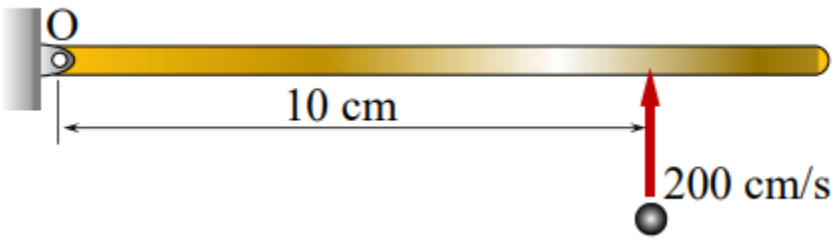
Air enters an adiabatic nozzle at 300 kPa, 500 K with a velocity of 10 m/s. It leaves the nozzle at 100 kPa with a velocity of 180 m/s. The inlet area is 80 cm^2. The specific heat of air C_p is 1008 J/kg.K.

Q28) The exit temperature of the air is
(A) 516 K
(B) 532 K
(C) 484 K
(D) 468 K

Q29) The exit area of the nozzle in cm^2 is
(A) 90.1
(B) 56.3
(C) 4.4
(D) 12.9

Q30) The state of stress at a point under plane stress condition is
σ_{xx} = 40 MPa, σ_{yy} = 100 MPa and τ_{xy} = 40 MPa.
The radius of the Mohr's circle representing the given state of stress in MPa is
(A) 40
(B) 50
(C) 60
(D) 100

Q31) The plane of the figure represents a horizontal plane. A thin rigid rod at rest is pivoted without friction about a fixed vertical axis passing through O. Its mass moment of inertia is equal to 0.1 kg·cm^2 about O. A point mass of 0.001 kg hits it normally at 200 cm/s at the location shown, and sticks to it. Immediately after the impact, the angular velocity of the rod is _____ rad/s (in integer).



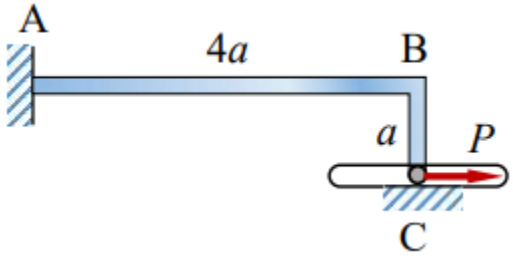
Q32) Electrochemical machining operations are performed with tungsten as the tool, and copper and aluminium as two different workpiece materials. Properties of copper and aluminium are given in the table below.

Material	Atomic mass (amu)	Valency	Density (g/cm^3)
Copper	63	2	9
Aluminium	27	3	2.7

Ignore overpotentials, and assume that current efficiency is 100% for both the workpiece materials. Under identical conditions, if the material removal rate (MRR) of copper is 100 mg/s, the MRR of aluminium will be _____ mg/s (round-off to two decimal places).

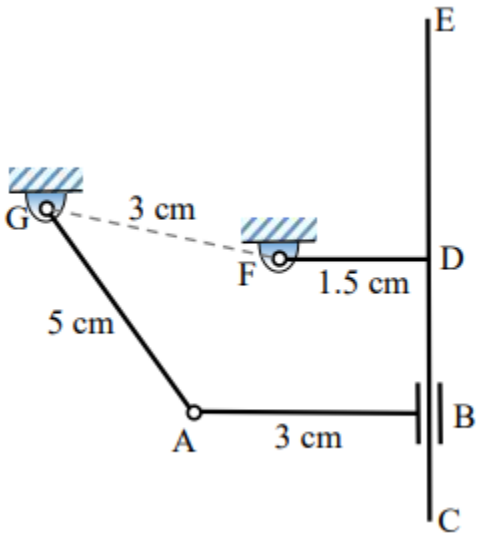
Q33) A polytropic process is carried out from an initial pressure of 110 kPa and volume of 5 m^3 to a final volume of 2.5 m^3. The polytropic index is given by $n = 1.2$. The absolute value of the work done during the process is _____ kJ (round off to 2 decimal places).

Q34) An L-shaped elastic member ABC with slender arms AB and BC of uniform cross-section is clamped at end A and connected to a pin at end C. The pin remains in continuous contact with and is constrained to move in a smooth horizontal slot. The the section modulus of the member is the same in both arms. The end C is subjected to a horizontal force P and all the deflections are in the plane of the figure. Given the length AB is $4a$ and length BC is a, the magnitude and direction of the normal force on the pin from the slot, respectively, are



(A) $3P/8$, and downwards
(B) $5P/8$, and upwards
(C) $P/4$, and downwards
(D) $3P/4$, and upwards

Q35) A planar four-bar linkage mechanism with 3 revolute kinematic pairs and 1 prismatic kinematic pair is shown in the figure, where AB $\perp$ CE and FD $\perp$ CE. The T-shaped link CDEF is constructed such that the slider B can cross the point D, and CE is sufficiently long. For the given lengths as shown, the mechanism is



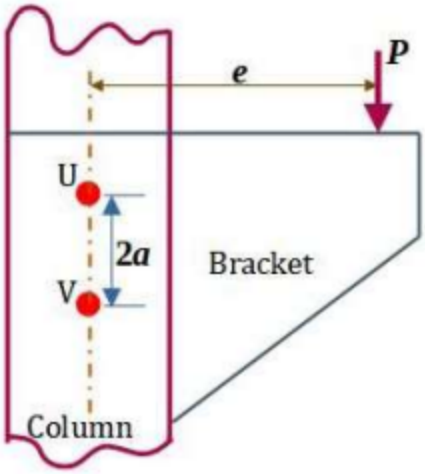
(A) a Grashof chain with links AG, AB, and CDEF completely rotatable about the ground link FG

(B) a non-Grashof chain with all oscillating links

(C) a Grashof chain with AB completely rotatable about the ground link FG, and oscillatory links AG and CDEF

(D) on the border of Grashof and non-Grashof chains with uncertain configuration(s)

Q36) A bracket is attached to a vertical column by means of two identical rivets U and V separated by a distance of 2a = 100 mm, as shown in the figure. The permissible shear stress of the rivet material is 50 MPa. If a load P = 10 kN is applied at an eccentricity $e = 3\sqrt{7}\,a$, the minimum cross-sectional area of each of the rivets to avoid failure is _____ mm^2.



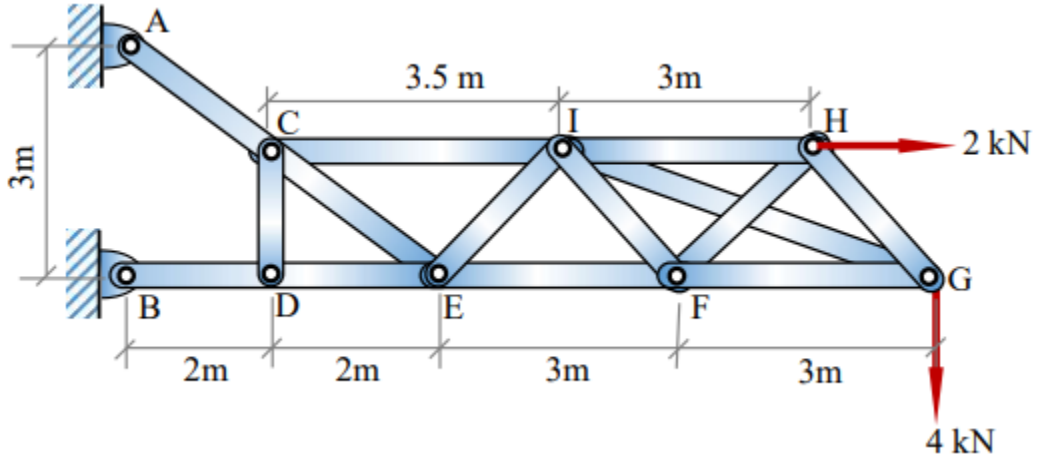
(A) 800
(B) 25
(C) $100\sqrt{7}$
(D) 200

Q37) In Fe-Fe^3C phase diagram, the eutectoid composition is 0.8 weight % of carbon at 725 ºC. The maximum solubility of carbon in α-ferrite phase is 0.025 weight % of carbon. A steel sample, having no other alloying element except 0.5 weight % of carbon, is slowly cooled from 1000 ºC to room temperature. The fraction of pro-eutectoid α-ferrite in the above steel sample at room temperature is
(A) 0.387
(B) 0.864
(C) 0.475
(D) 0.775

Q38) Consider steady, one-dimensional compressible flow of a gas in a pipe of diameter 1 m. At one location in the pipe, the density and velocity are 1 kg/m^3 and 100 m/s, respectively. At a downstream location in the pipe, the velocity is 170 m/s. If the pressure drop between these two locations is 10 kPa, the force exerted by the gas on the pipe between these two locations is __ N.
(A) $350\pi^2$
(B) 750π
(C) 1000π
(D) 3000

Q39) A structure, along with the loads applied on it, is shown in the figure. Self-weight of all the members is negligible and all the pin joints are friction-less. AE is a single member that contains

pin C. Likewise, BE is a single member that contains pin D. Members GI and FH are overlapping rigid members. The magnitude of the force carried by member CI is _____ kN (in integer)



Q40) A schematic of an epicyclic gear train is shown in the figure. The sun (gear 1) and planet (gear 2) are external, and the ring gear (gear 3) is internal. Gear 1, gear 3 and arm OP are pivoted to the ground at O. Gear 2 is carried on the arm OP via the pivot joint at P, and is in mesh with the other two gears. Gear 2 has 20 teeth and gear 3 has 80 teeth. If gear 1 is kept fixed at 0 rpm and gear 3 rotates at 900 rpm counter clockwise (ccw), the magnitude of angular velocity of arm OP is _____rpm (in integer).