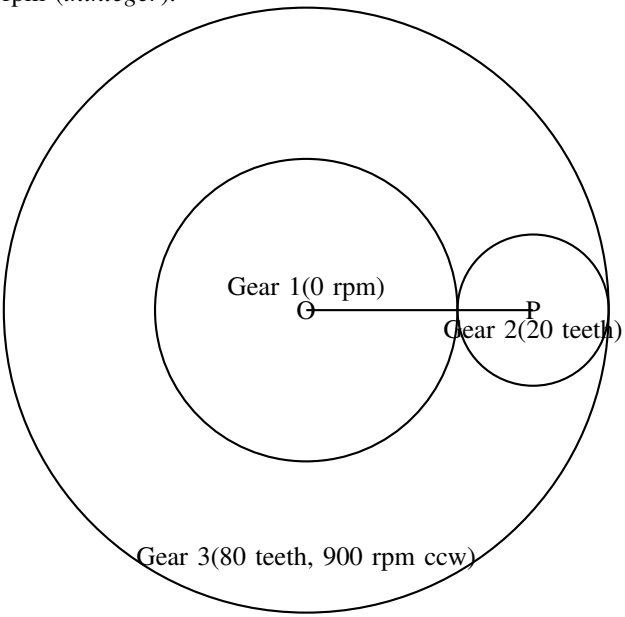
2022-GATE-ME-53-65

EE24BTECH11028 - Jadhav Rajesh

1) 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 *O*P 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 (*ininteger*).



2) Under orthogonal cutting condition, a turning operation is carried out on a metallic workpiece at a cutting speed of $4m/s$. The orthogonal rake angle of the cutting tool is 5°. The uncut chip thickness and width of cut are $0.2mm$ and $3mm$,respectively. In this turning operation ,the resulting friction angle and shear angle are 45° and 25°, respectively. If the dynamic yield shear strength of the workpiece material under this cutting condition is $1000MPa$, then the cutting force is _____N ($roundoffto onedecimalplace$).

3) A $1mm$ thick cylindrical tube, $100mm$ in diameter, is orthogonally turned such that the entire wall thickness of the tube is cut in a single pass. The axial feed of the tool is $1m/minute$ and the specific cutting energy (u) of the tube material is $6j/mm^3$.Neglect contribution of feed force towards power. The power required to

carry out this operation $\_\_\_\_kW\,(roundoffto one decimal place)$.

4) A $4mm$ thick aluminum sheet of width $w = 100mm$ is rolled in a two-roll mill of roll diameter $200mm$ each. The workpiece is lubrication with a mineral oil, which given a coefficient of friction, $\mu = 0.1$. The flow stress (σ) of the material in MPa is $\sigma = 207 + 414\xi$, where ξ is the true strain. Assuming rolling to be a plane strain deformation process, the roll separation force (F) for maximum permissible draft ($thickness reduction$) is $\_\_\_\_kN\,(roundoffto nearest integer)$.
Use:
$F = 1.15\bar{\sigma}\left(1 + \frac{\mu L}{2h}\right)$WL,where $\bar{\sigma}$ is average flow stress, L is roll-workpiece contact length, and $\bar{h}$ is the average sheet thickness.

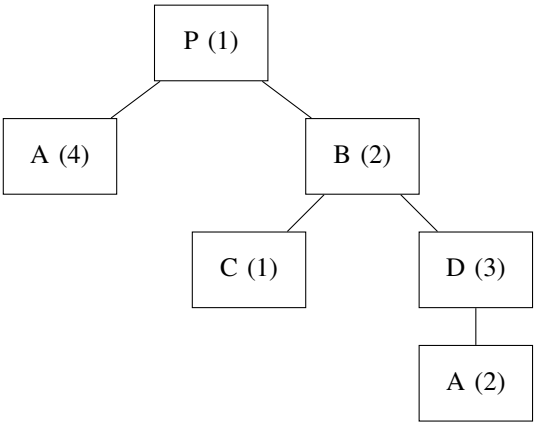
5) Two mild steel plates of similar thickness, in butt-joint configuration, are welded by gas tungsten arc welding process using the following welding parameters.

Welding voltage	**20 V**
Welding current	**150 A**
Welding speed	**5 mm/s**

A filler wire of the same mild steel material having $3mm$ diameter is used in this welding process. The filler wire feed rate is selected such that the final weld bead is composed of 60% volume of filler and 40% volume of plate material. The heat transfer factor is 0.7 and melting factor is 0.6. The feed rate of the filler wire is $\_\_\_\_mm/s\,(roundoffto one decimal place)$.

6) An assignment problem is solved to minimize the total processing time of four jobs $(1, 2, 3 and 4)$ on four different machines such that each job is processed exactly by one machine and each machine processes exactly one job. The minimum total processing time is found to be 500 minutes. Due to a change in design, the processing time of job 4 on each machine has increased by 20 minutes. The revised minimum total process time will be $\_\_\_\_$ minutes ($ininteger$).

7) The product structure diagram shows the number of different components required at each level to produce one unit of the final product P. If there are 50 units of on-hand inventory of component A, the number of additional units of component A needed to produce 10 units of product 10 units of P is $\_\_\_\_$ ($ininteger$).



8) Consider a one-dimensional steady heat conduction process through a solid slab of thickness $0.1m$. The higher temperature side A has a surface temperature of 80^{oc}, and the heat transfer rate per unit area to low temperature side B is$4.5kW/m^2$. The thermal conductivity of the slab is $15W/m.K$. The rate of entropy generation per unit area during the heat transfer process is $\_\_\_\_W/m^2.K$ $(roundoffto2decimalplaces)$.

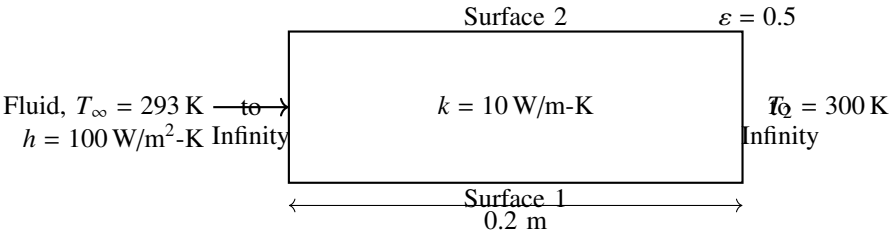
9) In a steam power plant based on Rankine cycle, steam is initially expanded in a high-pressure turbine. The steam is then reheated in a reheater and finally expanded in a low-pressure turbine. The expansion work in the high-pressure turbine is $400kJ/kg$ and in the low-pressure turbine is $850kJ/kg$, whereas the pump work is $15kJ/kg$. If the cycle effiecient is 32%, the heat rejected in the condenser is $\_\_\_\_kJ/kg$ $(roundoffto2decimalplaces)$.

10) An engine running on an air standard Otto cycle has a displacement volume $250cm^3$ and a clearance volume $35.7cm^3$. The pressure and temperature at the beginning of the compression process are $100kPa$ and $300K$, respectively. Heat transfer during constant-volume heat addition process is $800kJ/kg$. The specific heat at constant volume is $0.718kJ/kg.K$ and the ratio of specific heats at constant pressure and constant volume is 1.4. Assume the specific heats to remain constant during the cycle. The maximum pressure in the cycle is$____kPa$ $(roundoffto thenearestinteger)$.

11) A steady two-dimensional flow field is specified by the stream function
$\psi = kx^3y$,
where x and y are in meter and the constant $k = 1m^{-2}s^{-1}$. The magnitude of acceleration at a point $(x, y) = (1m, 1m)$ is $\_\_\_\_m/s^2$ $(roundoffto2decimalplaces)$.

12) Consider a solid slab $\left(thermalconductivity, k = 10W^{-1}K^{-1}\right)$ with thickness $0.2m$ and of infinite extent in the other two direction as shown in the figure.Surface 2, at $300k$, is exposed to a fluid flow at a free stream temperature $(T\infty)$ of $293K$,with a convectivee heat transfer coefficient (h) of $00Wm^1K^1$. Surface 2 is opaque, diffuse and gray with an emissivity (ξ) of 0.5 and exchanges heat by radiation with very

ladge surroundings at $0K$. Radiative heat transfer inside the solid slab is neglected. The stefan-Boltzmann constant is $5.67 * 10^{-8} Wm^2 K^{-4}$. The temperature T_1 of surface 1 of the slab, under steady-state conditions, is _____ K $(roundoffto the integer)$.



13) During open-heart surgery,a patient's blood is cooled down to $25°C$ from $37°C$ using a concentric tube counter-flow heat exchanger. Water enters the surgey is $5L/minute$. Use the folowing fluid properties:

Fluid	**Density (kg/m^3)**	**Specific heat (J/kg-K)**
Blood	1050	3740
Water	1000	4200

TABLE 13: Properties of fluids

Effectiveness of the heat exchanger is _____ $(roundoffto2decimalplaces)$.