INSTRUCTIONS

(i) All questions are compulsory.

(ii) Questions 1 and 2 carry 25 marks.

(iii) Questions 3 and 4 carry 30 marks each.

(iv) Questions 5, 6 and 7 carry 30 marks each.

(Please read each of the following instructions carefully before attempting questions)

There are EIGHT questions divided in two sections and printed both in KANNADA and in ENGLISH.

Candidate has to attempt FIVE questions in all.

Question No. 1 and 5 are compulsory and out of the remaining, THREE are to be attempted choosing at least ONE question from each Section.

The number of marks carried by a question/part is indicated against it.

Answers must be written in the medium authorized in the Admission Certificate, which must be stated clearly on the cover of this Question-cum-Answer (QCA) Booklet in the space provided. No marks will be given for answers written in a medium other than the authorized one.

Word limit in questions, wherever specified, should be adhered to.

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16. Mechanical Engineering-I
A compound bar is made of a central steel plate 60mm wide and 10mm thick to which copper plates 40mm wide by 5mm thick are connected rigidly on each side. The length of the bar at normal temperature is 1 meter, if the temperature is raised by 80°C, determine the stresses in each metal and change in length.

PQRS is a four bar chain with link PS fixed. The length of the links are PQ = 62.5mm; QR = 175mm; RS = 112.5mm and PS = 200mm. The crank PQ rotates at 10rad/s clockwise. Draw the velocity and acceleration diagram when angle QPS = 60° and Q and R lie on the same side of PS. Find the angular velocity and angular acceleration of the links QR and RS.
2. An epicyclic gear train consists of a sun wheel ‘S’, a stationary internal gear ‘E’ and three identical planet wheel ‘P’ carried on a star shaped planet carrier ‘C’. The size of different toothed wheels are such that the planet C rotates at \(15^{th}\) of the speed of the sun wheel ‘S’. The minimum number of teeth on any wheel is 16. The driving torque on the sun wheel is 100N-m.

Determine the:

(i) Number of teeth on the different wheel of the train.
(ii) Torque necessary to keep the internal gear stationary.

3. Design a pair of spur gear to transmit 20kW from a shaft rotating at 1000rpm to a parallel shaft which is to rotate at 310rpm. Assume:
- number of teeth on pinion is 31 and 20° full depth tooth form.
- material for pinion is C 45 steel untreated and for gear cast steel 0.20\%C untreated.
A certain machine requires a torque of \((5000 + 500 \sin \theta)\) N-m to drive it, where \(\theta\) is the angle of rotation of shaft measured from certain datum. The machine is directly coupled to an engine which produces a torque of \((5000 + 600 \sin 2\theta)\) N-m. The flywheel and the other rotating parts attached to the engine has a mass of 500 kg at a radius of gyration of 0.4 m. If the mean speed is 150 rpm, find:

(i) The fluctuation of energy.
(ii) The total percentage of fluctuation of speed and
(iii) The maximum and minimum angular acceleration of the flywheel and the corresponding shaft position.

List and describe the parameters which affect the material removal rate and surface finish in ultrasonic machine.
(b) Consider a box office ticket window being manned by a single server. Customers arrive to purchase tickets according to a Poisson's input process with a mean rate of 30 per hour. The time required to serve a customer has an exponential distribution with a mean of 90 seconds. Determine

(i) Mean queue length

(ii) Mean waiting time in the system

(iii) The probability of a customer waiting in the queue for more than 10 minutes.

(iv) The fraction of the time for which the server is busy.

A farmer has to plant trees of two kinds A and B in a land of 4400 m² in area. Each A tree requires at least 25 m² and tree B at least 40 m² of land. The annual water requirement of A is 30 units and B is 15 units/tree, while at most 3300 units of water is available. It is also estimated that the ratio of number of B tree to the number of tree A should not be less than 6/19 and not more than 17/8. The return per A tree is expected to be 1.5 times as much as B trees. Formulate the LPP for the profit on tree A is Rs. 1.5 and on tree B is Rs. 1.0.
A canning company operates 2 canning plants; 3 growers are willing to supply fruits in the following amounts.

Grower 1: 200 quintals at Rs 10/quintal
Grower 2: 300 quintals at Rs 9/quintal
Grower 3: 400 quintals at Rs 8/quintal

Shipping costs per quintals are

<table>
<thead>
<tr>
<th>From</th>
<th>Plant</th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grower 1</td>
<td></td>
<td>2</td>
<td>2.5</td>
</tr>
<tr>
<td>Grower 2</td>
<td></td>
<td>1</td>
<td>1.5</td>
</tr>
<tr>
<td>Grower 3</td>
<td></td>
<td>5</td>
<td>3</td>
</tr>
</tbody>
</table>

Plant capacity and labour costs are

<table>
<thead>
<tr>
<th></th>
<th>Plant A</th>
<th>Plant B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity in Quintals</td>
<td>450</td>
<td>350</td>
</tr>
<tr>
<td>Labour cost / Quintal</td>
<td>Rs. 25</td>
<td>Rs. 20</td>
</tr>
</tbody>
</table>

The canned fruits are sold at Rs 50 per Quintals to the distributors. How should the company plan its operation at the plant so as to minimize the profit?
Consider the following problems. Assume the cycle time = 1.0:

<table>
<thead>
<tr>
<th>Elements</th>
<th>Tej</th>
<th>Precedence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.2</td>
<td>--</td>
</tr>
<tr>
<td>2</td>
<td>0.4</td>
<td>--</td>
</tr>
<tr>
<td>3</td>
<td>0.7</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>0.1</td>
<td>1.2</td>
</tr>
<tr>
<td>5</td>
<td>0.3</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>0.11</td>
<td>3</td>
</tr>
<tr>
<td>7</td>
<td>0.32</td>
<td>3</td>
</tr>
<tr>
<td>8</td>
<td>0.6</td>
<td>3.4</td>
</tr>
<tr>
<td>9</td>
<td>0.27</td>
<td>6, 7, 8</td>
</tr>
<tr>
<td>10</td>
<td>0.38</td>
<td>5, 8</td>
</tr>
<tr>
<td>11</td>
<td>0.5</td>
<td>9, 10</td>
</tr>
<tr>
<td>12</td>
<td>0.12</td>
<td>11</td>
</tr>
</tbody>
</table>

Balance the line using ranked positional weights.
INSTRUCTIONS

(i) The duration is 3 hours.
(ii) All attempts are compulsory. No question is compulsory.
(iii) Attempt questions 1 and 5 separately.
(iv) Attempt questions 6 and 3 separately. As many as you can answer out of 1, as you can answer out of 1, as you can answer out of 1.

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State and explain second law of thermodynamics.

A large vessel contains steam of pressure of 20 bar and temperature of 350°C. This large vessel is connected to a steam turbine through a valve followed by a small initially evacuated tank with a volume of 0.8 m³. During emergency power requirement, the valve is opened and the tank fills with steam until the pressure is 20 bar. The temperature of the tank is then 400°C. Assume that the filling process takes place adiabatically and the changes in potential and kinetic energies are negligible. By drawing the control volume, calculate the amount of work developed by the turbine in kJ.
Write a note on critical thickness of insulation.

A long 8 cm diameter steel rod
\[ \alpha = 1.1 \times 10^{-5} \text{ m}^2/\text{s} \text{ and } K = 40 \text{ W/mK} \]
is initially at uniform temperature \[ T_2 = 225^\circ \text{C} \]. It is suddenly exposed to a convective environment \[ T_w = 25^\circ \text{C} \] with surface heat transfer coefficient
\[ h = 50 \text{ W/m}^2\text{K} \]. By using transient temperature chart determine,

(i) The center temperature

(ii) The surface temperature at \[ t = 1/10 \text{ and 1 hour after exposure to the cooler ambient.} \]
Show that the discharge through a reciprocating pump can be expressed as \( Q = \frac{ALN}{60} \) with usual notations.

A centrifugal pump is to discharge 0.118 m³/s at a speed of 1450 rpm against a head of 25 cm, its width at outlet is 5 cm and manometric efficiency is 75%. Determine the vane angle at the outer periphery of the impeller.

\[
T = N^2D^4 \rho\phi \left[ \frac{\mu}{D^4N\rho} \right].
\]

Write the significance of Nusselt number, Prandtl number, and Biot number.

The frictional torque \( T \) of a disc of diameter \( D \), rotating speed \( N \) in a fluid of viscosity \( \mu \) and density \( \rho \) in a turbulent flow is given by

\[
T = N^2D^4 \rho \phi \left[ \frac{\mu}{D^4N\rho} \right].
\]

Prove this by the method of dimensional analysis.

Define specific speed of a hydraulic turbine and pump. Obtain an expression for the specific speed of a hydraulic turbine and pump and explain its significance.
Write short notes on Psychrometric chart.

One kg of air at 35°C DBT and 60% RH is mixed with 2 kg of air at 20°C DBT and 13°C dew point temperature. Calculate the specific humidity, Temperature and enthalpy of the mixture. Assume specific heat of steam is 1.88 kJ/kgK and the following properties may be used.
5. (a) A 4 cm diameter tube is to be used in a process where the oil is heated from 22°C to 56°C. The speed of oil flow is 60 kg/min. The oil has a density of 895 kg/m³, a specific heat capacity of 0.52 kcal/kg°C, a conductivity of 0.13 kcal/hr·m·°C, and a thermal diffusivity of 0.4 × 10⁻⁶ m²/sec.

Oil is heated from 22°C to 56°C by passing through a tube of 4 cm in diameter. Find out the length of the tube required, for an oil flow rate of 60 kg/min if the surface temperature of the tube wall is maintained at 100°C. Assume the following properties of oil at mean temperatures: ρ = 895 kg/m³, Cp = 0.52 kcal/kg°C, K = 0.13 kcal/hr·m·°C, α = 0.4 × 10⁻⁶ m²/sec.

(b) CI and SI engines have different characteristics. CI engines require a high compression ratio, while SI engines require a compression ratio that is lower. List the distinguishing features of CI and SI engines.

With a line diagram describe the features of a fuel injection system for CI engines.
A four cylinder single acting ammonia compressor with cylinder dimensions as 7.5 × 10 cm operates at 600 rpm. Condenser and evaporator pressures are 12 and 2 bar respectively. The vapour from the evaporator to suction of compressor is dry and saturated and there is no under-cooling in the condenser. Compression takes place according to law PV^{1.2} = constant. If clearance is 2% of the stroke, calculate:

(i) Refrigerating capacity in tons of refrigeration.
(ii) Power required to drive the compressor in kW
(iii) Heat rejected to cylinder jacket water in kJ/min
(iv) Heat rejected to the condenser in kJ/min

7. (a) Compare the centrifugal and axial flow compressors. Derive a generalized conduction equation for Cartesian coordinates.

(b) NTU and effectiveness. Derive an expression for effectiveness in terms of NTU and capacity ratio for:

(i) Parallel flow heat exchanger
(ii) Counter flow heat exchanger
8. (a) T-s diagram

Show that Reheat cycle and Regenerative feed water heating cycle on T-s diagram. Highlight their significance on the performance of steam power plant.

A gas turbine plant operates on Brayton cycle with lower and upper temperature limits of 16°C and 725°C respectively. Assuming working substance as air and with isentropic compression and expansion. What is the pressure ratio for maximum pressure output? If you use a formula prove it.

(b) Describe with the help of neat sketches velocity compounding and pressure compounding as used in steam turbines. Give reasons for compounding and explain why velocity compounding with too large a number of moving blade rows is not preferred in turbine design.