Vellore Institute of Technology
(Deemed to be University under section 3 of UGC Act, 1956)

SCHOOL OF MECHANICAL ENGINEERING
CONTINUOUS ASSESSMENT TEST – I
WINTER SEMESTER 2023-2024

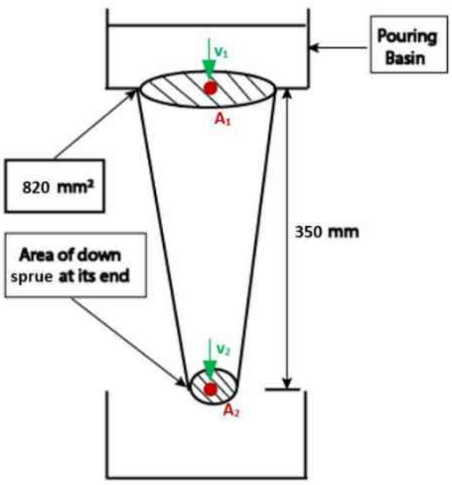
Key:
Prof. AK. Jeevanantham

Programme Name & Branch	**: B.Tech. Mechanical Engineering**
Course Code	**: BMEE302L**
Course Name	**: Metal Casting and Welding**
Faculty Name(s)	**: Dr.AK.Jeevanantham, Dr Raja Annamalai, Dr.SK.Ariful Rahaman, Dr.B.Venkateshwarlu, Dr.Ashish Kumar**
Class Number(s)	**: 4571, 4627, 4628, 4575, 4568**
Slot	**: G1+TG1**
Date of the Exam	**: 17-Feb-2024**
Exam Duration	**: 90 minutes** **Maximum Marks: 50**

Answer ALL the Questions

Q. No	Question	Marks	CO	BL
1.	The height of a down sprue is 350 mm. The cross-sectional area of the sprue where it meets the pouring basin, is 820 mm². The molten metal is to be poured with a constant flow rate of 7.8×10^5 mm³/s at pouring basin. Considering the end of down sprue with atmospheric pressure and results acceleration due to gravity of 10^4 mm/s². To prevent the aspiration effect, calculate the downsprue's area in mm² at it's end.	10	1	5

Key:



Metal flow rate (Q) = 7.8×10^5 mm³/s

Based on the law of mass continuity equation,

$A_1 v_1 = Q = 7.8 \times 10^5$

Therefore, $v_1 = \frac{7.8 \times 10^5}{820} = 951.22$ mm/s

Applying Bernoulli's theorem at points A_1 and A_2, we get

$$h_s + \frac{v_1^2}{2g} = \frac{v_2^2}{2g}$$

$$350 + \frac{951.22^2}{2 \times 10^4} = \frac{v_2^2}{2 \times 10^4}$$

$$v_2 = 2811.55\ mm/s$$

Now, area of down sprue at its end,

$$A_2 = \frac{Q}{v_2} = \frac{7.8 \times 10^5}{2811.55} = 277.43\ mm^2$$

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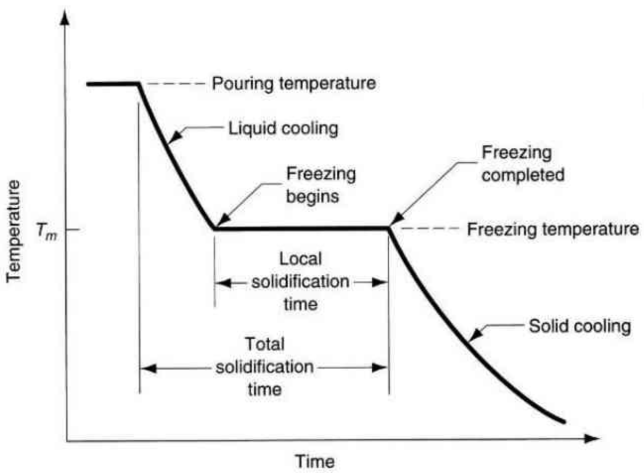
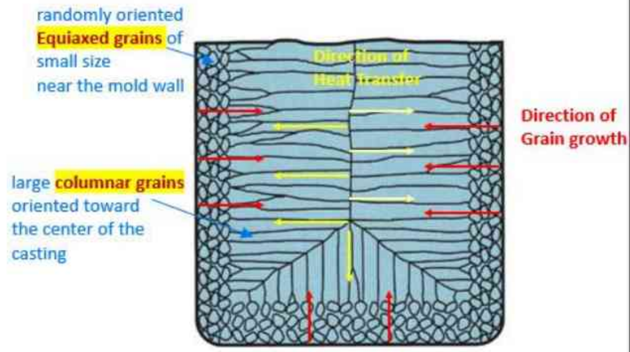
2.	Draw the cooling curve and various grain structures observed during the solidification of pure-metal and alloys.	10	1	4

Key:

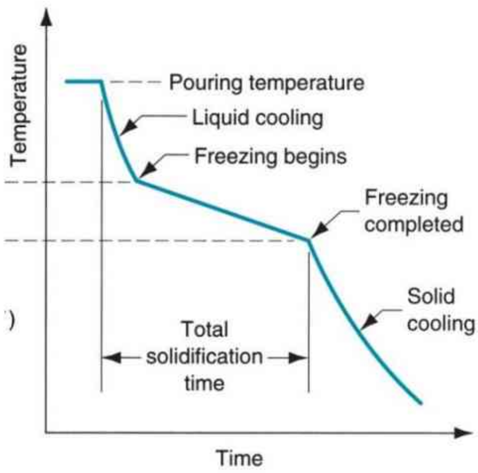
Cooling curve for a Pure Metal:



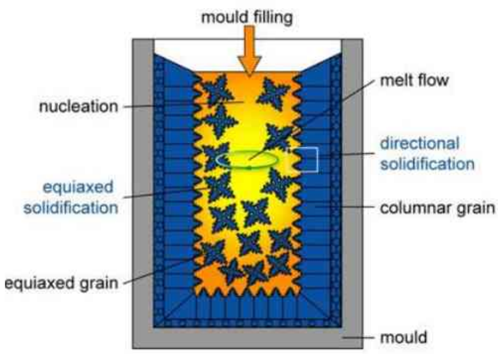
Grain structure in a casting of a pure metal:

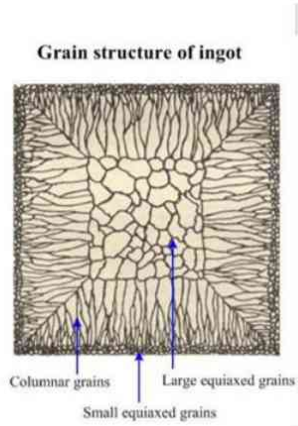


Cooling curve for alloy:



Grain structure in a casting of a pure metal:



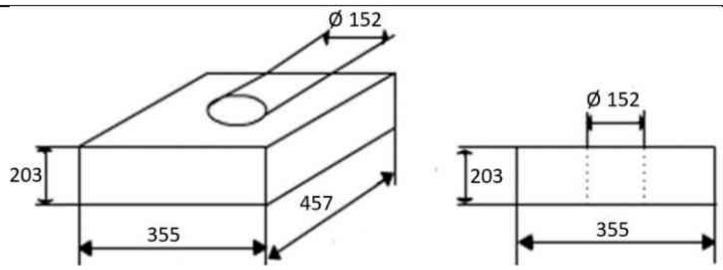


3.	a) List and define any five properties of moulding sand.	5	2	4

Key:

- Flowability: Ability to flow and get compacted all around the pattern and take up the required shape.
- Refractoriness: Ability to withstand the high temperature of the liquid metal to be poured.
- Permeability: Ability to allow hot gases to pass through it.

	• Green Strength (Compressive Strength): Ability of the green sand to retain the shape of the constructed mold. • Dry Strength: Ability to retain the exact shape of the mold cavity in the dry condition (when the molten metal is poured in the mold) and to withstand the metallostaic pressure of the liquid material. • Hot Strength: Ability of the molding material to retain the exact shape of the mold cavity at an elevated temperature. • Adhesiveness: Ability to stick with the walls of molding boxes. • Collapsibility: Ability to get collapsed after the casting solidifies. • Durability: Ability to withstand repeated cycles of heating and cooling during casting operations.			
	b) Explain how a core is prepared through CO_2 moulding process (indicate the ingredients and their chemical reaction).	5	2	4
	Key: • The mould/cores are prepared from a clean and dry silica sand with 3 to 5% by weight of sodium silicate solution (an inorganic binder which is a viscous fluid), and moisture up to 3%. • The sand is hardened by passing CO_2 for about one minute. • The CO_2 reacts with sodium silicate, forming a weak acid that hydrolyzes the sodium silicate (Na_2O, SiO_2), which with water (in the mould) forms a silica jel, which is a cement-like material and binds the sand grains together giving strength and hardness to the mould/core. • $Na_2SiO_3 + CO_2 + H_2O$ --> $Na_2CO_3 + SiO_2 + H_2O$ Silica jel			
4.	A job as shown in the following Figure (dimensions are in mm), is to be made by Al through sand casting process. It is planned to make the sand mould using wooden pattern. Design a wooden pattern with appropriate allowances. (For Al: Shrinkage allowance is 1.3%, Draft allowance is 1°, Machining allowance is 3mm.	10	2	6



Key:

- **1.3% Shrinkage Allowance**:
  - Height: 203 + $\left(203 \times \frac{1.3}{100}\right)$ = 203 + 2.639 = 205.639 mm
  - Width: 355+ $\left(355 \times \frac{1.3}{100}\right)$ = 355 + 4.615 = 359.615 mm
  - Length: 457 + $\left(457 \times \frac{1.3}{100}\right)$ = 457 + 5.941 = 462.941 mm
  - Internal hole dia: 152 $-$ $\left(152 \times \frac{1.3}{100}\right)$ = 152 – 1.976 = 150.024 mm
- **3mm Machining Allowance**:
  - Height: 205.639 + $(3\ mm \times 2\ sides)$ = 205.639 + 6 = 211.639 mm
  - Width: 359.615 + $(3\ mm \times 2\ sides)$ = 359.615 + 6 = 365.615 mm
  - Length: 462.941 + $(3\ mm \times 2\ sides)$ = 462.941 + 6 = 468.941 mm
  - Internal hole dia: 150.024 $-$ $(3mm \times 2)$ = 150.024 – 6 = 144.024 mm
- 1° **Taper Allowance (only on the top side, with respect to the height 211.639 mm)**:
  - Taper Allowance to be provided:
    - On External surface: 211.639 × tan (1) = 3.6942 mm
    - On Internal surface: 211.639 × tan (1) = 3.6942 mm
  - Width side:
    - ⇒ Top surface : 365.615 + 2x3.6942 = 373.0034 mm,
    - ⇒ Bottom: 365.615 mm.
  - Length side:
    - ⇒ Top surface: 468.941 + 2x3.6942 = 476.3294 mm,
    - ⇒ Bottom surface: 468.941 mm.
  - Internal hole:
    - ⇒ Top diameter: 144.024 - 2x3.6942 = 136.6356 mm,
    - ⇒ Bottom diameter: 144.024 mm.

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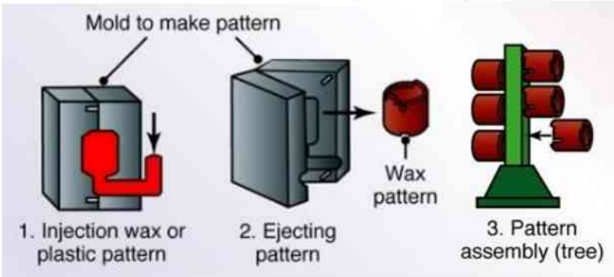
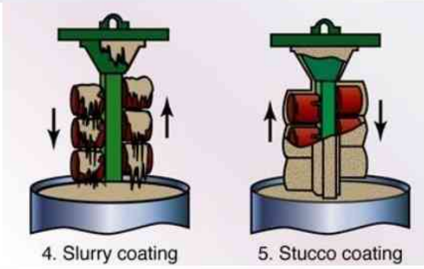
5.	With neat sketches, demonstrate the steps involved in investment casting process and list its merits, demerits and applications.	10	2	4

Key:



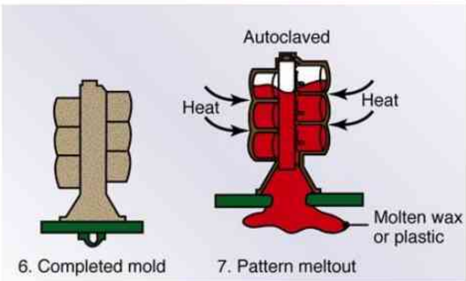
1, 2. The pattern is made of wax or plastic (polysterene) by Moulding or Rapid prototyping.

3. Several wax patterns are attached to a sprue to form a pattern tree.



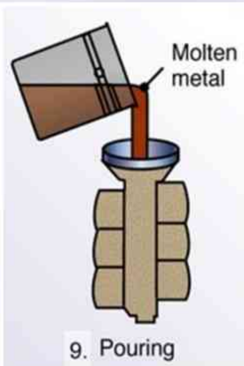
4. The pattern tree is dipped into a slurry of refractory material. (Very fine Silica + Binders + Water + Ethyl Silicate + Acids)

5. After this initial coating has dried in air (requires 2 hrs in relative humidity of 50% or less), the pattern tree is coated repeatedly to increase its thickness upto 5 to 8 mm. A final dip in the slurry material provides a sealing coating. Investment: The wax pattern is invested with the refractory material.



6. Thoroughly dried mold is held in an inverted position

7. The mold is burned out (90 to 175°C) for a minimum of 2 hrs to remove all traces of wax and to cure the investment. It is held in an inverted position for a few (12) hrs to melt out the wax.



8. The mold is then fired to 650 to 1050 °C (depends on the metal to be cast) for about 4 hrs to drive off the water of crystallization (chemically combined water) and to burn off any residual wax.

9. Molten metal is poured and solidified.

10. Shake out: After the mold cools and the cast metal solidifies, the mold material is removed from the tree, typically with an air-powered hammer or vibratory machine.

11. The tree is descaled. This is achieved by immersing the tree for 10 to 15 min in a 600°C (1100°F) caustic salt bath followed by an immediate cold-water dip and then neutralizing and cleaning rinses.

12. Parts are removed from the tree by bandsaw or abrasive wheel.

13. Gates are removed from the parts by means of a grinding wheel, abrasive belt, milling machine, or lathe. mold is broken away from the finished casting and the parts are separated from the sprue