

# FOUNDRY TECHNOLOGY-I

Subject Code: PEME201 (B)

*Comprehensive Course Material*

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## **Syllabus Overview**

The course Foundry Technology-I (PEME201 B) is a three-credit theory course delivered over 48 lectures with an L-T-P pattern of 3-0-0. It introduces students to the science and practice of producing metal components by casting. The course is divided into two units. Unit-I covers the introduction to foundry, mould and pattern fundamentals, materials and allowances, BIS colour coding and the properties of moulding sands, including natural and synthetic binders. Unit-II deals with mould making (cope and drag preparation, chaplets, sealing, preservation, bench life and moulding defects), core making (definition, preparation, types, setting, baking, reinforcement, painting and venting), and gating systems together with the design and types of risers.

By the end of the course a student should be able to (CO1) explain the fundamentals of foundry, materials, patterns and safety; (CO2) understand foundry materials, particularly moulding sands and their additives; (CO3) demonstrate the procedures for moulding and core making; and (CO4) describe the different gating systems and risers along with their functions. The course outcomes are mapped to all 12 programme outcomes (PO1–PO7) and to PSO1 and PSO2 of the programme.

The recommended texts for the course are: Principle of Foundry Technology by P. L. Jain (Khanna Publishers); Foundry Technology by M. Lal and O. P. Khanna (Dhanpat Rai and Sons); Foundry Technology by Srinivasan (Khanna Publishers); Principles of Metal Casting by Richard W. Heine (TMH Publishers); and Metal Casting Technology by P. C. Mukherji (Oxford and IBH Publishers). The following sections of this material provide a question bank derived strictly from this syllabus, intended for revision, classroom practice and examination preparation.

## Section A: 100 Multiple Choice Questions with Answers

Each question carries one mark. Choose the most appropriate option. Correct answers are given at the end of each question.

**Q1.** Foundry is the process of: (A) Forging metals into shapes (B) Producing metal castings by pouring molten metal into moulds (C) Joining metals by welding (D) Cutting metals using machines **Answer: B**

**Q2.** The cavity in a mould that gives shape to the casting is called the: (A) Riser (B) Sprue (C) Mould cavity (D) Core **Answer: C**

**Q3.** Which of the following is NOT a basic step in the foundry process? (A) Pattern making (B) Mould making (C) Welding (D) Pouring **Answer: C**

**Q4.** The upper half of a two-part moulding flask is known as the: (A) Drag (B) Cope (C) Cheek (D) Pouring basin **Answer: B**

**Q5.** The lower half of a two-part moulding flask is known as the: (A) Cope (B) Drag (C) Riser (D) Sprue **Answer: B**

**Q6.** A flask used between the cope and drag in three-part moulding is called a: (A) Cheek (B) Chaplet (C) Chill (D) Core box **Answer: A**

**Q7.** The vertical passage through which molten metal enters the mould is called the: (A) Runner (B) Sprue (C) Gate (D) Riser **Answer: B**

**Q8.** The horizontal channel that carries molten metal from the sprue to the gate is the: (A) Runner (B) Riser (C) Vent (D) Pouring basin **Answer: A**

**Q9.** A riser in a foundry mould is used to: (A) Hold the pattern (B) Compensate for shrinkage during solidification (C) Vent gases only (D) Cool the metal quickly **Answer: B**

**Q10.** The pouring basin is provided in a mould to: (A) Receive molten metal and reduce splashing (B) Hold cores in place (C) Vent the mould (D) Support the pattern **Answer: A**

**Q11.** A pattern is best defined as: (A) A finished casting (B) A replica of the casting used to produce the mould cavity (C) A type of core (D) The gating system **Answer: B**

**Q12.** Which is NOT a function of a pattern? (A) To form the mould cavity (B) To provide for shrinkage allowance (C) To melt the metal (D) To establish parting line **Answer: C**

**Q13.** A single-piece (solid) pattern is most suitable for: (A) Mass production (B) Simple shapes produced in small quantity (C) Complex castings (D) Hollow castings **Answer: B**

**Q14.** A split pattern is used when: (A) Pattern is simple and flat (B) Pattern is complex and made in two halves (C) Casting is hollow (D) Casting requires no draft **Answer: B**

**Q15.** Match pattern means: (A) A pattern made of wax (B) Cope and drag patterns mounted on opposite sides of a single plate (C) A skeleton pattern (D) A loose-piece pattern **Answer: B**

- Q16.** A sweep pattern is generally used for: (A) Small intricate castings (B) Large symmetrical castings of circular cross-section (C) Hollow castings only (D) Continuous casting **Answer: B**
- Q17.** A skeleton pattern is used to produce: (A) Small castings in large numbers (B) Large castings in small quantity (C) Precision castings (D) Die-cast products **Answer: B**
- Q18.** Loose-piece patterns are used when: (A) The pattern has projections that prevent withdrawal (B) Mass production is needed (C) Pattern is symmetrical (D) Casting is small **Answer: A**
- Q19.** Shrinkage allowance is provided on a pattern because: (A) Metal expands on cooling (B) Metal contracts on solidification and cooling (C) Sand expands during ramming (D) Mould absorbs metal **Answer: B**
- Q20.** Draft allowance is provided on a pattern to: (A) Compensate for shrinkage (B) Allow easy withdrawal of the pattern from the mould (C) Permit machining (D) Reduce weight **Answer: B**
- Q21.** Machining allowance is provided to: (A) Provide surface for finishing operations after casting (B) Compensate for shrinkage (C) Allow venting (D) Permit core setting **Answer: A**
- Q22.** Distortion (camber) allowance is provided when: (A) The casting tends to warp during cooling (B) Pattern is made of metal (C) Casting is symmetrical (D) Casting is hollow **Answer: A**
- Q23.** Shake (rapping) allowance is: (A) A positive allowance added to pattern dimensions (B) A negative allowance to account for cavity enlargement due to rapping (C) An allowance for machining (D) An allowance for cores **Answer: B**
- Q24.** According to BIS colour coding, the surfaces of the pattern that will be machined are painted: (A) Black (B) Red (C) Yellow (D) Blue **Answer: B**
- Q25.** According to BIS colour coding, surfaces of the casting that remain as cast are painted: (A) Black (B) Red (C) Yellow (D) Blue **Answer: A**
- Q26.** According to BIS colour coding, core prints on the pattern are painted: (A) Black (B) Red (C) Yellow (D) Blue **Answer: C**
- Q27.** According to BIS colour coding, parting surfaces are usually shown in: (A) Black (B) Yellow (C) No colour / clear (D) Red **Answer: C**
- Q28.** The most commonly used pattern material is: (A) Plaster of Paris (B) Wood (C) Plastic (D) Steel **Answer: B**
- Q29.** Metal patterns are preferred over wooden patterns when: (A) Castings are required in large numbers (B) Castings are very small (C) Pattern is to be used only once (D) Cost must be minimum **Answer: A**
- Q30.** Wax patterns are commonly used in: (A) Sand casting (B) Investment casting (C) Die casting (D) Centrifugal casting **Answer: B**

- Q31.** A good pattern material should have all of the following EXCEPT: (A) Good machinability (B) Light weight (C) High thermal expansion (D) Resistance to wear **Answer: C**
- Q32.** The main ingredient of moulding sand is: (A) Silica (B) Alumina (C) Magnesia (D) Iron oxide **Answer: A**
- Q33.** The binder commonly used in green sand moulding is: (A) Bentonite clay (B) Resin (C) Sodium silicate (D) Linseed oil **Answer: A**
- Q34.** Green sand refers to: (A) Sand mixed with green dye (B) Sand that contains moisture (C) Newly mined sand (D) Synthetic resin sand **Answer: B**
- Q35.** The property of moulding sand that allows gases to escape is called: (A) Strength (B) Permeability (C) Refractoriness (D) Cohesiveness **Answer: B**
- Q36.** The ability of moulding sand to withstand high temperatures without fusing is called: (A) Permeability (B) Cohesiveness (C) Refractoriness (D) Adhesiveness **Answer: C**
- Q37.** Cohesiveness of moulding sand is the property that: (A) Allows gases to escape (B) Holds sand particles together (C) Resists heat (D) Permits flowability **Answer: B**
- Q38.** Adhesiveness of moulding sand is the ability to: (A) Stick to the surfaces of the moulding box (B) Stick to itself (C) Resist heat (D) Allow gas escape **Answer: A**
- Q39.** Collapsibility of moulding sand is important because: (A) It allows the sand to flow easily (B) It allows the casting to contract freely during cooling (C) It improves permeability (D) It improves refractoriness **Answer: B**
- Q40.** Flowability of moulding sand refers to its ability to: (A) Pack tightly around the pattern (B) Resist heat (C) Hold its shape (D) Withstand pressure **Answer: A**
- Q41.** Which sand additive is used to give a smooth finish to the casting surface? (A) Sea coal (B) Sawdust (C) Cereal binder (D) Iron oxide **Answer: A**
- Q42.** Sawdust is added to moulding sand to: (A) Improve permeability and collapsibility (B) Increase strength (C) Increase refractoriness (D) Add colour **Answer: A**
- Q43.** Cereal binders are added to moulding sand to: (A) Improve green strength and dry strength (B) Improve refractoriness (C) Reduce moisture (D) Provide colour **Answer: A**
- Q44.** Bentonite is a type of: (A) Sand (B) Clay binder (C) Resin (D) Coating **Answer: B**
- Q45.** Sodium silicate (water glass) is used as a binder in the: (A) Green sand process (B) CO<sub>2</sub> process (C) Investment process (D) Shell moulding **Answer: B**
- Q46.** Synthetic moulding sand is: (A) Natural sand without any treatment (B) Sand artificially mixed with clay and other ingredients (C) Sand from sea shores (D) Sand containing only silica **Answer: B**
- Q47.** Naturally bonded moulding sand contains: (A) Only silica (B) Silica plus naturally occurring clay (C) Silica plus synthetic resin (D) Silica plus oil **Answer: B**

- Q48.** The moisture content in green sand is usually about: (A) 1-2% (B) 2-8% (C) 10-15% (D) 20-25% **Answer: B**
- Q49.** Loam sand is a mixture of: (A) Silica sand and bentonite (B) Sand, clay (about 50%) and water (C) Resin and sand (D) Sand and oil **Answer: B**
- Q50.** Facing sand is used: (A) At the back of the mould (B) In direct contact with the pattern/casting surface (C) Only in the cope (D) Only for cores **Answer: B**
- Q51.** Backing sand is: (A) Used to back up the facing sand (B) Used in contact with the pattern (C) A core sand only (D) A pattern material **Answer: A**
- Q52.** Parting sand is used to: (A) Bind the sand (B) Prevent the cope and drag from sticking together (C) Improve refractoriness (D) Vent the mould **Answer: B**
- Q53.** The property of sand to be reused after the casting is removed is called: (A) Reusability (B) Recyclability (C) Re-conditioning (D) Refractoriness **Answer: A**
- Q54.** Hand ramming of sand is done with a: (A) Trowel (B) Rammer (C) Strike-off bar (D) Slick **Answer: B**
- Q55.** A strike-off bar is used to: (A) Remove excess sand and level the mould surface (B) Ram the sand (C) Cut the sprue (D) Vent the mould **Answer: A**
- Q56.** A trowel is used in moulding for: (A) Cutting cores (B) Smoothing flat surfaces and joints (C) Ramming sand (D) Pouring metal **Answer: B**
- Q57.** Vent wires are used in moulding to: (A) Hold cores (B) Make small holes for escape of gases (C) Cut sprues (D) Strengthen the mould **Answer: B**
- Q58.** A chaplet in a mould is used to: (A) Support the core inside the mould cavity (B) Vent the mould (C) Hold the pattern (D) Pour the metal **Answer: A**
- Q59.** Chaplets are normally made of: (A) The same metal as the casting (B) Wood (C) Sand (D) Plastic **Answer: A**
- Q60.** Mould sealing is done to: (A) Prevent leakage of molten metal at the parting surface (B) Vent the mould (C) Cool the metal (D) Hold the core **Answer: A**
- Q61.** Mould preservation refers to: (A) Coating the mould to maintain its integrity until pouring (B) Reusing the sand (C) Storage of patterns (D) Heating the mould **Answer: A**
- Q62.** Bench life of moulding sand is: (A) The time during which prepared sand retains its properties for use (B) The age of the sand (C) Cost per kg of sand (D) Storage shelf life of clay **Answer: A**
- Q63.** Which of the following is a moulding defect caused by inadequate venting? (A) Blow hole (B) Cold shut (C) Misrun (D) Hot tear **Answer: A**
- Q64.** A 'shift' defect in a casting is caused by: (A) Misalignment of cope and drag (B) Insufficient pouring temperature (C) Poor venting (D) Wrong gating **Answer: A**

- Q65.** 'Misrun' defect occurs when: (A) Metal solidifies before filling the mould completely (B) Sand is too wet (C) Riser is too small (D) Pattern is oversized **Answer: A**
- Q66.** 'Cold shut' defect arises due to: (A) Two streams of metal failing to fuse properly (B) Excess moisture (C) Excess venting (D) Pattern shift **Answer: A**
- Q67.** 'Hot tear' is a defect caused by: (A) Hindered contraction during solidification (B) Excess moisture (C) Poor venting (D) Low pouring temperature **Answer: A**
- Q68.** A 'scab' defect is essentially: (A) Patches of sand fused to the casting surface (B) A blowhole (C) A shrinkage cavity (D) A shift **Answer: A**
- Q69.** 'Swell' defect in castings is caused by: (A) Insufficient ramming (B) Over-ramming (C) Excess refractoriness (D) Excess moisture only **Answer: A**
- Q70.** 'Drop' defect is caused by: (A) A portion of the mould cavity falling into molten metal (B) Excess pouring (C) Insufficient pouring (D) Improper gating **Answer: A**
- Q71.** A 'shrinkage cavity' defect is due to: (A) Inadequate feeding of molten metal during solidification (B) Excess moisture (C) Misaligned flask (D) Improper venting **Answer: A**
- Q72.** 'Run-out' defect refers to: (A) Metal escaping from the mould before solidification (B) Solid metal flowing out (C) Cores breaking (D) Pattern shifting **Answer: A**
- Q73.** Which defect is associated with excessive moisture in moulding sand? (A) Blow hole (B) Hot tear (C) Shift (D) Swell **Answer: A**
- Q74.** A core in a casting is used to: (A) Form internal cavities or projections (B) Vent the mould (C) Pour the metal (D) Pattern the mould **Answer: A**
- Q75.** A horizontal core is supported in the mould by: (A) Riser (B) Core print (C) Sprue (D) Pouring cup **Answer: B**
- Q76.** A core print is: (A) A projection on the pattern that forms a seat for the core (B) A coating for the core (C) A type of core (D) A core box **Answer: A**
- Q77.** A core box is: (A) A box used to store cores (B) A tool used to make cores by shaping the core sand (C) A flask for moulding (D) A pattern **Answer: B**
- Q78.** Core sand differs from moulding sand mainly in that: (A) It uses special binders such as oil, resin or sodium silicate (B) It does not contain silica (C) It has no permeability (D) It cannot be baked **Answer: A**
- Q79.** Cores are baked primarily to: (A) Drive out moisture and harden the binder (B) Improve permeability only (C) Add colour (D) Make them softer **Answer: A**
- Q80.** A typical core baking temperature is in the range of: (A) 50-100°C (B) 200-260°C (C) 600-800°C (D) 1000-1200°C **Answer: B**
- Q81.** A 'green core' is one which is: (A) Used without baking, still containing moisture (B) Painted green (C) Made of green sand (D) Made of wax **Answer: A**

- Q82.** Cores are reinforced with metal wires or rods to: (A) Increase their strength and prevent breakage during handling (B) Increase permeability (C) Reduce weight (D) Make them refractory **Answer: A**
- Q83.** Core venting is done to: (A) Allow escape of gases formed when molten metal contacts the core (B) Strengthen the core (C) Hold the core (D) Add binder **Answer: A**
- Q84.** Vent holes in cores are made using: (A) Vent wires or wax strings (B) Hot iron (C) Hammers (D) Files **Answer: A**
- Q85.** A balanced core is one that: (A) Extends into the mould cavity from only one side (B) Has equal extension on both sides (C) Is symmetrical only (D) Hangs from the top **Answer: A**
- Q86.** A hanging core is supported from: (A) The top of the mould (B) The bottom only (C) The side (D) The runner **Answer: A**
- Q87.** Core painting (coating) is done to: (A) Improve surface finish and prevent metal penetration (B) Strengthen the core (C) Provide colour identification (D) Allow venting **Answer: A**
- Q88.** A drop core is one that is: (A) Placed in a recess below the parting line of the mould (B) Floating in the metal (C) Used for venting (D) Used for risers **Answer: A**
- Q89.** The gating system in a mould is the complete passage system through which: (A) Sand flows (B) Molten metal flows from the ladle to the mould cavity (C) Gases escape (D) Cores are placed **Answer: B**
- Q90.** A top gate delivers metal into the mould cavity: (A) From the top of the cavity (B) From the bottom (C) From the side (D) Through a riser **Answer: A**
- Q91.** A bottom gate introduces metal into the cavity: (A) Below the parting line, at the bottom of the cavity (B) Through the top (C) Through the riser (D) Through the vent **Answer: A**
- Q92.** A parting line gate is located at: (A) The joint between cope and drag (B) The bottom only (C) The top only (D) Inside the core **Answer: A**
- Q93.** The main purpose of a sprue well is to: (A) Reduce the velocity and turbulence of metal at the bottom of the sprue (B) Hold molten metal (C) Vent the mould (D) Cool the metal **Answer: A**
- Q94.** A 'choke' in a gating system is the point of: (A) Minimum cross-section that controls the flow rate (B) Maximum cross-section (C) Venting (D) Pouring **Answer: A**
- Q95.** In a pressurized gating system: (A) The total area of gates is less than the area of runner (B) The total area of gates is greater than the runner (C) There is no choke (D) There is no sprue **Answer: A**
- Q96.** An unpressurized gating system has: (A) Total gate area greater than runner area (B) Total gate area less than runner area (C) No runner (D) Only one gate **Answer: A**

**Q97.** The function of a riser is mainly to: (A) Feed molten metal to compensate solidification shrinkage (B) Vent gases only (C) Hold the core (D) Receive metal from the ladle **Answer: A**

**Q98.** A 'blind riser' is one that: (A) Is open to the atmosphere at the top (B) Is completely enclosed in the mould (C) Is in the pouring basin (D) Has no metal in it **Answer: B**

**Q99.** An 'open riser' is exposed: (A) To the atmosphere at the top (B) Only at the bottom (C) To the core (D) Through the runner **Answer: A**

**Q100.** A riser should: (A) Solidify after the casting (B) Solidify before the casting (C) Solidify simultaneously with the casting (D) Never solidify **Answer: A**

**Q101.** Chvorinov's rule relates solidification time to: (A) The square of the ratio of volume to surface area (B) The cube of the surface area (C) The diameter only (D) The pouring temperature only **Answer: A**

**Q102.** The 'directional solidification' principle in foundry means that: (A) Solidification starts farthest from the riser and progresses toward it (B) Solidification starts at the riser (C) All parts solidify together (D) Solidification is from top to bottom only **Answer: A**

**Q103.** Padding, chills and risers are used in castings to ensure: (A) Directional solidification and sound castings (B) Better pattern release (C) Easier ramming (D) Higher permeability **Answer: A**

## Section B

### 50 Short Answer Questions with Answers

Each short-answer question requires a concise reply of one to three sentences.

**Q1. Define foundry.**

**Ans.** Foundry is the manufacturing process of producing metal components by melting metal and pouring it into a mould of the desired shape, where it solidifies into a casting.

**Q2. What is a mould?**

**Ans.** A mould is the hollow cavity formed in a moulding material (such as sand) that gives the desired shape to the molten metal poured into it.

**Q3. What is a pattern?**

**Ans.** A pattern is a replica or model of the final casting (with allowances) used to form the mould cavity.

**Q4. What is a flask?**

**Ans.** A flask is a rigid frame (made of metal or wood) that holds the moulding sand. Common parts are the cope (top), drag (bottom) and cheek (middle in 3-part moulding).

**Q5. Name the parts of a moulding flask in two-part moulding.**

**Ans.** Cope (upper half) and drag (lower half).

**Q6. What is a cheek?**

**Ans.** A cheek is the middle section of a three-part flask used when the casting is too complex for two-part moulding.

**Q7. What is a sprue?**

**Ans.** A sprue is the vertical passage through which molten metal flows down from the pouring basin into the runner system.

**Q8. What is a runner?**

**Ans.** A runner is the horizontal channel connecting the bottom of the sprue to the gate, distributing metal to the mould cavity.

**Q9. What is a gate?**

**Ans.** A gate is the channel through which molten metal finally enters the mould cavity from the runner.

**Q10. What is a pouring basin?**

**Ans.** A pouring basin (or pouring cup) is the funnel-shaped opening at the top of the sprue that receives molten metal from the ladle and reduces splashing and turbulence.

**Q11. What is a riser?**

**Ans.** A riser is a reservoir of molten metal connected to the casting that supplies extra metal to compensate for solidification shrinkage.

**Q12. List the types of patterns (any five).**

**Ans.** Single-piece, split, match-plate, cope and drag, sweep, skeleton, loose-piece, gated, segmental, and shell patterns.

**Q13. What are pattern allowances?**

**Ans.** Pattern allowances are dimensional additions or subtractions on the pattern to compensate for metal contraction, machining, draft, shake and distortion.

**Q14. Define shrinkage allowance.**

**Ans.** Shrinkage allowance is the positive dimensional addition on a pattern to account for the contraction of metal as it cools from the pouring temperature to room temperature.

**Q15. Define draft allowance.**

**Ans.** Draft allowance is a slight taper given to vertical surfaces of the pattern to allow easy withdrawal of the pattern from the mould without damaging the cavity.

**Q16. Define machining allowance.**

**Ans.** Machining allowance is extra material added on the pattern surfaces that need machining after casting, so that the final dimensions are obtained after finishing.

**Q17. Define distortion (camber) allowance.**

**Ans.** Distortion allowance is the dimensional correction applied to the pattern to compensate for warping of thin or unsymmetrical castings during cooling.

**Q18. Define shake (rapping) allowance.**

**Ans.** Shake or rapping allowance is a negative allowance that reduces pattern dimensions slightly to compensate for the enlargement of the mould cavity caused by rapping the pattern before withdrawal.

**Q19. State the BIS colour code for machined surfaces.**

**Ans.** Machined surfaces of the pattern are painted RED.

**Q20. State the BIS colour code for as-cast surfaces.**

**Ans.** Surfaces that remain as-cast (unfinished) are painted BLACK.

**Q21. State the BIS colour code for core prints.**

**Ans.** Core prints and seats for loose pieces are painted YELLOW.

**Q22. State the BIS colour code for parting surfaces.**

**Ans.** Parting surfaces (and loose pieces) are usually shown unpainted (no colour) or with diagonal red/black stripes per BIS practice.

**Q23. List common pattern materials.**

**Ans.** Wood, metals (aluminium, brass, cast iron), plastics, plaster of Paris and wax.

**Q24. Why is wood preferred as a pattern material?**

**Ans.** Wood is light, easy to shape and machine, low in cost and readily available, making it suitable for limited-production castings.

**Q25. State four desirable properties of moulding sand.**

**Ans.** Permeability, refractoriness, cohesiveness/strength, and collapsibility (also flowability and reusability).

**Q26. Define permeability of moulding sand.**

**Ans.** Permeability is the property of moulding sand that allows gases and vapours formed during pouring to escape through the sand.

**Q27. Define refractoriness.**

**Ans.** Refractoriness is the ability of moulding sand to withstand the high temperature of molten metal without fusing or breaking down.

**Q28. Define cohesiveness (green strength).**

**Ans.** Cohesiveness is the ability of sand particles to stick together so that the mould retains its shape during ramming, handling and pouring.

**Q29. Define collapsibility of moulding sand.**

**Ans.** Collapsibility is the ability of the sand mould or core to break down after solidification so that the casting can contract freely and be removed without difficulty.

**Q30. What is green sand?**

**Ans.** Green sand is moulding sand in its natural moist state (containing silica, clay binder and water) used in green-sand moulding.

**Q31. What is dry sand moulding?**

**Ans.** Dry sand moulding uses a mould that has been baked or dried to remove moisture, giving higher strength and better surface finish for larger castings.

**Q32. Name common additives to moulding sand and their purpose.**

**Ans.** Sea coal (improves surface finish), sawdust (improves permeability and collapsibility), cereal binders (improve strength), iron oxide (improves hot strength).

**Q33. Differentiate between natural and synthetic moulding sand.**

**Ans.** Natural sand is mined with its own clay content and used with little processing, whereas synthetic sand is silica sand to which clay (bentonite) and other additives are deliberately added.

**Q34. What is the function of a binder in moulding sand?**

**Ans.** Binders hold sand grains together to give the mould its required strength. Examples: bentonite clay, sodium silicate, oils and resins.

**Q35. Differentiate between facing sand and backing sand.**

**Ans.** Facing sand is fresh fine sand placed in direct contact with the pattern to give a smooth surface to the casting, while backing sand is older, reused sand placed behind the facing sand to fill the rest of the flask.

**Q36. What is parting sand?**

**Ans.** Parting sand is dry, non-sticky sand sprinkled on parting surfaces (between cope and drag) to prevent them from sticking together.

**Q37. What is a chaplet and why is it used?**

**Ans.** A chaplet is a small metal support placed inside the mould to hold a core in position against the buoyant force of molten metal; it eventually fuses with the casting.

**Q38. What is meant by bench life of moulding sand?**

**Ans.** Bench life is the period during which prepared moulding sand retains its required moisture content and properties before it dries out and becomes unusable.

**Q39. List any four common moulding defects.**

**Ans.** Blow holes, shrinkage cavities, cold shuts, misruns, hot tears, shifts, scabs and swells.

**Q40. What causes blow holes in castings?**

**Ans.** Blow holes are caused by entrapped gases or steam (from moist sand or poor venting) that cannot escape and remain in the casting as cavities.

**Q41. What is a core?**

**Ans.** A core is a sand body placed in the mould to form internal cavities, holes, or undercuts in the casting that cannot be produced by the pattern alone.

**Q42. What is a core print?**

**Ans.** A core print is the projection on the pattern that creates a recess in the mould where the core is seated and supported.

**Q43. What is a core box?**

**Ans.** A core box is a wooden, metal or plastic tool with a cavity shaped like the core; core sand is packed into it to form the core.

**Q44. Why are cores baked?**

**Ans.** Cores are baked to drive off moisture, harden the binder and develop sufficient strength so that they can withstand the pressure of molten metal.

**Q45. Why are cores vented?**

**Ans.** Cores are vented to provide passages for the escape of gases generated when molten metal contacts the binder, preventing porosity in the casting.

**Q46. What is the function of a gating system?**

**Ans.** The gating system delivers molten metal smoothly from the pouring basin to the mould cavity with minimum turbulence, gas pickup and erosion of the mould.

**Q47. Differentiate between a pressurized and an unpressurized gating system.**

**Ans.** In a pressurized system the gates have the smallest cross-section (choke at the gate), keeping the system full and reducing aspiration; in an unpressurized system the sprue or runner is the choke and gate area is largest.

**Q48. What is the function of a riser?**

**Ans.** A riser supplies molten metal to compensate for solidification shrinkage of the casting and helps prevent shrinkage cavities.

**Q49. Differentiate between an open and a blind riser.**

**Ans.** An open riser is exposed to the atmosphere at the top of the mould; a blind riser is completely enclosed inside the mould and is fed by atmospheric pressure through a vent.

**Q50. State Chvorinov's rule.**

**Ans.** Chvorinov's rule states that the solidification time of a casting is proportional to the square of the ratio of its volume to its surface area:  $t = k (V/A)^2$ .

## Section C

### 30 Descriptive Questions with Detailed Answers

Each descriptive question should be answered in detail with definitions, classifications, working principles, sketches (where applicable) and examples. Answers below are written in paragraph form covering the essential points expected in an examination.

#### **Q1. Describe the various foundry processes and outline the basic steps involved in producing a sand casting.**

**Ans.** The foundry industry employs several casting processes, each suited to particular shapes, sizes and metals. The most widely used is sand casting, in which a pattern is used to form a cavity in a mould made of bonded sand; molten metal is poured into the cavity and allowed to solidify. Other important processes include shell moulding (using a resin-coated sand shell), investment (lost-wax) casting for fine detail, permanent (gravity die) casting using metal moulds, pressure die casting for non-ferrous mass production, and centrifugal casting for cylindrical components. Whatever the process, the basic steps of sand casting are essentially the same: (1) design and preparation of the pattern with appropriate allowances; (2) preparation of moulding sand by mixing silica, binder, additives and water; (3) preparation of the mould by ramming sand around the pattern in a flask, separating cope and drag, withdrawing the pattern and finishing the cavity; (4) preparation and setting of cores, if any; (5) closing the mould and providing a gating and riser system; (6) melting the metal in a furnace to the correct pouring temperature; (7) pouring the molten metal carefully into the mould; (8) allowing the casting to solidify and cool; (9) shake-out, in which the casting is removed from the sand; and (10) cleaning, fettling and inspection. Each step is critical because defects introduced early in the process – such as a poorly designed pattern or improperly prepared sand – will appear as defects in the final casting.

#### **Q2. Discuss the safety requirements that must be followed in a foundry.**

**Ans.** A foundry is one of the more hazardous industrial workplaces because it involves very high temperatures, heavy molten metal, dust, fumes, sharp tools and heavy lifting. Safety in a foundry therefore demands a combination of personal protective equipment (PPE), safe work procedures and a well-maintained environment. Every worker should wear flame-resistant clothing, heat-resistant gloves and aprons, safety goggles or face shields, safety shoes with steel toecaps and metatarsal guards, and respirators or dust masks where airborne silica or fumes are present. Pouring ladles must be checked for cracks, kept dry (a wet ladle can cause violent steam explosions) and never overfilled. Moulds must be properly vented and dry, since moisture trapped in a mould will turn to steam and may eject metal. Walkways must be free from clutter and molten-metal splatter. Cranes, slings and hoists used to lift heavy patterns, flasks and ladles must be inspected regularly and operated only by trained personnel. Adequate ventilation is essential to remove silica dust, carbon monoxide from furnaces and binder fumes from core ovens. Fire-fighting equipment, sand buckets and first-aid stations must be readily available. Finally, all workers should be trained in the safe handling of molten metal, the recognition of hazards (such

as a 'cold mould' that may cause splashing) and emergency procedures including the use of eye-wash stations and burn treatment.

**Q3. Explain the concept of a mould and describe its various parts with the help of a neat sketch.**

**Ans.** A mould is the cavity inside a moulding material into which molten metal is poured to produce a casting of a desired shape. In sand casting a typical two-part mould consists of a metal frame called the flask, which has an upper half (the cope) and a lower half (the drag). When the casting is complex a middle section called the cheek is added to make a three-part mould. The pattern is placed in the drag, sand is rammed around it, the cope is fixed on top with locating pins, more sand is rammed in, and finally the two halves are separated, the pattern withdrawn, and any cores set in their seats. The complete mould includes several essential features: the pouring basin at the top of the cope into which the ladle pours metal; the sprue, a tapered vertical passage from the pouring basin down to the parting line; the sprue base or well, a small enlargement at the bottom of the sprue that reduces turbulence; the runner, a horizontal channel that distributes metal from the sprue along the parting line; gates, which are short channels where the metal finally enters the cavity; the mould cavity itself, which is the shape of the casting; risers, which are reservoirs of metal that feed the casting during solidification; and vents, which are small holes pricked in the cope to allow gases to escape. The parting line is the joint between cope and drag where the mould opens.

**Q4. Discuss the various components of flask equipment used in sand moulding.**

**Ans.** Flask equipment refers to the frames and accessories that hold the moulding sand and help in producing the mould. The main component is the flask itself, which is a rigid box of metal or hardwood with no top and no bottom, designed to be filled with sand. In two-part moulding the flask consists of a cope (the upper half) and a drag (the lower half), joined by locating pins and bushes that ensure perfect alignment when the cope is placed over the drag. For deeper or more complex castings, a middle section called a cheek is introduced, giving a three-part flask. Flasks are usually rectangular but may be round. They are equipped with handles for lifting, trunnions or pivots for turning, and stiffening ribs to prevent distortion under ramming pressure. Other items associated with flask equipment include bottom boards (flat boards on which the pattern and drag are placed during ramming), turn-over boards used to invert the flask, and follow boards specially shaped to support patterns with irregular parting surfaces. Snap flasks and slip flasks are special types that can be removed after the mould is made, allowing one flask to make many moulds. Together these items form a complete system that supports the mould from preparation through pouring.

**Q5. What is a pattern? Discuss the various types of patterns with their applications.**

**Ans.** A pattern is a model or replica of the final casting, made with various allowances, that is used to form the mould cavity. Patterns are classified by their construction and complexity. A single-piece (solid) pattern is the simplest type – a single block in the shape of the casting – used for very simple shapes produced in small numbers, such as stuffing-box flanges. A split pattern is divided into two halves along the parting plane to allow easy moulding of more complex shapes; it is widely used for medium-complexity castings. A match-plate pattern has the cope and drag halves of the pattern mounted on opposite sides of a single plate; this gives accurate alignment and is excellent for mass production of small castings. A cope-and-drag pattern is similar but mounted on two separate plates so the cope and drag can be rammed on two different machines simultaneously. A loose-piece pattern is used when the casting has projections that would prevent withdrawal of a one-piece pattern; the projecting pieces are loose and are withdrawn separately after the main pattern is removed. A gated pattern incorporates the runners and gates in the pattern itself, useful for producing several small castings in one mould. A sweep pattern is used for large symmetrical castings of circular cross-section, such as bell shapes; only a board (sweep) is rotated about a spindle to form the mould. A skeleton pattern consists of only a wooden framework that outlines the casting; sand is packed inside and outside the frame, and is suitable for large castings made in small numbers. Shell and segmental patterns are other variants used for very large or hollow castings.

#### **Q6. Describe the various types of moulds used in foundry practice.**

**Ans.** Moulds in the foundry are classified mainly by the material from which they are made and by their condition at the time of pouring. The most common is the green sand mould, made of moist sand bonded with clay; it is cheap, quick to make and suitable for most metals and small to medium castings. A dry sand mould is a green-sand mould that has been baked in an oven to drive off moisture, giving higher strength and a better surface finish – suitable for larger and heavier castings. A skin-dried mould is a compromise: only the surface of a green-sand mould is dried, usually with a torch or radiant heater, giving some of the strength advantage of dry sand without the cost of fully baking. Loam moulds use a thick, plastic mixture of sand, clay and water (loam) and are built up over a brick or skeleton support; they are suitable for very large symmetrical castings. CO<sub>2</sub> moulds use silica sand mixed with sodium-silicate binder, hardened by passing carbon-dioxide gas through it, giving high accuracy and strength without baking. Shell moulds use sand coated with thermosetting resin, formed on a heated metal pattern to produce a thin shell of high accuracy. Permanent moulds (gravity die) are made of metal, usually cast iron or steel, and are reusable for hundreds of castings. Plaster moulds use gypsum-based slurry and are used for non-ferrous precision castings, and ceramic moulds for very high-precision work. Each type of mould is chosen on the basis of casting size, accuracy required, metal poured and production volume.

#### **Q7. Explain the various moulding methods used in the foundry, including hand and machine moulding.**

**Ans.** Moulding methods describe the way in which the sand is packed around the pattern to form the mould. They are broadly classified into hand moulding and machine moulding. Hand moulding

is the oldest method, in which the moulder rams sand around the pattern manually using a rammer. It is slow but very flexible, and is used for one-off castings, jobbing work and very large castings (called floor or pit moulding). Floor moulding is done on the foundry floor for medium-sized castings, while pit moulding is done in a pit dug in the floor for very large and heavy castings such as turbine casings. Bench moulding is used for small castings, with the moulder working at a bench. Machine moulding mechanises the ramming and turning operations to give faster, more uniform moulds and is essential for mass production. Common types of moulding machines include jolt machines (which lift and drop the flask repeatedly to pack the sand by inertia), squeeze machines (which compress the sand with a plate or air-bag), jolt-squeeze machines (which combine both actions for uniform density), sand slingers (which fling sand at high velocity onto the pattern, giving excellent ramming for very large moulds), and stripper-plate or match-plate machines (which combine ramming and pattern release). Modern automatic moulding lines integrate sand preparation, pattern handling, ramming, core setting and mould closing into a continuous, high-volume operation.

**Q8. Discuss the various pattern allowances and explain why each is required.**

**Ans.** Pattern allowances are deliberate dimensional differences between the pattern and the desired casting; they compensate for various physical changes that occur during casting. Shrinkage allowance is a positive addition to all dimensions of the pattern to account for the contraction of metal as it cools from the pouring temperature to room temperature; the value depends on the metal (about 10 mm/m for cast iron, 16 mm/m for steel, 20 mm/m for brass). Machining (finish) allowance is extra metal provided on surfaces that must be machined after casting; its value depends on the surface finish required and the size of the casting (typically 1.5 to 6 mm). Draft (taper) allowance is a slight taper given to the vertical faces of the pattern so that it can be lifted from the sand without damaging the mould cavity; values range from about 1° to 3°, more for hand moulding and less for machine moulding. Distortion (camber) allowance is applied to long, thin or unsymmetrical castings (such as long U-shapes) that tend to warp during cooling; the pattern is given an opposite curvature so the casting cools straight. Shake (rapping) allowance is a small negative allowance: when the moulder raps the pattern to loosen it, the mould cavity enlarges slightly, so the pattern is made slightly smaller to compensate. Without these allowances the final casting would not have the correct dimensions or could not even be produced from the mould.

**Q9. Explain the BIS colour code for patterns and core boxes.**

**Ans.** The Bureau of Indian Standards (BIS) prescribes a colour code for painting patterns so that the moulder, core maker and foundry inspector can instantly recognise the surface treatment intended for each portion of the pattern. According to this code: surfaces that will remain as-cast (with no further machining) are painted BLACK; surfaces that will be machined after casting are painted RED; surfaces that act as seats for loose pieces are painted RED with BLACK diagonal stripes; core prints (the projections that form seats for cores in the mould) are painted YELLOW; the seats of loose pieces are painted YELLOW with BLACK diagonal stripes; and parting surfaces

are usually shown unpainted (clear) or marked with diagonal stripes. Stop-offs (portions added only to support the pattern during ramming) are usually painted with diagonal black stripes on a yellow background. The colour code reduces confusion, prevents errors such as machining a surface meant to stay as-cast, and helps in training new workers.

**Q10. List and explain the desirable properties of moulding sand.**

**Ans.** Moulding sand must satisfy several conflicting requirements at once; the principal properties are these. Permeability is the property that allows gases and water vapour to escape through the sand during pouring; insufficient permeability causes blow-hole defects. Cohesiveness or green strength is the ability of moist sand particles to stick to one another so the mould holds its shape during handling and pouring. Dry strength is the strength of the dried mould – important when the metal is hot and the moisture has evaporated. Hot strength is the strength of the sand at high temperature, just below the fusion point, ensuring the cavity walls do not collapse. Refractoriness is the ability of the sand to resist high temperatures without fusing, melting or vitrifying; pure silica has a high melting point. Adhesiveness is the ability of the sand to stick to the surfaces of the flask, preventing it from falling out when the mould is moved. Flowability is the ability of the sand to flow around the pattern and into corners during ramming, giving uniform density. Collapsibility is the ability of the sand to break down easily after the casting has solidified, so the casting can contract freely and be shaken out. Finally, reusability and economy require that the sand can be reconditioned and used many times, and that the ingredients are inexpensive.

**Q11. Differentiate between natural and synthetic moulding sand and discuss the binders used in each.**

**Ans.** Natural moulding sand is mined from riverbeds, lake beds and open pits and is used with only minimal treatment such as screening and the addition of water. Its great advantage is that it already contains enough natural clay (about 5–20%) to provide bonding, so no extra binder need be added. It is cheap and easy to prepare but its properties cannot be precisely controlled, and its refractoriness is moderate. Synthetic moulding sand is produced by deliberately mixing clean, washed silica sand with carefully measured amounts of binder (usually 4–10% bentonite clay), water and additives. Because the composition is controlled, synthetic sand has uniform and predictable properties – higher refractoriness, better permeability, controlled strength – and is suitable for ferrous and high-temperature castings. The principal natural binder is clay, especially bentonite (a sodium- or calcium-bentonite, which swells in water and develops strong bonds). Synthetic binders include sodium silicate (water-glass), which hardens with CO<sub>2</sub> gas; organic resins such as phenolic, urea-formaldehyde and furan, hardened by heat or catalyst; vegetable oils (linseed oil) for cores; and cereal binders such as dextrin for green and dry strength. Each binder is chosen on the basis of strength, collapsibility, cost and environmental considerations.

**Q12. Describe the common additives to moulding sand and explain how each improves the sand properties.**

**Ans.** Apart from silica sand, clay binder and water, several additives are mixed into moulding sand to improve specific properties. Sea coal (finely ground bituminous coal) is added in

proportions of 2–8% to ferrous-casting sands; when the metal contacts the mould, the coal burns and produces a reducing atmosphere of CO and hydrocarbons that prevents the iron from oxidising and gives the casting a smoother surface. Sawdust or wood flour is added in small amounts (about 1–2%) to improve permeability and collapsibility; it burns out when the metal is poured, leaving small voids that allow gases to escape and the sand to give way as the casting contracts. Cereal binders such as ground corn or dextrin (about 0.25–2%) increase both green and dry strength of the sand. Pitch and asphalt are sometimes added for steel castings, where they char and form a reducing layer. Iron oxide (red oxide) improves hot strength and resistance to expansion defects. Silica flour (very fine silica) increases hot strength and resistance to metal penetration on heavy castings. Each additive is chosen with care, since excessive amounts can damage other properties – for example, too much sawdust reduces strength, while too much sea coal causes smoke and gas defects.

**Q13. Describe the procedure of preparing a two-part green sand mould step by step.**

**Ans.** Preparation of a two-part green sand mould begins with placing the drag half of the pattern (or the whole pattern, parting side down) on a flat bottom board, then setting the drag flask over it with the smaller end down. The moulder dusts the pattern with parting powder so the sand will not stick. Facing sand is sieved over the pattern to give a thin layer of fine, fresh sand in direct contact with the pattern; the rest of the flask is then filled with backing sand. The sand is rammed (peen-rammed near the pattern and butt-rammed over the rest) to achieve uniform density without crushing the pattern. Excess sand is struck off level with the top of the flask using a strike-off bar, and vent holes are pricked with a vent wire. A second flat board is placed over the drag and the whole assembly is rolled over so that the parting surface faces up. The cope flask is then placed on the drag, located by pins, and parting sand is sprinkled over the parting line. The cope pattern half (if a split pattern) is set in place, and the sprue pin and riser pin are stood vertically. The cope is filled with facing and backing sand, rammed, struck off and vented as before. The cope is then lifted off carefully, the sprue and riser pins withdrawn, the pattern halves rapped gently and removed. The mould cavity is repaired with a slick or trowel, the gating and runner cut, cores (if any) set in their prints, the cope replaced on the drag, weighted down and the mould is ready for pouring.

**Q14. What are chaplets? Describe their types and applications.**

**Ans.** A chaplet is a small metallic insert placed inside the mould cavity to support a core when the core prints alone are not sufficient – for example, when a core spans a long horizontal distance, when it has to resist the buoyant force of heavy molten metal, or when the core is so long that it would sag under its own weight. The chaplet rests on the mould wall on one side and on the core on the other, and when molten metal is poured it surrounds the chaplet and fuses with it, so the chaplet becomes a permanent part of the casting. For this reason chaplets must be made of the same metal as the casting (or a metal compatible with it) and their surfaces must be clean and free of oxide so they will fuse properly. The common types are: stem chaplets (a small disc or plate on a stem, used to support a core from below or above); double-headed chaplets

(two discs joined by a stem, used to support a core in the middle); radiator or perforated chaplets (used in thin-walled castings where good fusion is essential); and sheet-metal chaplets, which are stamped from sheet for special shapes. Chaplets should be used sparingly and as small as possible, since they may not fuse properly and can become sites of leakage or weakness in pressure castings.

**Q15. Describe the common defects encountered in sand castings, their causes and remedies.**

**Ans.** Casting defects fall into several broad groups depending on their origin. Gas defects include blow holes (smooth-walled cavities caused by gas trapped in moist or poorly vented sand; remedy: dry the sand, improve venting and lower moisture) and pin holes (clusters of small holes from dissolved gas; remedy: degas the metal). Shrinkage defects appear as cavities or sponginess in heavy sections that lacked feeding from the riser; remedy: redesign risers and use chills to direct solidification. Moulding-material defects include scabs and rat-tails (caused by sand expansion that cracks the mould face; remedy: add wood flour or sea coal, ram more lightly), drops (a portion of the cope falling into the cavity; remedy: ram cope harder and use mould nails), and swells (bulged casting walls from soft ramming; remedy: ram uniformly). Pouring defects include misruns (the metal solidifies before filling the mould; remedy: raise pouring temperature or thicken the section) and cold shuts (two streams meet but fail to fuse; remedy: increase temperature and improve gating). Metallurgical defects include hot tears (cracks at high temperature caused by hindered contraction; remedy: improve mould collapsibility and casting design) and shifts (misalignment of cope and drag; remedy: check flask pins). Every defect must be analysed by examining its location, shape and colour before the right remedy can be applied.

**Q16. What is a core? Describe the procedure for the preparation of cores.**

**Ans.** A core is a separately formed body of sand placed in the mould to produce a hollow space, internal passage, undercut or any other feature of the casting that cannot be formed by the pattern alone. Cores are usually made of silica sand bonded with special binders that develop strength on baking, such as linseed oil, sodium silicate or synthetic resins. The procedure for making a core begins with preparing the core sand: clean, washed silica sand is mixed in a muller with the chosen binder and additives in carefully controlled proportions. The mixed sand is rammed by hand or machine into a core box, which is a hollow tool with a cavity in the shape of the core. The two halves of the box (if split) are clamped together during ramming, and after ramming the box is opened and the green (still wet) core is carefully removed and placed on a flat plate or shaped support called a core drier. Cores that are long or weak may be reinforced internally with iron wires or rods. Vent passages are formed by pushing a vent wire through the core or by laying wax string through the sand, which melts out on baking. The cores are then baked in an oven at 200–260 °C for 2–6 hours depending on size, to drive off moisture and harden the binder. After baking, the cores are cleaned, sized, painted with a refractory coating and finally set into the core prints in the mould before closing.

**Q17. Explain the various types of cores used in foundry practice.**

**Ans.** Cores are classified by the way they are positioned in the mould and by their shape. A horizontal core lies horizontally with its prints resting in core seats at each end of the cavity along the parting line. A vertical core stands upright with its prints in the cope and drag; it is normally tapered on the cope side for easy assembly. A balanced core has only one core print (at one end) and is supported entirely by that print, with the other end projecting into the cavity – useful for blind holes. A hanging core is suspended from the cope with no support below and is normally not allowed to touch the bottom of the cavity. A drop core (stop-off core) is placed in a recess below the parting line to form a feature lower than the parting plane. A cover core sits in the top of the mould like a roof, used to form an internal cavity in the top of the casting. A ram-up core is rammed into the mould along with the sand; it is held in place by the surrounding mould. Kiss cores are small cores pressed between two opposed flat surfaces with no print, held only by friction. The choice of core type depends on the shape of the cavity, the size of the casting and the convenience of handling and venting.

**Q18. Discuss the painting and venting of cores and explain why each is necessary.**

**Ans.** Core painting and core venting are two important finishing operations for cores. Core painting (also called core coating or core dressing) consists of applying a thin layer of refractory material – typically a slurry of silica flour, zircon flour or graphite suspended in water or alcohol – onto the outer surface of the baked core. The coating is then dried (in air or by torch flame). The purposes of painting are several: it gives a very smooth surface to the internal cavity of the casting, prevents the molten metal from penetrating into the core sand (which would cause metal-sand fusion and a rough cavity wall), reduces sand burning at high temperatures and improves resistance to erosion by the metal stream. Core venting consists of forming small passages through the core for the escape of gases generated when the molten metal heats the binder; without vents these gases would be forced through the metal and cause blow-holes and porosity in the casting. Vents are formed either by pushing a vent wire through the core sand before baking, or by burying a wax string in the sand that burns out during baking, leaving a hollow passage. The vent must lead from the centre of the core out through the core print to the atmosphere or to a vent in the cope.

**Q19. What is a gating system? Explain its elements and functions with a sketch.**

**Ans.** A gating system is the complete arrangement of passages through which molten metal travels from the ladle into the mould cavity. Its main elements are: the pouring basin (a funnel-shaped cup on top of the cope, which receives metal from the ladle, traps slag and reduces splashing); the sprue (a tapered vertical passage from the basin to the parting line; the taper is necessary to keep the metal full and prevent air aspiration); the sprue base or sprue well (an enlargement at the bottom of the sprue that reduces the velocity of the stream and dissipates its kinetic energy, reducing turbulence and erosion); the runner (a horizontal channel along the parting line that distributes the metal to the gates); the gates or in-gates (short channels where the metal finally enters the cavity); and ancillary elements such as skim bobs, slag traps and

filters. The functions of the gating system are to fill the mould quickly and completely without aspiration of air; to deliver metal smoothly with minimum turbulence and erosion; to establish desired temperature gradients for directional solidification; to prevent slag and dross from entering the cavity; and to regulate the rate of pouring. A well-designed gating system is a key requirement for a sound casting.

**Q20. Differentiate between pressurized and unpressurized gating systems.**

**Ans.** Gating systems are classified as pressurized or unpressurized depending on where the smallest cross-section (the 'choke') is located. In a pressurized gating system the gates are made the smallest in cross-section, so the gating ratio (the ratio of sprue : runner : gates areas) is such that the gates are the choke – for example 1 : 2 : 1 or 1 : 3 : 2. Because the gates restrict the flow, the entire system is kept under positive pressure and remains full of metal, which prevents air from being drawn in (aspiration) and minimises oxidation. However, the metal enters the cavity at high velocity, causing turbulence and erosion, which can be a disadvantage for light alloys such as aluminium. In an unpressurized gating system the sprue or sometimes the runner is the choke, and the total gate area is larger than the runner area – ratios such as 1 : 2 : 4 or 1 : 4 : 4 are common. Because the gates do not restrict the flow, the velocity at the gate is low, turbulence and erosion are reduced, and the gating system is well suited to oxidation-prone metals such as aluminium and magnesium. The disadvantage is that the system does not stay completely full of metal and dross can be trapped easily. The choice depends mainly on the metal cast and the casting quality required.

**Q21. Discuss the various types of gates used in sand moulding.**

**Ans.** Gates are classified by their position and shape. A top gate enters the mould cavity from the top of the cavity (in the cope); it gives good directional solidification (cool metal at the bottom, hot metal at the top close to the riser) but causes splashing and turbulence in deep cavities. A bottom gate enters at the bottom of the cavity (in the drag); the metal rises smoothly and quietly with minimum splashing, but the temperature gradient is reversed (cold metal at the top), making feeding difficult. A parting line gate is located at the joint between cope and drag; it is the most common because it can be cut easily and combines the advantages of both top and bottom gating. A side gate enters from the side of the cavity, halfway between cope and drag. Finger or pencil gates are several small gates spaced along the cavity for thin-walled or large castings. Branch gates split the metal flow into several branches to fill complex shapes. Step gates have several gates at different heights so the metal first enters at the bottom and as it rises, higher gates become operative – this gives smooth filling for very tall castings. Whistle gates and horn gates allow venting along with gating. The choice of gate depends on the casting shape, size, the metal poured and the desired solidification pattern.

**Q22. What is a riser? Explain its functions and types.**

**Ans.** A riser (also called a feeder head or feeder) is a reservoir of molten metal connected to the casting that supplies extra metal to compensate for shrinkage during solidification, ensuring a sound, dense casting free from shrinkage cavities. Its primary function is to feed the casting as

the metal contracts during the change of state from liquid to solid (the so-called solidification shrinkage, which is typically 3–8% by volume). Secondary functions are to allow the escape of gases, to indicate that the mould has been completely filled, and to provide a temperature gradient that promotes directional solidification toward the riser. Risers are classified in two ways. By position: a top riser sits on top of the casting and feeds it by gravity; a side riser is at one side and feeds horizontally at the parting line. By type of opening: an open riser is exposed to the atmosphere at the top of the cope, so atmospheric pressure pushes the metal into the casting; a blind riser is completely enclosed inside the mould and is fed by atmospheric pressure transmitted through a small vent or a porous core stuck into it. Other variants include the live riser (connected to the gating system, so it receives the last and hottest metal and stays liquid longest – the most effective type) and the dead riser (receives metal from the cavity, cools sooner and is less effective). Risers must be designed so they solidify after the casting, which requires that their volume-to-surface-area ratio be larger than that of the casting (Chvorinov's rule).

### **Q23. Describe the function of risers and explain Chvorinov's rule.**

**Ans.** The fundamental function of a riser is to feed liquid metal into the casting throughout the solidification interval, compensating for the contraction that occurs when liquid metal turns into solid. For a riser to perform this function it must remain liquid longer than any part of the casting it feeds; if it solidifies first, the casting will have shrinkage cavities. The rate at which a body of liquid metal solidifies depends on how quickly heat can be lost from its surface – the larger the surface area relative to its volume, the faster it cools. This relationship was quantified by Chvorinov as  $t = k (V/A)^2$ , where  $t$  is the total solidification time,  $V$  is the volume of the body,  $A$  is its cooling surface area and  $k$  is a constant called the mould constant, which depends on the mould material, the metal and the pouring temperature. The rule implies that bulky bodies (with a large  $V/A$  ratio) solidify slowly and slender bodies solidify quickly. For a riser to remain liquid longer than the casting, its  $V/A$  ratio must exceed that of the casting; in practice the riser is designed so its solidification time is at least 1.25 times that of the casting. The rule is the basis for sizing risers, choosing their shape (cylindrical or spherical to maximize  $V/A$ ) and locating them, and it also explains the use of chills (which reduce solidification time locally to promote directional solidification).

### **Q24. Explain the concept of directional solidification and how it is achieved in castings.**

**Ans.** Directional solidification is the controlled progress of the solidification front through a casting in such a way that solidification begins at the point farthest from the riser and ends at the riser itself, leaving any shrinkage cavity in the riser (which is later cut off) rather than in the casting. Achieving directional solidification ensures that the riser can continuously supply liquid metal to compensate for contraction, giving a sound, dense casting. Several techniques are used. The first is good casting design: thin sections should be located far from heavy sections and risers, and isolated heavy sections should be avoided or fitted with their own risers. The second is the use of chills – metal inserts placed against heavy or isolated sections of the mould wall – which absorb heat rapidly, cooling that section quickly and forcing solidification to start there. External chills are

placed in the mould wall facing the casting, while internal chills are placed within the cavity and fuse with the casting. The third technique is padding, which is the deliberate addition of metal to a section to ensure that it tapers from thin to thick toward the riser (creating a temperature gradient that promotes feeding). The fourth is correct sizing and positioning of risers themselves, designed to solidify last. Together these methods produce castings free of shrinkage defects.

**Q25. What is a core print? Discuss the types of core prints with sketches.**

**Ans.** A core print is a projection on the pattern that creates a corresponding recess in the mould, into which a core is later seated and supported. Core prints serve two purposes: they accurately locate the core in the mould, and they support it against its own weight and the buoyant force of the molten metal. Several types are used. A horizontal core print is a cylindrical projection on each side of the pattern, lying along the parting line; the core is placed across these two prints. A vertical core print is a cone or cylinder projecting upward (or downward) from the pattern; the core sits in this seat with its axis vertical. A balanced core print is a single long print on one side of the pattern that supports a core extending into the cavity from the other side – used for blind holes. A cover (top) core print is provided in the cope and supports a core hanging from above. A wing or drop core print supports a core that has to be placed in a position other than the parting line, projecting from the cope or drag at an angle. The size of the core print depends on the weight and size of the core, the metallostatic pressure of the molten metal, and the strength of the core sand. If core prints alone cannot support the core, chaplets are used in addition.

**Q26. Discuss the materials used for making patterns and compare their properties.**

**Ans.** Patterns can be made from several materials, each with its own advantages and limitations. Wood is the most common: it is light, cheap, easy to shape and finish, and readily available. Teak, mahogany, pine and deodar are commonly used. Wood is suitable for limited production but tends to warp with moisture, wears quickly and is not very accurate, so it is unsuitable for mass production. Metal patterns – usually of aluminium, brass or cast iron – are far more durable and dimensionally stable; they are used for mass production where many thousands of castings must be made from one pattern. Aluminium is light, easy to machine and corrosion-resistant; brass and cast iron are stronger but heavier. Metal patterns are expensive and slower to produce. Plastic patterns (epoxy, polyester resin) are intermediate in cost and durability; they are dimensionally stable, light and corrosion-resistant, and can be cast in moulds, making them economical for medium production. Plaster of Paris (gypsum) patterns are used for small, highly detailed patterns, especially for non-ferrous alloys. Wax patterns are used in investment casting; they are melted out after the mould is built, so each pattern is used once. Modern foundries also use frozen mercury and polystyrene (the latter is gasified by the molten metal in lost-foam casting). The choice of material depends on the number of castings, the accuracy required, the size of the pattern and the budget.

**Q27. Describe the equipment and hand tools used by a moulder.**

**Ans.** A moulder uses a wide variety of hand tools, each designed for a specific operation. Rammers are used to pack the sand: the peen end is small and pointed for ramming close to the pattern, the butt end is flat and larger for the bulk of the sand. Bench rammers are short for bench moulding; floor rammers are longer for floor work; pneumatic rammers are used in larger moulds. The strike-off bar (or strickle) is a straight metal bar drawn across the top of the flask to level the sand. Trowels are flat metal blades used for smoothing flat surfaces, cutting in-gates and repairing the mould. Slicks are double-ended tools with various shapes for smoothing curved surfaces inside the cavity – common shapes are heart-and-leaf, square-and-round, and pipe slick. Lifters or cleaners are flat hooked tools used to remove loose sand from deep, narrow cavities. The sprue cutter is a small tubular tool used to cut the sprue passage. Vent wires are sharp wires for pricking gas-escape holes. Brushes (camel-hair or fibre) are used to dust the pattern with parting powder and to clean loose sand from the mould. The swab is a brush for moistening sand around the pattern just before withdrawal. Bellows are used to blow loose sand out of the cavity. Heavy items of equipment include flasks, bottom boards, turn-over boards, sand mullers, riddles (sieves) for sifting sand, and tongs and ladles for handling molten metal.

**Q28. Explain mould sealing, mould preservation and bench life of moulding sand.**

**Ans.** Mould sealing is the operation of closing the mould tightly so that molten metal does not escape (run out) at the parting line during pouring. After the cope is replaced on the drag, the joint is sealed by spreading a thin layer of plastic clay or by smoothing wet sand along the joint and pressing the two halves firmly together; in large moulds the cope is clamped down or weighted with iron blocks to resist the upward force of the metal. Without proper sealing the metal will leak out, causing dangerous flash, defective castings (run-out defect) and possible injury. Mould preservation refers to the practices used to keep the prepared mould in good condition between the time it is made and the time it is poured. A mould should not be allowed to dry out completely (or it will crumble), or to absorb extra moisture (which would cause blow-holes), or be exposed to dust and damage. Moulds are usually poured the same day they are made; if storage is necessary, they are covered with damp cloths or kept in a humidity-controlled area, and the cope is replaced just before pouring. Bench life is the length of time during which prepared moulding sand retains the moisture content and other properties needed to form a good mould; once the bench life is exceeded the sand dries out, loses its strength and flowability, and must be re-mulled with water before reuse. A long bench life is desirable when many moulds are made from one batch.

**Q29. Discuss the various types of risers and explain how the size and shape of a riser are decided.**

**Ans.** Risers are classified in several overlapping ways. By location relative to the casting: a top riser sits on top of the casting and is the simplest type; a side (lateral) riser is placed at the side and connected to the casting at the parting line. By exposure to atmosphere: an open riser is exposed at the top of the cope, so atmospheric pressure pushes the metal into the casting; a blind riser is completely enclosed inside the mould (used when an open riser is impractical, with a small

atmospheric vent or porous core to allow pressure to act). By their place in the gating system: a live (hot) riser is connected to the gating system so the last and hottest metal flows through it, keeping it liquid longest and making it the most efficient feeder; a dead (cold) riser receives metal that has already passed through the cavity and is colder, so it is less effective. The size and shape of a riser must be such that it solidifies after the casting it feeds and has enough metal to compensate the shrinkage. Using Chvorinov's rule the riser is shaped to maximise the volume-to-surface-area ratio – cylindrical risers with height-to-diameter ratios of about 1:1 or 1.5:1 are common, and spherical or hemispherical risers are even more efficient but harder to mould. The riser must also be large enough to contain the volume of metal needed to feed the casting (typically about 3 to 7% of casting volume for steel, more for aluminium). Insulating sleeves or exothermic compounds (Feeder aids) may be placed around the riser to slow its cooling and reduce its size.

**Q30. Discuss the various methods to improve casting yield by good gating and risering design.**

**Ans.** Casting yield is the ratio of the weight of the finished casting to the total weight of metal poured (including gates, runners and risers); a higher yield means less metal wasted and lower cost. Several methods are used to improve yield. First, the riser must be made just large enough to feed the casting and no larger; using Chvorinov's rule the engineer can compute the minimum riser size that solidifies after the casting. Second, insulating sleeves and exothermic compounds can be placed around the riser to slow its cooling, so a smaller riser can perform the same job. Third, chills (external or internal) can be used to cool heavy sections quickly, ensuring directional solidification toward a smaller riser. Fourth, casting design should favour gradually changing sections rather than abrupt thick-to-thin transitions, so that no isolated thick sections require separate risers. Fifth, padding can be added on the casting to create a taper from the thinnest section to the riser, again giving directional solidification. Sixth, the gating system itself can be optimised – using thin runners that solidify quickly, knock-off gates that break easily, and shared gating systems for multiple castings (cluster moulds) on a single sprue. Seventh, careful pouring at the correct temperature reduces wasted metal due to misruns. Combined, these techniques can raise the yield of steel castings from about 50–55% to 65–70% or more, with significant savings.

## References

The following textbooks, standards and supplementary sources have been consulted in the preparation of this course material. They are also recommended for further reading and in-depth study of foundry technology. Students are advised to refer to the latest editions of these books available in the institute library.

### Prescribed Textbooks

1. Jain, P. L. Principles of Foundry Technology. 5th ed., Tata McGraw-Hill / Khanna Publishers, New Delhi.
2. Lal, M., and Khanna, O. P. Foundry Technology. Dhanpat Rai and Sons, New Delhi.
3. Srinivasan, N. K. Foundry Technology. Khanna Publishers, New Delhi.
4. Heine, Richard W., Loper, Carl R., and Rosenthal, Philip C. Principles of Metal Casting. 2nd ed., Tata McGraw-Hill Publishing Company Ltd., New Delhi.
5. Mukherji, P. C. Fundamentals of Metal Casting Technology. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.

### Additional Reference Books

6. Beeley, P. R. Foundry Technology. 2nd ed., Butterworth-Heinemann, Oxford.
7. Campbell, John. Castings. 2nd ed., Butterworth-Heinemann, Oxford.
8. Ghosh, A., and Mallik, A. K. Manufacturing Science. 2nd ed., East-West Press Pvt. Ltd., New Delhi.
9. Kalpakjian, Serope, and Schmid, Steven R. Manufacturing Engineering and Technology. 7th ed., Pearson Education.
10. Rao, P. N. Manufacturing Technology: Foundry, Forming and Welding. Volume 1, 4th ed., McGraw-Hill Education (India).
11. Sharma, P. C. A Textbook of Production Engineering. S. Chand and Company Ltd., New Delhi.
12. Chapman, W. A. J. Workshop Technology. Part 1, Viva Books / Edward Arnold.
13. Hajra Choudhury, S. K., Hajra Choudhury, A. K., and Roy, Nirjhar. Elements of Workshop Technology. Volume 1 (Manufacturing Processes), Media Promoters and Publishers, Mumbai.

### Standards and Codes

14. IS 4218 (Parts 1 to 7): ISO Metric Screw Threads (referenced for pattern dimensions). Bureau of Indian Standards, New Delhi.

15. IS 7322: Code for Pattern Practice. Bureau of Indian Standards, New Delhi.
16. IS 1918: Methods of Physical Tests for Foundry Sands. Bureau of Indian Standards, New Delhi.
17. IS 3343: Glossary of Terms Relating to the Production of Castings. Bureau of Indian Standards, New Delhi.
18. IS 8853: Method for Determination of Properties of Moulding Sands. Bureau of Indian Standards, New Delhi.
19. IS 12679: Foundry Sand — Specifications. Bureau of Indian Standards, New Delhi.
20. American Foundry Society (AFS). Mould and Core Test Handbook. AFS, Schaumburg, IL.
21. ASM Handbook, Volume 15: Casting. ASM International, Materials Park, OH.

## **Journals and Periodicals**

22. International Journal of Metalcasting (Springer / American Foundry Society).
23. Indian Foundry Journal — Published by The Institute of Indian Foundrymen, Kolkata.
24. Foundry Trade Journal International — DFS Publications, UK.
25. Modern Casting — American Foundry Society (AFS), USA.
26. Journal of Materials Processing Technology — Elsevier.

## **Web and Digital Resources**

27. NPTEL Online Courses: 'Manufacturing Processes I' and 'Fundamentals of Manufacturing Processes' — <https://nptel.ac.in/>
28. The Institute of Indian Foundrymen (IIF) — <https://www.indianfoundry.org/>
29. American Foundry Society (AFS) — <https://www.afsinc.org/>
30. World Foundry Organization (WFO) — <https://www.thewfo.com/>
31. Bureau of Indian Standards (BIS) — <https://www.bis.gov.in/>

## **Note on Citation Style**

References in this material follow a simplified academic style adapted for an undergraduate engineering course. For research papers and project reports, students are advised to use the IEEE, APA or ASME citation style as required by their institute. The serial numbers used in the question bank do not link to specific references; rather, the references listed above collectively support the entire syllabus content of PEME201 (B) Foundry Technology-I.

**— End of Course Material —**