JEPPIAAR ENGINEERING COLLEGE

DEPARTMENT OF MECHANICAL ENGINEERING

ME 6403 ENGINEERING MATERIALS AND METALLURGY

II YEAR/ IV SEMESTER

QUESTION BANK

Vision of Institution

To build Jeppiaar Engineering College as an institution of academic excellence in technological and management education to become a world class university.

Mission of Institution

- To excel in teaching and learning, research and innovation by promoting the principles of scientific analysis and creative thinking.
- To participate in the production, development and dissemination of knowledge and interact with national and international communities.
- To equip students with values, ethics and life skills needed to enrich their lives and enable them to meaningfully contribute to the progress of society.
- To prepare students for higher studies and lifelong learning, enrich them with the practical and entrepreneurial skills necessary to excel as future professionals and contribute to Nation's economy.

PO1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2	**Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations
PO4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6	**The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	**Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9	**Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	**Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	**Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	**Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

JEPPIAAR ENGINEERING COLLEGE

DEPARTMENT OF MECHANICAL ENGINEERING

VisionoftheDepartment

To create excellent professionals in the field of Mechanical Engineering and to uplift the quality of technical education on par with the International Standards.

Department Mission

1. To reinforce the fundamentals of Science and Mathematics to Mechanical Engineering and critically and relatively investigate complex mechanical systems and processes.
2. To engage in the production, expansion and practice of advanced engineering applications through knowledge sharing activities by interacting with global communities and industries.
3. Toequip students with engineering ethics, professional roles, corporate social responsibility and life skills and apply them for the betterment of society.
4. To promote higher studies and lifelong learning and entrepreneurial skills and develop excellent professionals for empowering nation's economy.

PEO's

5. To enrich the technical knowledge of design, manufacturing and management of mechanical systems and develop creative and analytical thinking in research.
6. To relate, strengthen and develop the theoretical knowledge of the Mechanical Engineering by exhibiting various concepts applied through diverse industrial exposures and experts' guidance.
7. Facilitate the students to communicate effectively on complex social, professional and engineering activities with strict adherence to ethical principles.
8. Create awareness for independent and life long learning and develop the ability to keep abreast of modern trends and adopt them for personal technological growth of the nation.

PSO's

1. To understand the basic concept of various mechanical engineering field such as design, manufacturing, thermal and industrial engineering.
2. To apply the knowledge in advanced mechanical system and processes by using design and analysis techniques.
3. To develop student's professional skills to meet the industry requirements and entrepreneurial skills for improving nation's economy stronger.

ME 6403 ENGINEERING MATERIALS AND METALLURGY

COURSE OUTCOMES

C213.1	Relate the atomic arrangements of different metal combination and variation of carbon content in iron
C213.2	Outline the knowledge of various heat treatment process with different cooling curves
C213.3	Classify the physicsl characteristics of ferrous and non ferrous metals and its alloys
C213.4	Distinguish the knowledge of various polymers,ceramics and composites.
C213.5	Elaborate mechanical properties and different deformation mechanisms.

ME6403 ENGINEERING MATERIALS AND METALLURGY L T P C 3 0 0 3

OBJECTIVES:

- To impart knowledge on the structure, properties, treatment, testing and applications of metals and non-metallic materials so as to identify and select suitable materials for various engineering applications.

UNIT I ALLOYS AND PHASE DIAGRAMS 9

Constitution of alloys – Solid solutions, substitutional and interstitial – phase diagrams, Isomorphous, eutectic, eutectoid, peritectic, and peritectoid reactions, Iron – carbon equilibrium diagram. Classification of steel and cast Iron microstructure, properties and application.

UNIT II HEAT TREATMENT 10

Definition – Full annealing, stress relief, recrystallisation and spheroidising – normalising, hardening and Tempering of steel. Isothermal transformation diagrams – cooling curves superimposed on I.T. diagram CCR – Hardenability, Jominy end quench test - austempering, martempering – case hardening, carburizing, Nitriding, cyaniding, carbonitriding – Flame and Induction hardening – Vacuum and Plasma hardening. .

UNIT III FERROUS AND NON-FERROUS METALS 9

Effect of alloying additions on steel- α and β stabilisers– stainless and tool steels – HSLA, Maraging steels – Cast Iron - Grey, white, malleable, spheroidal – alloy cast irons, Copper and copper alloys – Brass, Bronze and Cupronickel – Aluminium and Al-Cu – precipitation strengthening treatment – Bearing alloys, Mg-alloys, Ni-based super alloys and Titanium alloys.

UNIT IV NON-METALLIC MATERIALS 9

Polymers – types of polymer, commodity and engineering polymers – Properties and applications of various thermosetting and thermoplastic polymers (PP, PS, PVC, PMMA, PET,PC, PA, ABS, PI, PAI, PPO, PPS, PEEK, PTFE, Polymers – Urea and Phenol formaldehydes)- Engineering Ceramics – Properties and applications of Al2O3, SiC, Si3N4, PSZ and SIALON –Composites-Classifications- Metal
Matrix and FRP - Applications of Composites.

UNIT V MECHANICAL PROPERTIES AND DEFORMATION MECHANISMS 8

Mechanisms of plastic deformation, slip and twinning – Types of fracture – Testing of materials under tension, compression and shear loads – Hardness tests (Brinell, Vickers and Rockwell), hardness tests, Impact test lzod and charpy, fatigue and creep failure mechanisms.

TOTAL : 45 PERIODS

OUTCOMES:

- Upon completion of this course, the students can able to apply the different materials, their processing, heat treatments in suitable application in mechanical engineering fields.

TEXT BOOKS:

1. Avner,, S.H., "Introduction to Physical Metallurgy", McGraw Hill Book Company,1994.
2. Williams D Callister, "Material Science and Engineering" Wiley India Pvt Ltd, Revised Indian Edition 2007

REFERENCES:

1. Raghavan.V, "Materials Science and Engineering", Prentice Hall of India Pvt. Ltd., 1999.
2. Kenneth G.Budinski and Michael K. Budinski, "Engineering Materials", Prentice Hall of India Private Limited, 4th Indian Reprint 2002.
3. Upadhyay. G.S. and Anish Upadhyay, "Materials Science and Engineering", Viva Books Pvt. Ltd., New Delhi, 2006.
4. U.C.Jindal : Material Science and Metallurgy, "Engineering Materials and Mettalurgy", First Edition, Dorling Kindersley, 2012

JEPPIAAR ENGINEERING COLLEGE

Jeppiaar Nagar, Rajiv Gandhi Salai – 600 119

DEPARTMENT OF MECHANICAL ENGINEERING

QUESTION BANK

IV SEMESTER
ME 6403 ENGINEERING MATERIALS AND METALLURGY
Regulation – 2013

JEPPIAAR ENGINEERING COLLEGE

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DEPARTMENT OF MECHANICAL ENGINEERING

QUESTION BANK

SUBJECT : ME 6403 ENGINEERING MATERIALS AND METALLURGY

YEAR /SEM: II /IV

UNIT I ALLOYS AND PHASE DIAGRAMS

Constitution of alloys – Solid solutions, substitutional and interstitial – phase diagrams, Isomorphous,eutectic, eutectoid, peritectic, and peritectoid reactions, Iron – carbon equilibrium diagram.Classification of steel and cast Iron microstructure, properties and application.

PART-A

CO Mapping: C212.1

Q.No	Questions	BT Level	Competence	PO
1	What is an alloy?	BTL-1	Remembering	P01
2	How many components are found in an alloy?	BTL-2	Understanding	P02
3	What is meant by base metal?	BTL-2	Understanding	P02
4	What are alloying elements?	BTL-1	Remembering	P01
5	Distinguish between substitutional and interstitial solid solution.	BTL-1	Remembering	P01
6	How Hume Ruther's rules for formation of substitutional solid solutions.	BTL-1	Remembering	P04
7	What are intermediate phases?	BTL-1	Remembering	P01,P02
8	What are intermetallic compounds?	BTL-1	Remembering	P01,P02
9	What are electron compounds?	BTL-1	Remembering	P01,P02
10	Define phase'. What different kinds of phases are possible?	BTL-1	Remembering	P01,P02
11	What is an equilibrium phase diagram?	BTL-1	Remembering	P06
12	What are the advantages of the equilibrium diagrams?	BTL-1	Remembering	P01
13	Explain Gibb's phase rule?	BTL-1	Remembering	P11
14	What are cooling curves?	BTL-2	Understanding	P02

15	What is liquids line? A Solidus line? A solves line?	BTL-1	Remembering	P01
16	What pieces of information can be obtained for each point in a phase diagram?	BTL-1	Remembering	P10
17	What is tie-line?	BTL-1	Remembering	P09
18	What is the lever-law calculation and what information can it provide? Opposite arm of lever	BTL-1	Remembering	P11
19	What is mean by invariant reaction?	BTL-1	Remembering	P07
20	What do you understand by allotropy of iron'?	BTL-5	Evaluating	P01,P02,P03
21	Define: ferrite and austenite.	BTL-1	Remembering	P01,P02
22	Define: Cementite and Pearlite?	BTL-2	Understanding	P02
23	Define: martensite, and bainite?	BTL-1	Remembering	P12
24	Define: martensite, and bainite?	BTL-1	Remembering	P01,P02
25	Define: martensite, and bainite?	BTL-3	Applying	P08
26	Define Solid Solution	BTL-1	Remembering	P01,P02
27	Define eutectic reaction	BTL-3	Applying	P01
28	What are three primary groups of plain carbon steels?	BTL-1	Remembering	P13
29	Define solid solution?	BTL-1	Remembering	P01
30	What are the limitations of equilibrium diagram?	BTL-1	Remembering	P01
	PART-B&C			
1	Explain the various invariant reactions involved in the system with the help of the Fe-C equilibrium diagram.	BTL-1	Remembering	P01
2	Metal 'A' has melting point of 1000° C. Metal 'B' has melting point of 500° C. Draw one phase diagram (between the elements 'A' and 'B') for each of the following conditions The two elements exhibit unlimited solid solubility. ii. The alloy system shows formation of two terminal solid solutions and a Eutectic point at 60% A at 700 ° C.	BTL-2	Understanding	P01,P02
3	Explain the microstructure, properties and applications of any two types of Steel and Cast iron.	BTL-2	Understanding	P10
4	Explain with a phase diagram of eutectoid and paratactic reaction.	BTL-1	Remembering	P10
5	Explain with neat sketch the eutectic systems. Give examples for these systems.	BTL-2	Understanding	P10
6	Explain the two types of solid solution with the help of neat sketch	BTL-1	Remembering	P01,P02

UNIT II HEAT TREATMENT

Definition – Full annealing, stress relief, recrystallisation and spheroidising – normalising, hardening and Tempering of steel. Isothermal transformation diagrams – cooling curves superimposed on I.T. diagram CCR – Hardenability, Jominy end quench test - austempering, martempering – case hardening, carburizing, Nitriding, cyaniding, carbonitriding – Flame and Induction hardening – Vacuum and Plasma hardening.

PART-A

CO Mapping: C212.2

Q.No	Questions	BT Level	Competence	PO
1	Define the term heat treatment	BTL-1	Remembering	P01,P02
2	What are the purposes of the processing heat treatments?	BTL-1	Remembering	P01,P02
3	List the various stages of a heat treatment process.	BTL-1	Remembering	P05
4	List some of the important heat treatment operations widely used.	BTL-1	Remembering	P01,P02
5	What is meant by annealing?	BTL-1	Remembering	P01
6	What are the purposes of annealing?	BTL-1	Remembering	P03
7	List the different types of annealing.	BTL-1	Remembering	P01,P02
8	What is meant by normalizing?	BTL-1	Remembering	P01,P02
9	What is quenching? List some of the quenching medium generally used in industries.	BTL-1	Remembering	P01,P02
10	What are the factors should be considered while selecting a quenching?	BTL-1	Remembering	P04
11	What are the three stages for quenching	BTL-1	Remembering	P01
12	What does the term hardening refer? What are the factors affecting the hardness?	BTL-1	Remembering	P09
13	Distinguish the work hardening with the age hardening process.	BTL-4	Analyzing	P01,P02
14	Justify the tempering process usually follows hardening process.	BTL-5	Evaluating	P10
15	What is the effect of: (a) tempering temperature, and (b) tempering time, on the hardness of steels?	BTL-1	Remembering	P06
16	What do you mean by temper embrittlement?	BTL-2	Understanding	P05

17	What is TTT diagram?	BTL-1	Remembering	P01
18	What is the significance of TTT diagram in the heat treatment of steel?	BTL-1	Remembering	P13
19	Why are TTT diagrams usually not applicable to industrial engineering practices?	BTL-1	Remembering	P01,P02
20	What is CCT diagram?	BTL-1	Remembering	P09
21	Define the term critical cooling rate. What are the factors affecting it?	BTL-1	Remembering	P11
22	What is significance of the critical cooling rate?	BTL-1	Remembering	P01
23	What is meant by hardenability? What are the factors affecting it?	BTL-1	Remembering	P01,P02
24	What is the difference between hardness and hardenability?	BTL-1	Remembering	P01
25	What is martempering and austempering?	BTL-1	Remembering	P12
26	Define hardenability.	BTL-1	Remembering	P01,P02
27	Define spheroidizing?	BTL-1	Remembering	P01
28	What is the purpose of the deep freezing in the heat treatment of steel?	BTL-1	Remembering	P10
29	Differentiate annealing and normalizing?	BTL-1	Remembering	P01,P02
30	Differentiate carburizing and nitriding?	BTL-1	Remembering	P01,P02
PART-B&C				
1	Distinguish between annealing and normalizing.	BTL-4	Analyzing	P01,P02,P03
2	Explain with neat setup figure the working principle of an induction hardening	BTL-5	Evaluating	P01,P02,P03
3	Explain Jominy test (or) End quench hardenability test with the help of the neat sketches	BTL-5	Evaluating	
4	What is annealing? Discuss in detail on different types of annealing and compare with normalizing.	BTL-1	Remembering	P07
5	Develop a short note on: (i)Hardenability , (ii) Nitriding, (iii) Flame hardening ,(iv) Cyaniding.	BTL-3	Applying	P10
6	Distinguish between hardness and hardenability. With suitable sketches, explain the hardness test for hardenability.	BTL-4	Analyzing	P01,P02
7	Explain TTT diagram with neat sketch and indicte all the phases with microsturcture.	BTL-5	Evaluating	P05

UNIT III FERROUS AND NON-FERROUS METALS

Effect of alloying additions on steel- α and β stabilisers– stainless and tool steels – HSLA, Maraging steels – Cast Iron - Grey, white, malleable, spheroidal – alloy cast irons, Copper and copper alloys – Brass, Bronze and Cupronickel – Aluminium and Al-Cu – precipitation strengthening treatment – Bearing alloys, Mg-alloys, Ni-based super alloys and Titanium alloys.

PART-A

CO Mapping: C212.3

Q.No	Questions	BT Level	Competence	PO
1	What are the properties of steel?	BTL-1	Remembering	P01
2	What are metals? Classify engineering materials	BTL-1	Remembering	P01,P02
3	What are ferrous metals? Classify ferrous materials.	BTL-1	Remembering	P01,P02
4	How to you enhance mechanical strength of Al?	BTL-1	Remembering	P01
5	How can you specify steel? What is the difference between 4140 steel and 4340 steel?	BTL-1	Remembering	P01
6	What are three primary groups of plain carbon steels?	BTL-1	Remembering	P03
7	What are alloy steels? How are alloy steels classified?	BTL-1	Remembering	P01,P02
8	List four important alloying elements added in alloy steels.	BTL-3	Analyzing	P01,P02
9	Why is alloying done?	BTL-1	Remembering	P01,P02
10	What are the primary effects of chromium, and copper as alloying elements in steel?	BTL-1	Remembering	P01
11	What are the effects of lead and sulphur on the machinability of steels?	BTL-1	Remembering	P01
12	Which alloy elements are basically a) carbide formers, and b) graphite promoters?	BTL-1	Remembering	P01,P02
13	What makes stainless steel stainless?	BTL-1	Remembering	P01
14	Why do stainless steels lose their corrosion resistance when the chromium in solution drops below 12%?	BTL-1	Remembering	P01,P02
15	What determines whether a stainless steel is austenitic ferritic, or martenistic?	BTL-1	Remembering	P06
16	What are the required properties of a tool steel?	BTL-1	Remembering	P01,P02
17	How can you classify tool steels?	BTL-1	Remembering	P01,P02
18	What is meant by 18-4-1 high speed steel?	BTL-1	Remembering	P08
19	What are HSLA steels? Where are they used?	BTL-1	Remembering	P01,P02
20	What are maraging steels? Give its composition.	BTL-1	Remembering	P01,P02
21	What are the heat resisting steels and free-machining steels?	BTL-1	Remembering	P09

22	What are the features that make cast iron an important material?	BTL-1	Remembering	P01,P02
23	What are the effects of carbon on the properties of cast iron?	BTL-1	Remembering	P01
24	What is the influence of cooling rate on the properties of a cast iron?	BTL-1	Remembering	P10
25	How can you classify cast irons?	BTL-1	Remembering	P12
26	Define Toughness	BTL-1	Remembering	P01,P02
27	What is twinning in metals?	BTL-1	Remembering	P12,P13
28	What is creep?	BTL-1	Remembering	P01,P02
29	What is the effect of chromium alloying element on the properties of steel?	BTL-1	Remembering	P01,P02
30	What is bearing alloys?	BTL-1	Remembering	P11
	PART-B&C			
1	Explain precipitation hardening with a neat sketch,	BTL-1	Remembering	P01,P02
2	Choose the composition, properties and uses of bearing alloys.	BTL-1	Remembering	P01,P02
3	Develop short notes about the following materials in terms of composition ,properties and applications.(i) Maraging steels (ii) Alpha-beta brasses (iii) Austenitic stainless steels (iv) Ferrite stainless steels	BTL-3	Applying	P01,P02
4	What are the influences of alloying Al, Cr, Ni, Mo, Si, Mn, V and Cu in steel? Explain in brief.	BTL-1	Remembering	P01,P02
5	What are the properties of aluminium? And what is the effect of different types of alloying elements such as copper, iron, managanese, magnesium used with aluminium and its application? Explain.	BTL-1	Remembering	P01,P02,P03
6	Develop short notes on: i)Maraging steels, (ii) Stainless steels, (iii) High speed steels iv) Tool steels iv)HSLA	BTL-5	Applying	P01,P02,P03
7	Name non-ferrous materials for the following articles a. Bush b. Furnaces heating element c. Type writer parts d. Coins e. Girders for airship f. Big end bearing g. Filament of electric lamps h. Turbine blades (ii)Write short notes on Bearing metals, Brasses.	BTL-1	Remembering	P01,P02
8	Explaining age hardening of Al-Cu with the heplp of phase diagram	BTL-5	Evaluating	P01,P02,P03

UNIT IV NON-METALLIC MATERIALS

Polymers – types of polymer, commodity and engineering polymers – Properties and applications of various thermosetting and thermoplastic polymers (PP, PS, PVC, PMMA, PET,PC, PA, ABS, PI, PAI, PPO, PPS, PEEK, PTFE, Polymers – Urea and Phenol formaldehydes)- Engineering Ceramics – Properties and applications of Al2O3, SiC, Si3N4, PSZ and SIALON –Composites-Classifications- Metal Matrix and FRP - Applications of Composites.

PART-A

CO Mapping: C212.4

Q.No	Questions	BT Level	Competence	PO
1	What are polymers?	BTL-1	Remembering	P01
2	List any four attractive characteristics of polymers.	BTL-1	Remembering	P01
3	Classify polymers.	BTL-1	Remembering	P02
4	Define the following terms: i) Monomer, ii) Homo polymer, and iii) Copolymer.	BTL-1	Remembering	P01
5	What is meant by isomerism?	BTL-1	Remembering	P01,P02
6	What is meant by the term „unsaturated molecule'? State its significance in plastics	BTL-1	Remembering	P01
7	What is polymerisation?	BTL-1	Remembering	P01,P03
8	Define the term „degree of polymerisation'?	BTL-1	Remembering	P01
9	What is the difference between addition polymerisation and condensation polymerisation?	BTL-1	Remembering	P01,P02
10	Why are additives added to polymers?	BTL-1	Remembering	P01
11	What are the characteristics of plastics which account for their wide use as engineering materials?	BTL-2	Understanding	P01,P02
12	Why are the fillers and plasticizers added to polymers?	BTL-1	Remembering	P01
13	Distinguish commodity plastics with engineering plastics.	BTL-4	Analyzing	P01
14	Name any four commodity plastics and engineering plastics.	BTL-1	Remembering	P01
15	Name any four thermoplastics and thermosetting plastics. Thermoplastics:	BTL-1	Remembering	P01,P02
16	What advantages do thermoplastic polymers have over thermosetting polymers, and vice versa?	BTL-1	Remembering	P06

17	What are the sources of raw materials for plastics?	BTL-1	Remembering	P12
18	What do the following acronyms PE, PP, PS, PVC, PTFE, and PMMA	BTL-1	Remembering	P01
19	List the properties and typical applications of PVC.	BTL-1	Remembering	P01
20	What are acrylic materials? Name two of them.	BTL-2	Understanding	P01,P02
21	Write short notes on nylons	BTL-4	Analyzing	P01,P02
22	What are bakelites? Also state their applications.	BTL-1	Remembering	P10
23	List the characteristics of urea-formaldehyde.	BTL-1	Remembering	P13
24	What are engineering ceramics?	BTL-1	Remembering	P01
25	List some of the distinct characteristics of engineering ceramics.	BTL-1	Remembering	P08
26	Discuss fiber reinforced composites?	BTL-6	Creating	P01
27	What do you understand by the plastic deformation?	BTL-1	Remembering	P01
28	What does impact test signify	BTL-1	Remembering	P01
29	Define degree of polymerization?	BTL-1	Remembering	P09
30	Distinguish brass from bronze?	BTL-4	Analyzing	P01
PART-B&C				
1	Develop notes on: i)PVC (ii) PF (iii) Glass (iv) PMMA v)Formaldehyde	BTL-6	Creating	P01,P02,P03
2	What is polymerization? Describe addition polymerization and condensation polymerization	BTL-1	Remembering	P01,P02,P03
3	How plastic materials are classified? Explain each classification	BTL-1	Remembering	P01,P02,P03
4	What are the properties and application of PVC, PET, PP and PC? Explain	BTL-1	Remembering	P03,P04
5	Develop a short note on i)PTFE ii)Phenol formaldehyde (iii)Engineering Ceramics (iv)Fiber Reinforced Plastic.	BTL-3	Applying	PO1,PO2, PO3,PO4
6	What do you understand by polymerization? With the help of suitable examples, compare and contrast the process of addition polymerization and condensation polymerization.	BTL-1	Remembering	P01,P02,P03
7	i) Develop short note about the different types of matrix materials and reinforcement materials used to make polymer matrix composites.(8)	BTL-6	Creating	P01,P02,P03
	(ii) Discuss the properties and application of Al3O and SiC.	BTL-6	Creating	P10,P11,P12

Unit – V MECHANICAL PROPERTIES AND DEFORMATION MECHANISMS				
Mechanisms of plastic deformation, slip and twinning – Types of fracture – Testing of materials under tension, compression and shear loads – Hardness tests (Brinell, Vickers and Rockwell), hardness tests, Impact test lzod and charpy, fatigue and creep failure mechanisms.				
PART-A				
CO Mapping: C212.5				
Q.No	**Questions**	**BT Level**	**Competence**	**PO**
1	What is meant by mechanical properties of materials?	BTL-1	Remembering	P01
2	Distinguish between elasticity and plasticity.	BTL-4	Analyzing	P01
3	Distinguish between ductility and malleability.	BTL-4	Analyzing	P01,P02
4	Define the terms brittleness and hardness.	BTL-1	Remembering	P01,P02
5	What do you mean by toughness and stiffness?	BTL-1	Remembering	P01
6	List any four technological properties of metals.	BTL-1	Remembering	P01,P02
7	What are the factors affecting mechanical properties?	BTL-1	Remembering	P01,P02
8	What is the effect of the grain size on the mechanical properties of the materials?	BTL-1	Remembering	P04
9	What is the effect of heat treatment on the mechanical properties of the materials?	BTL-1	Remembering	P01
10	Define the terms slip and twinning.	BTL-1	Remembering	P01
11	Explain the Schmid's law.	BTL-2	Understanding	P07,P08
12	What are the causes of twins?	BTL-1	Remembering	P01
13	What is meant by fracture?	BTL-1	Remembering	P03
14	List the different types of fracture in a material.	BTL-1	Remembering	P01
15	What is brittle fracture?	BTL-1	Remembering	P01
16	What is ductile fracture?	BTL-1	Remembering	P01,P02
17	How can you prevent the ductile fracture?	BTL-1	Remembering	P13
18	What is meant by fatigue fracture?	BTL-1	Remembering	P01
19	What is S-N diagram? What is the significance of it?	BTL-1	Remembering	P01,P02
20	What are the factors affecting fatigue strength?	BTL-1	Remembering	P01
21	How can you prevent fatigue fracture?	BTL-1	Remembering	P12
22	What is meant by creep fracture?	BTL-1	Remembering	P01
23	What are the factors affecting creep?	BTL-1	Remembering	P01
24	How can you prevent the creep fractures?	BTL-1	Remembering	P09

25	Distinguish between destructive and non-destructive tests.	BTL-4	Analyzing	P11
26	List some important destructive tests carried out on a material.	BTL-1	Remembering	P01
27	What is creep?	BTL-2	Understanding	P01,P02
28	What is the difference between HRB and HRC?	BTL-1	Remembering	P01
29	Define plastic deformations	BTL-1	Remembering	P01
30	What is endurance limit?	BTL-1	Remembering	P01
	PART-B&C			
1	Explain the different types of mechanical properties and mechanism of plastic deformation by slip and twinning.	BTL-2	Understanding	P01,P02
2	Choose the S-N curve for mild steel and aluminum and explain its features .Explain the procedure used to obtain S-N diagram	BTL-3	Applying	P01,P02,P03
3	Explain briefly about Charpy impact test.	BTL-2	Understanding	P01,P02
4	Explain in brief the testing of materials to measure tension and compression with a graph and an example.	BTL-2	Understanding	P01,P02,P03
5	What is hardness test and impact test? Explain with a sketch and an example.	BTL-1	Remembering	P11,P12
6	Ilustrate and describe the fatigue test.	BTL-2	Understanding	P08,P09
7	Distinguish between ‘ductile’ and ‘brittle’ fracture. Name two ductile and brittle materials and also derive Schmid’s law of critical resolved shear stress.	BTL-4	Analyzing	P01,P02
8	Construct a typical creep curve and brief on the mechanism	BTL-3	Applying	P01,P02,P03

UNIT – I ALLOYS AND PHASE DIAGRAMS

Constitution of alloys – Solid solutions, substitutional and interstitial – phase diagrams, Isomorphous,eutectic, eutectoid, peritectic, and peritectoid reactions, Iron – carbon equilibrium diagram.Classification of steel and cast Iron microstructure, properties and application.

1. What is an alloy? **MAY 2012**

   A metal alloy, or simple an alloy, is a mixture of two or more metals or a metal (Metals) and a non-metal (non-metals).

2. Classify the components are found in an alloy? **May 2012**
Two or more components are found in an alloy.

3. What is meant by base metal?
   In an alloy, the element which is present in the largest proportion is called the base metal.

4. What are alloying elements?
   In an alloy, all elements other than the base metal are called the alloying elements.

5. Distinguish between substitutional and interstitial solid solution.

   substitutional solid solution:

   In a substitutional solid solution, the solute atoms (impurities) substitute for parent solvent atoms in a crystal lattice.

   interstitial solid solution:

   In interstitial solid solution, the solute atoms fit in to the space between the solvent or parent atoms.

6. How Hume Ruther's rules for formation of substitutional solid solutions. **June 2014**
1. Size factor: The atoms must be of similar size, with less than a 15% difference in
2. Atomic radius (in order to minimize the lattice strain).
3. Crystal structure: The materials must have the same crystal structure.
4. 4. Valence: The atoms must have the same valence.

Electro negativity: The atoms must have approximately the same electro Negativity.

7. What are intermediate phases?
   If an alloying element is added in excess of the limit of solid solubility, a second Phase appears along with the primary solution. If the second phase differs in both crystal Structure and properties from primary solid solution, then it is known as an intermediate Phase.

8. What are intermetallic compounds?

   The compound formed by two or more metals in apparently stoichiometric proportion is called intermetallic compounds.

9. What are electron compounds?

   If two metals consist of atoms more or less similar size but different valency, then the Compounds formed are called electron compounds.

10. Define phase'. What different kinds of phases are possible?

    A phase is defined as any physically distinct, homogeneous and mechanically Separable portion of a substance. Three different kinds of phases are solid, liquid and vapour.

11. What is an equilibrium phase diagram?

    A phase diagram can be defined as a plot of the composition of phases as a function of temperature in any alloy system under equilibrium condition.

12. What are the advantages of the equilibrium diagrams?
    1. To show what phases are present at different compositions and temperature Under equilibrium conditions.
    2. To indicate the equilibrium solid solubility of one element in other element.
    3. To indicate the temperature range over which solidification of a material occurs.
    4. To indicate the temperature at which different phases start to melt.

13. Explain Gibb's phase rule? June 2014

    Gibb's phase rule is given by

    $$F=C-P+2$$

    Where,

    F=degrees of freedom of system or number of variables (such as temperature,

    Pressure or composition) that may be changed independently without altering the Equilibrium;

    C=number of components (usually elements or compounds) forming the system;

    P=no of phases present in the system

14. What are cooling curves?
    Cooling curves are obtained by plotting the measured temperatures at equal intervals during the cooling period of a melt to a solid.

15. What is liquids line? A Solidus line? A solves line?
    In a phase diagram, liquidus line is the line or boundary that separates liquid and liquid+solid phase regions. Solidus line is a line or boundary that separate solid and solid liquid phase region.Solvus line separate single-phase solid regions from two-phase solid region.

16. What pieces of information can be obtained for each point in a phase diagram?

Using a phase diagram, one can obtain at least the following three information.

1. The phases that are present,
2. The composition of each phase, and
3. The amount of each phase present.

17. What is tie-line?

A tie line is simply an isothermal line drawn through point of consideration, extending across the two-phase region and terminating at the phase boundary lines on either side.

18. What is the lever-law calculation and what information can it provide?

$$\text{Phase fraction} = \frac{\text{Opposite arm of lever}}{\text{Total length of tie line}}$$

$$\text{And phase percentage} = \frac{\text{Opposite arm of lever}}{\text{Total length of tie line}} \times 100$$

Using the lever law calculations, one can compute the phase fraction and the phase percentage.

19. What is mean by invariant reaction? **NOV 2015**

The eutectic reaction is also called an invariant reaction since it occurs under equilibrium conditions at a specific temperature and alloy composition that cannot be varied.

20. What do you understand by allotropy of iron'?

Allotropy refers to the possibility of existence of two or more different crystal Structures for a substance depending upon temperature.

21. Define: ferrite and austenite. **MAY 2013**

Ferrite

Ferrite is a primary solid solution based on iron having BCC structure. Maximum solubility of carbon in iron is 0.025% carbon at 723°C, while its solubility at room Temperature is only about 0.008%.

Austenite

Austenite is a primary solid solution based on iron having FCC structure. The maximum solubility of carbon in FCC iron is about 2% at 1140°C.

22. Define: Cementite and Pearlite?

Cementite

Cementite is the name given to the carbide of iron (Fe3C). It is the hard, brittle, intermetallic compound of iron with 6.69% of carbon.

Pearlite

Pearlite is the eutectoid mixture of ferrite (87.5%) and cementite (12.5%). It is formed when austenite decomposes during cooling. It contains 0.8% of carbon.

23. Define: martensite and bainite?

Martensite

It is the super saturated solid solution of carbon in iron. It is formed when steel is very rapidly cooled from the austenitic state.

Bainite

It is a decomposition product of austenite, consisting of an aggregate of ferrite and carbide. Bainite has hardness in between the hardness of pearlite and martensite.

24. Define Solid Solution **Dec 2011**

A solid solution may be defined as a solid that consist of two or more elements atomically dispersed in a single- phase structure.

25. Define eutectic reaction **Dec 2013**

A reaction wherein, upon cooling, one liquid phase transforms isothermally and Reversibly into two new solid phases that are intimately mixed is called eutectic Reaction.

26. What are three primary groups of plain carbon steels? **May 2013**

1. Low-carbon steels: Those contain less than 0.25% carbon.
2. Medium-carbon steels: Those containing between 0.25 and 0.60% carbon.
3. High-carbon steels: Those containing more than 0.60% carbon.

27. Define solid solution? **Nov /Dec 2011**

Solution: Homogenous mixture in which the atoms or molecules of one substance are dispersed at random in to another substance.

Solid Solution: Solid that consists of two or more elements automatically dispersed in a single phase structure.

Solute: Solute is the minor part of the solution or the material which dissolved.

Solvent: Solvent constitutes the major portion of the solution.

28. What are the limitations of equilibrium diagram?

A phase diagram (or equilibrium diagram) is a diagram with T and composition as axes, showing the equilibrium constitution. (or) It is graphical representation of what phase present in a materials system at various temperature, pressure and compositions.

Phase is the part of an alloy with the same physical and chemical properties and the same

composition. Phase must be distinguished from component, which is a distinct chemical substance from which the phase is formed.

For solids: Chemically and structurally distinct

For liquids: Miscibility

For gases: Always 1 phase

E-g: water is one phase, but water mixed with ice is two phases.

The Al-Si, Cd-Zn and Al-Cu alloys are all made up of two phases.

PART – B

1. Explain the various invariant reactions involved in the system with the help of the Fe-C equilibrium diagram. **(MAY 2015, 2016 & 2017)**
   Refer: "Introduction physical metallurgy" by Avner. S. H Page No: 230 – 234

2. Metal 'A' has melting point of 1000° C. Metal 'B' has melting point of 500° C. Draw one phase diagram (between the elements 'A' and 'B') for each of the following conditions. **(MAY/JUNE 2014)**
   i. The two elements exhibit unlimited solid solubility.
   ii. The alloy system shows formation of two terminal solid solutions and a Eutectic point at 60% A at 700 ° C.
   Refer: "Introduction physical metallurgy" by Avner. S. H Page No: 170 – 172

3. Explain the microstructure, properties and applications of any two types of Steel and Cast iron. (**NOV 2015 , JUNE & NOV2016)**
   Refer: "Introduction physical metallurgy" by Avner. S. H Page No: 394 – 406

4. Explain with a phase diagram of eutectoid and paratactic reaction. (**NOV/DEC 2013) (APRIL 2017)**
   Refer: "Introduction physical metallurgy" by Avner. S. H Page No: 313 – 314

5. Explain with neat sketch the eutectic systems. Give examples for these systems. **MAY/JUNE 2013**
   Refer: "Introduction physical metallurgy" by Avner. S. H Page No: 298 – 311

6. Explain the two types of solid solution with the help of neat sketch. (**MAY/JUNE 2013 & NOV/DEC 2015)**
   Refer: "Introduction physical metallurgy" by Avner. S. H Page No: 150 – 154

UNIT – II HEAT TREATMENT

Definition – Full annealing, stress relief, recrystallisation and spheroidising – normalising, hardening and Tempering of steel. Isothermal transformation diagrams – cooling curves superimposed on I.T. diagram CCR – Hardenability, Jominy end quench test - austempering, martempering – case hardening, carburizing, Nitriding, cyaniding, carbonitriding – Flame and Induction hardening – Vacuum and Plasma hardening.

1. Define the term heat treatment

   Heat treatment may be defined as an operation or combination of operations involving Heating and cooling of a metal/alloy in solid state to obtain desirable properties.

2. What are the purposes of the processing heat treatments?
   a. To relieve internal stresses.
   b. To improve machinability.
   c. To refine grain size.
   d. To soften the metal.
   e. To improve hardness of the metal surface.

3. List the various stages of a heat treatment process.
   Stage 1: Heating a metal/alloy beyond the critical temperature.

   Stage 2: Holding at that temperature for a sufficient period of time to allow necessary changes to occur.

   Stage 3: Cooling the metal/alloy (i.e., quenching) at a rate necessary to obtain the desired properties. That is, cooling at a rate necessary to obtain the desired Changes in the nature form, size and distribution of micro-constituents.

4. List some of the important heat treatment operations widely used.
   1. Annealing2. Normalizing. 3. Hardening. 4. Tempering. 5. Austempering. 6. Martempering and 7. Case hardening.

5. What is meant by annealing?

   Annealing is defined as a softening process consisting of heating the steal to a Temperature at or near the critical point, holding there for a proper time and then allowing it to cool slowly in the furnace itself.

6 .What are the purposes of annealing? **MAY 2013**
   i. To relieve or remove stresses.
   ii. To induce softness.
   iii. To refine grain structure.
   iv. To alter ductility, toughness, electrical, magnetic or other properties.
   v. To remove gases.
   vi. To produce a definite microstructure.

7. List the different types of annealing.
   i. Full annealing.
   ii. Process annealing.
   iii. Stress relief annealing.
   iv. Recrystallization annealing, and
   v. Spheroidise annealing.

8. What is meant by normalizing?

   Normalizing is similar to full annealing, but cooling is established in still air rather than in the furnace.

9. What is quenching? List some of the quenching medium generally used in industries.

   Quenching refers accelerated cooling. Some of the quenching medium that is usedgenerally in industries are: 5-10% caustic soda, 5-20% brine (NaCl), cold water,

   Warm water, mineral oil (obtained during the refining of crude petroleum), animal oil, and vegetable oil (such as linseed, cottonseed, and rapeseed).

10. What are the factors should be considered while selecting a quenching?
   i. Desired rate of heat removal.
   ii. Required temperature interval.
   iii. Boiling point.
   iv. Viscosity.
   v. Flash point (if combustible).
   vi. Stability under repeated use.
   vii. Possible reactions with the material being quenched.
   viii. Cost.

11. What are the three stages for quenching? **MAY2014**
   i. Stage 1: Vapour-jacket stage.
   ii. Stage 2: Vapour-transport cooling stage.
   iii. Stage 3: Liquid Cooling stage.

12. What does the term hardening refer? What are the factors affecting the hardness? **MAY 2012**

   Hardening refers to the heat treatment of steel which increases its hardnes. The hardness obtained from the hardening process depends upon the Following factors: 1. Carbon content, 2. quenching medium, 3. Specimen size, and 4. other factors.

13. Distinguish the work hardening with the age hardening process. **June 2014**

   Work hardening also known as strain hardening, is the process of hardening a metal, while working on it (under cold-working conditions).

   Age hardening also known precipitation hardening, is the process of hardening a metal when allowed to remain or age after heat treatment.

14. The tempering process usually follows hardening process. Justify.

The martensite which is formed during hardening process is too brittle and lacks good ductility and toughness. Hence, it cannot be used for more applications. Also the internal residual stresses that are introduced during hardening have a weakening effect. The ductility and toughness of martensite can be enhanced and these internal stresses are relieved by a heat treatment process known as tempering.

15. What is the effect of: (a) tempering temperature, and (b) tempering time, on the hardness of steels?

a. The hardness gradually decreases as the temperature is increased.
b. The hardness decreases with the increase in tempering.

16. What do you mean by temper embrittlement?

The tempering of some steels/steel alloys may result in a reduction of toughness (i.e., increase in brittleness). This phenomenon is referred as temper embritlement.

17. What is TTT diagram?

The TTT diagram is a plot of temperature versus the logarithm of time for a steel alloy of definite composition. It is a tool used by heat treaters to predict quenching reactions in steels.

18. W
hat is the significance of TTT diagram in the heat treatment of steel? **MAY 2014**
The TTT diagram is most useful in giving an overall picture of the transformation behavior of austenite. This enables the metallurgist to interpret the response of steel to any specified heat treatment.

Using a TTT diagram, one can plan practical heat treatment operations to get desirable micro constituents, to control limited hardening or softening, and the time of soaking.

19. Why are TTT diagrams usually not applicable to industrial engineering practices?

The data for the construction of TTT diagrams are obtained from the isothermal transformation of austenite at differing temperatures. But most industrial heat treatments involve continuous cooling from the austenitic temperature to room temperature. Thus a TTT diagram may not five a fully accurate representation of the temperatures and times of the transformations occurring.

20. What is CCT diagram?

The CCT diagram is a plot of temperature versus the logarithm of time for a steel alloy of definite composition. It is used to indicate when transformations occur as the initially austenitised material is continuously cooled at a specified rate. In addition, it is also used to predict the final microstructure and mechanical characteristics.

21. Define the term critical cooling rate. What are the factors affecting it?

The slowest rate of cooling of austenite that will result in 100% martensite transformation is known as the critical cooling rate. Factors affecting the critical rate are: 1. Chemical composition of steel, 2.Hardening temperature, and 3. Metallurgical nature (i.e, Purity) of steel.

22. What is significance of the critical cooling rate?

The critical cooling rate is most important in hardening. In order to obtain a 100% martensitic structure on hardening, the cooling must be must be much higher than the critical cooling rate.

23. What is meant by hardenability? What are the factors affecting it? **NOV 2015**

The term hardenability refers to the ease with which hardness may be attained. In other words, hardenability is a measure of ease of forming martensite.The factors affecting the hardenability are: 1. Composition of the steel, 2.Austenitic grain size, 3. Structure of the steel before quenching, and 4.Quenching medium and the method of quenching.

24. What is the difference between hardness and hardenability?

The term hardness is the property of a material by virtue of which it is able to resist abrasion, indentation and scratching. It is mechanical property related to strength and is a strong function of the carbon content of a metal.

On the other hand, hardenability is the susceptibility of a material to get hardened. It is affected by the alloying elements in the material and grain size.

25. What is martempering and austempering? **MAY 2012**

Martempering, also known as marquenching, is an interrupted cooling procedure used for steels to minimize stresses, distortion and cracking of steels that may develop during rapid quenching. The Austempering is an isothermal heat treatment process, usually used to reduce quenching distortion and to make tough and strong steels.

26. Define hardenability. **JUNE 2012**

It is the property of material by virtue of which it is able to resist abrasion, indentation and scratching.

27. Define spheroidizing?

The steel is cooled by quenching (in a water bath or oil bath) to the room temperature. The cooling rate should be higher than the critical cooling rate (deep freezing) in order to get the completely martensitic structure.

28. What is the purpose of the deep freezing in the heat treatment of steel?

Medium and high carbon steels having a microstructure containing even coarse pearlite is too hard to conveniently machine or plastically deform. These steels are spheroidising annealed.ie heat treated to develop the spheroidite structure. The spheroidised steels have a maximum softness and ductility and also they are easily machined or deformed.

29. Differentiate annealing and normalizing?

Annealing:	Normalizing:
• It refers to heat treatment in which a material is exposed to an elevated temperature for an extended time period and then slowly cooled.	• It is similar to full annealing but cooling is established in still rather than in the furnace.
• It is costly treatment	• It is more economical
• It is more time consuming	• It is less time consuming
• It provides a fine grain structure	• It provides coarse grain structure

30. Differentiate carburizing and nitriding?

carburizing	Nitriding
• It is process in which carbon atoms are introduced on to the surface of low carbon steels to produce a hard case of surface, while the interior or core remains soft.	• It is a process of introducing nitrogen atoms to obtain hard surface of steel components.

PART – B

1. a. Distinguish between annealing and normalizing. (6) (**MAY/JUNE 2013, 2014)**
   Refer: "Introduction physical metallurgy" by Avner. S. H Page No: 248 - 254

   b. Explain with neat setup figure the working principle of an induction hardening (10). (**MAY/JUNE 2013,2016)**
   Refer: "Introduction physical metallurgy" by Avner. S. H Page No: 333 – 335

2. Explain Jominy test (or) End quench hardenability test with the help of the neat sketches. (**MAY/JUNE 2013,2016)**
   Refer: "Introduction physical metallurgy" by Avner. S. H Page No: 298 – 301

3. What is annealing? Discuss in detail on different types of annealing and compare with normalizing. **(MAY/JUNE 2012**, **APRIL 2017)**
   Refer: "Introduction physical metallurgy" by Avner. S. H Page No: 248 – 254

4. Write a short note on:(i)Hardenability, (ii) Nitriding, (iii) Flame hardening, (iv) Cyaniding. **NOV/DEC 2013**
   Refer: "Introduction physical metallurgy" by Avner. S. H Page No: 316 – 328

5. Distinguish between hardness and hardenability. With suitable sketches, explain the hardness test for hardenability. **MAY/JUNE 2014 (APRIL 2017)**
   Refer: "Introduction physical metallurgy" by Avner. S. H Page No: 333 – 337

6. Explain TTT diagram with neat sketch and indicted all the phases with microstructure. (**JUNE 2016)**
   Refer: "Introduction physical metallurgy" by Avner. S. H Page No: 264 - 266

UNIT – III FERROUS AND NON-FERROUS METALS

Effect of alloying additions on steel- α and β stabilisers– stainless and tool steels – HSLA, Maraging steels – Cast Iron - Grey, white, malleable, spheroidal – alloy cast irons, Copper and copper alloys – Brass, Bronze and Cupronickel – Aluminium and Al-Cu – precipitation strengthening treatment – Bearing alloys, Mg-alloys, Ni-based super alloys and Titanium alloys.

1. What are the properties of steel? **Nov 2013**

1. Conductivity
2. Malleability
3. Ductility

2. What are metals? Classify engineering materials.

Metals are elemental substances. Metals are composed of elements which readily give up electrons to provide a metallic bond and electrical conductivity.

Types of metals:

i. Ferrous metals, and
ii. Non-ferrous metals.

3. What are ferrous metals? Classify ferrous materials.
The metals, which contain iron as their main constituent, are called ferrous Metals.

Types of ferrous metals:

i. Steels, and
ii. Cast irons.

4. How to you enhance mechanical strength of Al? **Nov 2010**
By alloying aluminium with one or more allying element such as Cu, Mg, Mn, Si and Ni.

5. How can you specify steel? What is the difference between 4140 steel and 4340 steel?
The AISI/SAE designation for the steels is a four digit number: First two Digits indicate the alloy content, and Last two digits indicate the carbon concentration. 4140 steels is alloy of Cr-Mo with 0.40% C, whereas 4340 steel is an alloy of Mo-Cr-Ni with 0.40%C.

6. What are three primary groups of plain carbon steels? **June 2013**

1. Low-carbon steels: Those contain less than 0.25% carbon.
2. Medium-carbon steels: Those containing between 0.25 and 0.60% carbon.
3. High-carbon steels: Those containing more than 0.60% carbon.

7. What are alloy steels? How are alloy steels classified?

Alloy steels mean may steels other than carbon steels. Alloy steels can be divided into two main groups as:

i. Low alloy steels: These contain up to 3 to 4% of alloying elements.
ii. High alloy steels: These contain more than 5% of alloying elements.

8. List four important alloying elements added in alloy steels.
The most commonly used alloying elements are chromium, nickel, molybdenum, Vanadium, tungsten, cobalt, boron, copper and others.

9. Why is alloying done?

The alloying steel is generally done:

To increase its strength.

To improve hardness. To improve toughness.

To improve resistance to abrasion and water. To improve machinability.

To improve ductility.

10. What are the primary effects of chromium, and copper as alloying elements in steel? **Dec 2011**

Effects of alloying chromium: Increases corrosion and oxidation resistance, increases hardenability, increases high-temperature strength, and resists abrasion and wear (with high carbon).

Effects of alloying copper: Increases strength, and increases corrosion resistance.

11. What are the effects of lead and sulphur on the machinability of steels?

Lead improves the machinability whereas sulphur reduces it.

12. Which alloy elements are basically a) carbide formers, and b) graphite promoters?

i. Carbide formers: Cr, W, Ti, Mo, Nb, V, and Mn.
ii. Graphite promoter: Si, Co, Al, and Ni.

13. What makes stainless steel stainless?

The chromium oxide (extremely dense-thin) protective layer acts as a barrier to retard further oxidation, rust or corrosion. As this steel cannot be stained easily, it is called stainless steel.

14. Why do stainless steels lose their corrosion resistance when the chromium in solution drops below 12%?

When the weight% of chromium drops below 12% the corrosion rate increases sharply. As the corrosion rate increases, the resultant chromium-oxide protective layer unable to retard oxidation, rust or corrosion effectively.

15. What determines whether a stainless steel is austenitic ferritic, or martensitic?

The predominant phase constituent of the microstructure present in a stainless steel determines whether a stainless steel is austenitic, ferritic, or martensitic.

What are the required properties of a tool steel?

Tool steels should have the following requirements: 1. Good toughness, 2. Good wear resistance, 3. Very good machinability, 4. Slight change of form during hardening, 5. Little risk of cracking during hardening.5. Resistance to softening on heating.

17. How can you classify tool steels?

1. Cold work tool steels, 2. Shock resisting tool steels, 3. Hot work tool steels,

4. High speed tool steels, 5. Plastic mold tool steels and 6. Special purpose tool steels.

18. What is meant by 18-4-1 high speed steel?

A widely used high-speed tool steel is 18-4-1 high speed steel. This steel contains 18% tungsten, 4% chromium, and 1% vanadium. It is considered to be one of the best of all purpose steels.

19. What are HSLA steels? Where are they used? **MAY 2015**

HSLA steels are nothing but high-strength low-alloy steels. HSLA steels, also known as micro alloyed steels, are low-carbon steels containing small amounts of alloying elements. These HSLA steels are widely used as structural or constructional alloy steels.

20. What are maraging steels? Give its composition.

Maraging steels are low-carbon, highly alloyed steels. These are very high strength materials that can be hardened to obtain tensile strengths of up to 1900 Mpa.

Composition: Maraging steels contain 18% nickel, 7% cobalt, and small amounts of other elements such as titanium. The carbon content is low, generally less than .05%.

21. What are the heat resisting steels and free-machining steels?

Steels which can resist the creep and oxidation at high temperatures and retain sufficient strength are called heat resisting steels. Free-machining steels, also known as free cutting steels, machine readily and form small chips so as to reduce the rubbing against the cutting tool and associated friction and wear.

22. What are the features that make cast iron an important material?

1. It is a cheap metallurgical substance,

2. Good castability,

3. Good mechanical rigidity and good strength under compression.

4. Good machinability can achieved when a suitable composition is selected.

23. What are the effects of carbon on the properties of cast iron?

If a cast iron contains more of the brittle cementite, then its mechanical properties will be poor.

24. What is the influence of cooling rate on the properties of a cast iron?

High rate of cooling results in a weak and brittle cast iron. Slow cooling rate results in tough and strong cast iron.

25. How can you classify cast irons?

Grey (General-Purpose) White (Hard and wear resistant) Malleable (Heat-treated for ductility) SpheroidalGraphite (Some ductility) Alloy cast irons (Special-purpose)

26. Define Toughness **Dec 2011**
Toughness is the property of a material by virtue of which it can absorb maximum energy before fracture takes place.

27. What is twinning in metals? **April 2010**
Atoms in a part of crystal subjected to stress rearrange themselves so that one part of the crystal became a mirror image of the other part.

28. What is creep? **Dec 2011**
The creep is defined as the property of a material by virtue of which it deforms continuously under a steady load.

29. What is the effect of chromium alloying element on the properties of steel?
    i. Increase corrosion and oxidation resistance.
    ii. Increase hardenability.
    iii. Increases high temperature strength.
    iv. Resists abrasion and wear.

30. What is bearing alloys? **May 2012**
Bearing alloys are the materials used for making bearing. The widely used bearing materials are white metals copper base alloys aluminum base alloy.

PART – B

1. a. With a neat sketch, explain precipitation hardening. (8) (**MAY/JUNE 2014,2016)**
   b. State the composition, properties and uses of bearing alloys. (8)
   Refer: "Introduction physical metallurgy" by Avner. S. H Page No: 374 – 376

2. Write short notes about the following materials in terms of composition, properties and applications.
   (i) Maraging steels

   (ii) Alpha-beta brasses (iii) Austenitic stainless steels (iv) Ferrite stainless steels (**MAY/JUNE 2014)**

   Refer: "Introduction physical metallurgy" by Avner. S. H Page No: 527

3. What are the influences of alloying Al, Cr, Ni, Mo, Si, Mn, V AND Cu in steel? Explain in brief. **(NOV/DEC 2013 APRIL 2017)**
   Refer: "Introduction physical metallurgy" by Avner. S. H Page No: 377-383, 469-471, 629

4. What are the properties of aluminium? And what is the effect of different types of alloying elements such as copper, iron, managanese, magnesium used with aluminium and its application? Explain. **NOV/DEC 2013**
   Refer: "Introduction physical metallurgy" by Avner. S. H Page No: 353 - 353

5.Write short notes on: (**MAY 2013, 2016)**

(i)Maraging steels, (ii) Stainless steels (iii) High speed steels. iv) Tool steels and iv) HSLA

Refer: "Introduction physical metallurgy" by Avner. S. H Page No: 409 – 411

6. i. Name non-ferrous materials for the following articles (8). **MAY/JUNE 2013**
   i. Bush
   j. Furnaces heating element
   k. Type writer parts
   l. Coins
   m. Girders for airship
   n. Big end bearing
   o. Filament of electric lamps
   p. Turbine blades

ii. Write short notes on (8):

Bearing metals, Brasses.

Refer: "Introduction physical metallurgy" by Avner. S. H Page No: 380, 387 - 392

a. Explaining age hardening of Al-Cu with the heplp of phase diagram **(MAY 2016)**

Refer: "Introduction physical metallurgy" by Avner. S. H Page No: 390 – 391

UNIT – IV NON-METALLIC MATERIALS

Polymers – types of polymer, commodity and engineering polymers – Properties and applications of various thermosetting and thermoplastic polymers (PP, PS, PVC, PMMA, PET,PC, PA, ABS, PI, PAI, PPO, PPS, PEEK, PTFE, Polymers – Urea and Phenol formaldehydes)- Engineering Ceramics – Properties and applications of Al2O3, SiC, Si3N4, PSZ and SIALON –Composites-Classifications- Metal Matrix and FRP - Applications of Composites.

1. What are polymers?

   Polymers are composed of a large number of repeating units of small molecules called manometers. Polymers may be defined as giant organic, chain-like molecules having molecular weight from 10000 to more than 1,000,000 g.mol.

2. List any four attractive characteristics of polymers.
   q. Low density.
   ii. Good thermal and electrical insulation properties.
   iii. High resistance to chemical attack.
   iv. Ease of fabrication.
   v. Relatively low cost.

3. Classify polymers.
   1. Elastomers,
   2. Adhesives,
   3. Coatings,
   4. Fibres.

4. Define the following terms: i) Monomer, ii) Homopolymer, and iii) Copolymer.

   Monomer is a small molecule consisting of a single mer i.e., a single unit/blocking block.

   Homopolymer is a polymer made out of identical monomer. Copolymer is a polymer which is obtained by adding different types of monomers.

5. What is meant by isomerism?

   Isomerism is a phenomenon wherein different atomic configurations are possible for the same configuration.

6. What is meant by the term „unsaturated molecule?
   State its significance in plastics. A compound in which the valence bonds of the carbon atoms are not satisfied is said to be unsaturated. Such unsaturated molecules are important in the polymerization i.e.,joining together of small molecules into large one having the same constituents.

7. What is polymerisation? **NOV 2011**
   Polymerisation is the process of forming a polymer.

8. Define the term degree of polymerisation''? **MAY 2012**

Degree of polymerisation is the number of repetitive units (or mers) present in One molecule of a polymer.

Mathematically,

$$\text{Degree of polymerisation} = \frac{\text{Molecular weight of a polymer}}{\text{Molecular weight of a single monomer}}$$

9. What is the difference between addition polymerisation and condensation polymerisation?

Addition polymerization, also known as chain reaction polymerisation, is a process by which two or more chemically similar monomers are polymerized to form long chain molecules. Condensation polymerization, also known as step-growth polymerisation, is the formation of polymers by stepwise intermolecular chemical reactions that normally involve at least two different monomers

10. Why are additives added to polymers?

The various polymer additives include:1. Filler materials, 2. Plasticizers, 3. Stabilizers, 4. Colorants, 5. Flame retardants,6. Reinforcements, and 7. Lubricants.

11. What are the characteristics of plastics which account for their wide use as engineering materials?

Plastics are extensively used in engineering applications due to their important properties such as low price, colour range, toughness, water resistance, low electrical and thermal conductivity, ease of fabrication, etc.

12. Why are the fillers and plasticizers added to polymers?

1. Fillers

To improve tensile and compressive strengths.

To improve dimensional and thermal stability, and other properties. To reduce the cost of the final product.

2. Plasticisers

To improve the flexibility, ductility, and toughness. To reduce the hardness and stiffness.

To increase and control the flow of the polymer duringmolding.

13. Differentiate commodity plastics with engineering plastics.

The plastics which are not generally used for engineering applications are known as commodity plastics. H plastics which are used in engineering applications are known as engineering plastics.

14. Name any four commodity plastics and engineering plastics.

Commodity plastics: i) Polyethylene (PE), ii) Polypropylene (PP), iii) Polystyrene (PS), iv) Polyvinyl chloride (PVC).

Enginering Plastics: i) Ethenic, ii) Polyamides, iii) Cellulosics, iv) Acetals.

15. Name any four thermoplastics and thermosetting plastics.
Thermoplastics: Polythenes, Polypropylene, Polystyrenes, PVC. Thermosetting plastics: Polyesters, phenolics, epoxides, melamine formaldehyde.

16. What advantages do thermoplastic polymers have over thermosetting polymers, and vice versa?
Since thermoplastics have low melting temperature and can be repeatedly moulded and remoulded to the desired shape, they have a good resale/scrap value. The thermosetting plastics are generally stronger, harder, more brittle, more resistant to heat and solvents than thermoplastics.

17. What are the sources of raw materials for plastics?
    1. Animal and vegetable by-products,
    2. Coal by-products,
    3. Petroleum by-products.

18. What do the following acronyms PE, PP, PS, PVC, PTFE, and PMMA.**MAY 2012**
PE: Polyethylene; PP: Polypropylene; PS: Polystyrene; PVC; Polyvinyl chloride;

PTFE: Polytetrafluro ethylene; PMMA: Polymethyl methacrylate

19. List the properties and typical applications of PVC.

Properties: Good low-cost, general purpose materials; ordinary rigid, but can be made flexible with plasticizers; susceptible to heat distortion.

Typical applications: Pipes, valves, fittings, floor tiles, wire insulations, toys, phonograph records, safety glass interlayers.

20. What are acrylic materials? Name two of them.

Acrylic materials are thermoplastic polymers based on the polymerization of esters of acrylic acid and/or methacrylic acid.The most commonly used acrylic polymers are:

i. PMMA (Polymethyl methacrylate),
ii. PAN (Polyacrylonitrile)

21. Write short notes on nylons. **JUNE 2013**

Polyamides (PA), also known as nylons, are the products of condensation reactions between an amine and an organic acid.There is number of common polyamides. They are usually designated as nylon 6, nylon 6/6, nylon 6/10, nylon 6/12, nylon 11, and nylon 12. These suffixes refer to the number of carbon atoms in each of the reacting substances involved in the condensation polymerization process.

22. What are bakelites? Also state their applications.

Phenolics, also known as Bakelites, are the oldest family of thermosetting plastics. The most important phenolic materials is the polyformaldehydes.Typical applications include electrical plugs, sockets, switches, telephones,door knobs and handles, adhesives, coatings, and laminates.

23. List the characteristics of urea-formaldehyde.

1 They are similar to the phenolics.
2 They are hard and rigid thermosets.
3 They have good electrical insulation properties.
4 They are light in colour.
5 They exhibit good resistance to most chemicals.

23. What are engineering ceramics?

Engineering ceramics are also known as technical/industrial ceramics, are those ceramics that are specially used for engineering applications or in industries.

25. List some of the distinct characteristics of engineering ceramics.

1. High resistance to abrasion and wear.
2. High strength at high temperature.
3. Good chemical stability.
4. Good electrical insulation characteristics.

26. Discuss fiber reinforced composites?

Fibre reinforced composites are those in which the dispersed phase is in the form of a fibre. In these composites high strength fibres are encased within a tough matrix.

27. What do you understand by the plastic deformation?

Plastic deformation is the deformation of a body which remains even after removing the external load from the body.

28. What does impact test signify?

The impact test is performed to study the behavior of materials under dynamic load i.e., suddenly applied load.

29. Define degree of polymerization?

Degree of polymerization is the number of repetitive units present in one molecule of a polymer.

30. Differentiate brass from bronze?

Brass:	Bronze :
• It contain zinc as the alloying element	• It contain copper as the alloying element
• Brass has high resistance to corrosion and is easily machinable it also act as good bearing material	• Bronze possesses superior mechanical properties and corrosion resistance

PART - B

1. Write notes on: **MAY/JUNE 2013,NOV 2016**
   a. PVC (ii) PF (iii) Glass (iv) PMMA v)Formaldehyde

   Refer: "Introduction physical metallurgy" by Avner. S. H Page No: 538 - 540

2. What is polymerization ? Describe addition polymerization and condensation polymerization.(10) **MAY/JUNE 2013,2016**
   a. (ii) How plastic materials are classified? Explain each classification.(6) **MAY/JUNE 2013**

   Refer: "Introduction physical metallurgy" by Avner. S. H Page No: 400

3. What are the properties and application of PVC, PET, PP and PC? Explain.(16) **Nov/Dec 2013**

   Refer: "Introduction physical metallurgy" by Avner. S. H Page No: 538-540

4. Write a short note on (**Nov/Dec 2013,2016)**
   a. PTFE
   b. Phenol formaldehyde
   c. Engineering Ceramics
   d. Fiber Reinforced Plastic.

   Refer: "Introduction physical metallurgy" by Avner. S. H Page No: 541-542

5. What do you understand by polymerization? With the help of suitable examples, compare and contrast the process of addition polymerization and condensation polymerization. (**MAY/JUNE 2014)**

   Refer: "Introduction physical metallurgy" by Avner. S. H Page No: 545-546

6. Write short note about the different types of matrix materials and reinforcement materials used to make polymer matrix composites. (8)
   a. (ii)Discuss the properties and application of Al_3O and SiC. (8) (**MAY/JUNE2014,NOV 2016)**

   Refer: "Introduction physical metallurgy" by Avner. S. H Page No: 555-556

UNIT – V MECHANICAL PROPERTIES AND DEFORMATION MECHANISMS

Mechanisms of plastic deformation, slip and twinning – Types of fracture – Testing of materials under tension, compression and shear loads – Hardness tests (Brinell, Vickers and Rockwell), hardness tests, Impact test lzod and charpy, fatigue and creep failure mechanisms.

1. What is meant by mechanical properties of materials?
   Mechanical properties are those characteristics of material that describe its behavior under the action of external forces.

2. Distinguish between elasticity and plasticity.

   Elasticity is the property of a material by virtue of which it is able to retain its original shape and size after the removal of the load.

   Plasticity is the property of a material by virtue of which a permanent deformation (without fracture) takes place, whenever it is subjected to the action of external forces.

3. Differentiate between ductility and malleability.

   Ductility is the property of a material by virtue of which it can be drawn into wires before rupture takes place.

   Malleability is the property of a material by virtue of which it can withstand deformation under compression without rupture.

4. Define the terms brittleness and hardness.

   Brittleness is the property of a material by virtue of which it can withstand deformation under compression without rupture.

   Hardness is the property of a material by virtue of which it able to resist abrasion, indentation (or penetration), machining, and scratching.

5. What do you mean by toughness and stiffness?

   Toughness is the property of a material by virtue of which it can absorb maximum energy before fracture takes place.

   Stiffness is the property of a material by virtue of which it resists deformation.

6. List any four technological properties of metals.
   i. Machinability
   ii. Castability,
   iii. Weldability,
   iv. Formability or workability.

7. What are the factors affecting mechanical properties?
   i. Grain size,
   ii. Heat treatment,
   iii. Atmospheric exposure, and
   iv. Low and high temperatures.

8. What is the effect of the grain size on the mechanical properties of the materials?

   The materials having smaller grains (i.e., fine grained structure) have high yield strength, high tensile strength, and more hardness. Also fine grain results in better resistance to cracking and better surface finish.

9. What is the effect of heat treatment on the mechanical properties of the materials?
   The heat treatment improves mechanical properties like tensile strength, toughness, hardness, ductility, shock resistance and resistance to corrosion. It also improves workability, forgeability and machinability of metals.

10. Define the terms slip and twinning.

    Slip may be defined as the sliding of blocks of the crystal over one another along definite a mirror image of the other part.

    Twinning is the process in which the atoms in a part of a crystal subjected to stress, rearrange themselves so that one part of the crystal becomes a mirror image of the other part.

11. State the Schmid's law.

    The stress required at a given temperature to initiate slip in a pure and perfect single crystal, for a material is constant. This is known as Schmid's law.

12. What are the causes of twins?

    1. Mechanical twins: Twins that are produced by mechanical deformation are called mechanical twins.
    2. Annealing twins: Twins that are produced by annealing are called annealing twins.

13. What is meant by fracture?

    Fracture is the mechanical failure of the material which will produce the separation or fragmentation of a solid into two or more parts under the action of stresses.

14. List the different types of fracture in a material.
    1. Brittle fracture,
    2. Ductile fracture,
    3. Fatigue fracture,
    4. Creep fracture.

15. What is brittle fracture?

    A brittle fracture may be defined as a fracture which takes place by a slow propagation of crack with appreciable plastic deformation.

16. What is ductile fracture?

    Ductile fracture may be defined as the fracture which takes place by a slow propagation of crack with appreciable plastic deformation.

17. How can you prevent the ductile fracture?

In order to prevent the ductile fracture, the material should have the following characteristics:

The material should have fine grains. It should have higher hardness value.

It should have higher Young's modulus and cohesive energy.

It should not have any defects/dislocations.

18. What is meant by fatigue fracture?

A fatigue fracture is defined as the fracture which takes place under repeatedly applied fatigue stresses.

19. What is S-N diagram? What is the significance of it?

The S-N diagram is a graph obtained by plotting the number of cycles of stress reversals (N) required to cause fracture against the applied stress level (S). Using S-N diagram, the fatigue life of a material can be determined.

20. What are the factors affecting fatigue strength?

1. Fatigue strength is influenced by many factors such as chemical composition, grain size, and amount of cold working.
2. Fatigue strength is high at low temperatures and gradually decreases with Rise in temperature.
3. Environmental effects such as corrosion of the product by moisture Decreases.
4. The design of the product also influences the fatigue strength.

21. How can you prevent fatigue fracture?

The following methods can be adopted to prevent the fatigue failure.

1. Use of good design to avoid stress concentration by eliminating sharp recesses and severe stress raisers.
2. Control of the surface finish by avoiding damage to surface machining, punching, stamping, shearing, etc.
3. Reduction of corrosion environmental effects by surface heat treatments like polishings, coatings, carburizing, nitriding, etc.

22. What is meant by creep fracture?

The creep is defined as the property of a material by virtue of which it deforms continuously under a steady load.

23. What are the factors affecting creep?

1 Grain,
2 Thermal stability of the micro-structure,
3 Chemical reactions,
4 Prior strain.

24. How can you prevent the creep fractures?

The following methods can be adopted to prevent the creep failure.

1. Use of coarse grained materials will avoid creep fracture.
2. Strain hardening can be done to avoid creep fracture.
3. The material should be free from any residual stresses and dislocations.
4. Precipitation-hardened alloys can be used to avoid creep fracture.

25. Differentiate between destructive and non-destructive tests.

In destructive type of testing, the component or specimen to be tested is destroyed and cannot be reused.In non-destructive type of testing, the component or specimen to be tested is not destroyed and can be reused after the test.

26. List some important destructive tests carried out on a material.

1. Tensile test, 2. Impact test, 3. Bend test, 4. Fatigue test, 5. Torsion test and 6. Creep test.

27. What is creep? **May 2013**

It is the property of a material by virtue of which deforms continuously under steady load.

28. What is the difference between HRB and HRC?

Brinell hardness test (HRB)	Rockwell hardness test (HRC)
• An indenter is pressed in to the testing surface of the material by slowly applied known load and the extent of the resulting impression is measured mathematical or optically. a large impression for a given load and indenter indicates a soft material and a small impression indicates a hard material.	• In this the dial gives a direct reading of hardness no need for measuring indention diameter or diagonal length using the microscope.

29. Define plastic deformations **May 2013**

It is the deformations of body which remains even after removing the external load from the body

30. What is endurance limit? **May 2006**

It is defined as the maximum stress which a specimen can endure without failure when this stress is repeated for a specified number of cycles.

PART – B
1. Explain the different types of mechanical properties and mechanism of plastic deformation by slip and twinning. (**MAY 2014,2016, 2017)** *Refer: "Introduction physical metallurgy" by Avner. S. H Page No: 118, 203 and 211*
2. a. Draw the S-N curve for mild steel and aluminum and explain its features .Explain the procedure used to obtain S-N diagram. **MAY/JUNE 2014** b. Explain briefly about Charpy impact test. **MAY/JUNE 2014** *Refer: "Introduction physical metallurgy" by Avner. S. H Page No: 45 – 46*
3. Explain in brief the testing of materials to measure tension and compression with a graph and an example. **NOV/DEC 2013** *Refer: "Material Science and Engineering", by Williams D Callister Page No: 154 – 155*
4. What is hardness test and impact test? Explain with a sketch and an example. (**NOV/DEC 2013) & (APRIL 2017)** *Refer: "Introduction physical metallurgy" by Avner. S. H Page No: 42*
5. Sketch and describe the fatigue test. **MAY/JUNE 2013** *Refer: "Introduction physical metallurgy" by Avner. S. H Page No: 44*
6. a. Distinguish between 'ductile' and 'brittle' fracture. Name two ductile and brittle materials and also derive Schmid's law of critical resolved shear stress.(8) (**MAY/JUNE 2012)** b. Draw a typical creep curve and brief on the mechanism (8). (**NOV/DEC 2015, 2016)** *Refer: "Introduction physical metallurgy" by Avner. S. H Page No: 118 - 119*