



ACE

Engineering Academy

TEST ID: 409

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ESE- 2019 (Prelims) - Offline Test Series

Test – 17

MECHANICAL ENGINEERING

Engineering Materials + Manufacturing, Industrial And Maintenance Engineering + Mechatronics & Robotics — SOLUTIONS

01. Ans: (d)

Sol: Gray cast iron has number of attractive properties, including high compressive strength good machinability, good resistance to sliding wear, good resistance to thermal fatigue, good thermal conductivity and good vibration damping.

02. Ans: (a)

Sol: Pouring time:

- For the gating-system design is to fill the mould in the smallest time. The time for complete filling of a mould termed pouring time, is a very important criterion for design.
- Too long a pouring time requires a higher pouring temperature and too less a pouring time means turbulent flow in the mould, which makes the casting defect-prone. There is thus an optimum pouring time for any given casting.

- The pouring time depends on the casting materials, complexity of the casting, section thickness and casting size. The various relations used are not theoretically obtained but established generally by the practice at various foundries and by experimenters.

03. Ans: (c)

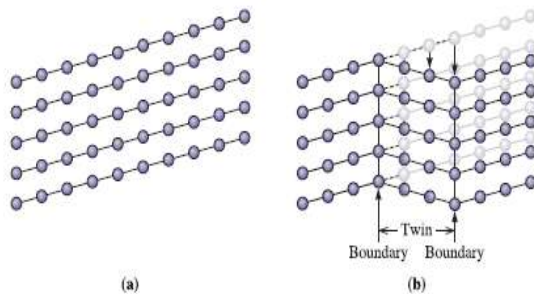
04. Ans: (d)

Sol:
$$F_7 = \frac{145 + 130 + 125 + 120 + 130}{5} = 130$$

05. Ans: (a)

06. Ans: (b)

Sol: Twin boundary is a plane across which there is a special mirror image mis-orientation of the crystal structure (*Fig. (a)*). Twins can be produced when a shear force, acting along the twin boundary, causes the atoms to shift out of position. (*Fig. (b)*)



07. Ans: (a)

08. Ans: (a)

Sol: $\lambda = 6/\text{hr}$

$$\mu = \frac{1}{5} \times 60 = 12/\text{hr}$$

$$\rho = \frac{\lambda}{\mu} = \frac{6}{12} = 0.5$$

$$L_q = \frac{\rho^2}{1-\rho} = \frac{0.5^2}{1-0.5} = 0.5$$

$$W_q = \frac{L_q}{\lambda} = \frac{0.5}{6} = \frac{1}{12} \text{ hr}$$

$$= \frac{1}{12} \times 60 = 5 \text{ min}$$

09. Ans: (b)

10. Ans: (d)

Sol: The effects of solid-solution strengthening on the properties of a metal include the following:

- The yield strength, tensile strength, and hardness of the alloy are *greater than* those of the pure metals. This is one

reason why we most often use alloys rather than pure metals. For example, small concentrations of Mg are added to aluminum to provide higher strength to the aluminum alloys used in making aluminum beverage cans.

- Almost always, the ductility of the alloy is less than that of the pure metal. Only rarely, as in copper-zinc alloys, does solid-solution strengthening increase both strength and ductility.
- Electrical conductivity of the alloy is much lower than that of the pure metal. This is because electrons are scattered by the atoms of the alloying elements more so than the host atoms. Solid-solution strengthening of copper or aluminum wires used for transmission of electrical power is not recommended because of this pronounced effect. Electrical conductivity of many alloys, although lower than pure metals, is often more stable as a function of temperature.
- The resistance to creep and strength at elevated temperatures are *improved* by solid-solution strengthening. Many high-temperature alloys, such as those used for jet engines, rely partly on extensive solid-solution strengthening.



11. Ans: (c)

Sol:

- Submerged arc welding (SAW) is an arc-welding process that uses a continuous, *consumable bare wire electrode*, and arc shielding is provided by a cover of granular flux.
- The slag and un-fused flux granules on top provide good protection from the atmosphere and good *thermal insulation* for the weld area, resulting in relatively slow cooling and a high-quality weld joint, noted for toughness and ductility.
- SAW is known to be a high current (sometimes even greater 1000A) welding process that is mostly used for joining of heavy sections and *thick plates* as it offers deep penetration with *high deposition rate* and so high welding speed.

12. Ans: (c)

13. Ans: (c)

Sol: Interference float = Slack at head event

$$= 24 - 21 = 3$$

$$\text{Total float} = (24 - 15) - 4 = 5$$

Free float = Total float – Slack at head event

$$= 5 - 3 = 2$$

Free float – Interference float – Total float

14. Ans: (c)

15. Ans: (d)

Sol: In the bottom-up approaches, the starting materials are atoms, molecules, and ions. The processes bring these basic building blocks together, in some cases one at a time, to fabricate the desired nanoscale entity. The three approaches that are of considerable interest in nanotechnology are: (1) production of carbon nanotubes, (2) nanofabrication by *scanning probe techniques*, and (3) self-assembly.

16. Ans: (d)

Sol: **Zones in Arc Gap:** On establishing the welding arc, drop in arc voltage is observed across the arc gap. However, rate of drop in arc voltage varies with distance from the electrode tip to the weld pool (Fig.1). Generally, five different zones are observed in the arc gap namely cathode spot, cathode drop zone, plasma, anode drop zone and anode spot (Fig.2).

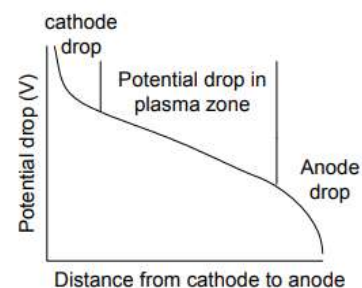


Fig. 1: Potential drop as function of distance from the cathode to anode

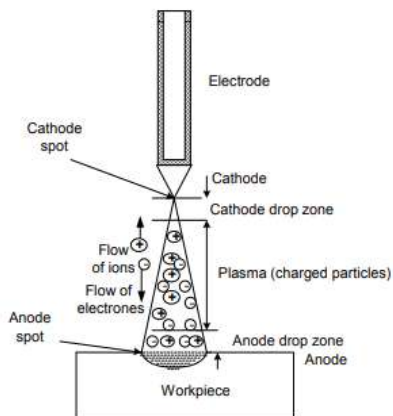


Fig 2: Zones in arc gap of a welding arc

17. Ans: (c)

18. Ans: (a)

Sol: Immediate addressing ----- LXIH, 2050

Implied addressing----- RRC

Register addressing----- MOV A, B

Direct addressing----- LDA 30 FF

19. Ans: (a)

Sol: Dual model can be used to solve the given LP model.

Dual model:

Maximize $W = 600y_1 + 700y_2$

Subjected to

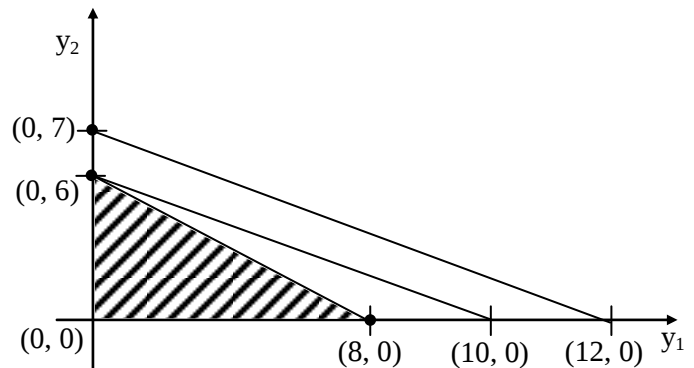
$$6y_1 + 10y_2 \leq 60$$

$$6y_1 + 8y_2 \leq 48$$

$$7y_1 + 12y_2 \leq 84$$

$$y_1 \geq 0,$$

$$y_2 \geq 0$$



$$W|_{(0,0)} = 600(0) + 700(0) = 0$$

$$W|_{(0,6)} = 600(0) + 700(6) = 4200$$

$$W|_{(8,0)} = 600(8) + 700(0) = 4800$$

$$W_{\max} = 4800 \Rightarrow Z_{\min} = 4800$$

20. Ans: (b)

21. Ans: (d)

Sol: A major advantage of precipitation hardening is that it can be used to *increase the yield strength* of many metallic materials via relatively simple heat treatments and without creating significant changes in density. Thus, the strength-to-density ratio of an alloy can be improved substantially using age hardening.

22. Ans: (b)

Sol: Feed (f) = 0.5 mm/rev

Principal cutting edge angle (ϕ) = 60°

Auxiliary cutting edge angle (ϕ_1) = 15°



The maximum value of surface roughness ($h_{\max}$) is

$$\begin{aligned} h_{\max} &= \frac{f}{\cot \phi + \cot \phi_1} \\ &= \frac{0.5}{\cot 60^\circ + \cot 15^\circ} = \frac{0.5}{0.58 + 3.73} \\ &= \frac{0.5}{4.31} = 0.116 \text{ mm} = 116.00 \mu\text{m} \end{aligned}$$

23. Ans: (d)

Sol: The unbalance force $F = m\omega^2$ by centrifugal force $F_I = m\omega^2$ and $F_{II} = m\omega^2$, the following relationship must hold

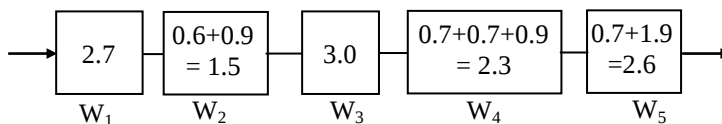
$$F_I + F_{II} = F \text{ and } F_I \ell_1 = F_{II} \ell_2$$

$$F_I = \frac{\ell_2 F}{\ell_1 + \ell_2} \text{ and } F_{II} = \frac{\ell_1 F}{\ell_1 + \ell_2}$$

24. Ans: (b)

25. Ans: (a)

Sol:



$$\begin{aligned} \text{Cycle time} &= \text{Maximum of } (2.7, 1.5, 3, 2.3, 2.6) \\ &= 3 \end{aligned}$$

26. Ans: (b)

27. Ans: (a)

Sol:

- *Plasticizers* are added to polymers to impart flexibility and softness by lowering their glass-transition temperature.
- *Fillers* used in plastics are generally wood flour (fine sawdust), silica flour (fine silica powder), clay, powdered mica, talc, calcium carbonate, and short fibres of cellulose, glass, or asbestos. Because of their low cost, fillers are *important in reducing the overall cost of polymers*. Depending on their type, *fillers also may improve the strength, hardness, toughness, abrasion resistance, dimensional stability, or stiffness of plastics*.
- The flammability of polymers can be reduced either by making them from less flammable raw materials or by *adding flame retardants*, such as compounds of chlorine, bromine, and phosphorus. Cross-linking also reduces polymer flammability.

28. Ans: (c)

Sol: *Cutting force components and their significances:*

The single point cutting tools being used for turning, shaping, planing, slotting, boring etc. are characterized by having only one cutting force during machining. But that



force is resolved into two or three components for ease of analysis and exploitation. Figure visualizes how the single cutting force in turning is resolved into three components along the three orthogonal directions; X, Y and Z.

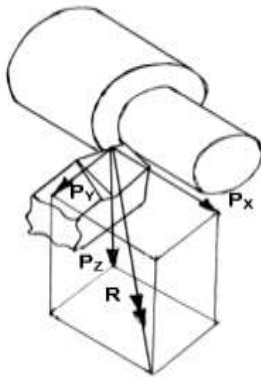


Fig: Cutting force R resolved into P_x , P_y and P_z

where, $P_x = P_{xy} \sin \phi$ and $P_y = P_{xy} \cos \phi$

P_z = tangential component taken in the direction of Z_m axis

P_x = axial component taken in the direction of longitudinal feed or X_m axis.

P_y = radial or transverse component taken along Y_m axis.

Significance of P_z , P_x and P_y

P_z : Called the main or major component as it is the largest in magnitude. It is also called power component as it being acting along and being multiplied by V_c decides cutting power ($P_z \cdot V_c$) consumption.

P_y : may not be that large in magnitude but is responsible for causing dimensional inaccuracy and vibration.

P_x : It, even if larger than P_y , is least harmful and hence least significant.

$$\text{Power} = P_z V_c + P_x V_f$$

Usually $P_x < P_z$ and

Feed velocity, $V_f \ll V_c$

Thus power = $P_z V_c$

29. Ans: (b)

Sol: Power (P) = Force $\times$ Velocity

$$= 20 \text{ kN} \times \frac{150 \times 10^{-3}}{0.5} = 6 \text{ kW}$$

30. Ans: (b)

Sol: No of containers

$$= \frac{\text{Demand during lead time} + \text{Safety stock time}}{\text{Size of a container}}$$

Demand during lead time

$$= 2000 \times (0.08 + 0.02)$$

$$= 200 \text{ units}$$

safety stock = 10% of demand during lead time

$$= 0.1 \times 200$$

$$= 20 \text{ units}$$

$$\text{No. of containers} = \frac{220}{22} = 10$$



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31. Ans: (d)

Sol:

- The usefulness of some level of oxidation is exhibited in the corrosion resistance of aluminum, titanium, and stainless steel.
- Aluminum develops a thin (a few atomic layers), strong, and adherent hard-oxide film (Al_2O_3) that better protects the surface from further environmental corrosion.
- Titanium develops a film of titanium oxide (TiO_2). A similar phenomenon occurs in stainless steels, which, because of the chromium present in the alloy, develop a protective film on their surfaces. These processes are known as *passivation*. When the protective film is scratched and the metal underneath is exposed, a new oxide film begins to form.

32. Ans: (d)

Sol: Hobbing machines:

These are used for generation of teeth of straight and single helical external spur gears, gear sectors, spiral gears and worm wheels. The grooves of spline shafts are also produced in some hobbing machine using suitable tool.

33. Ans: (c)

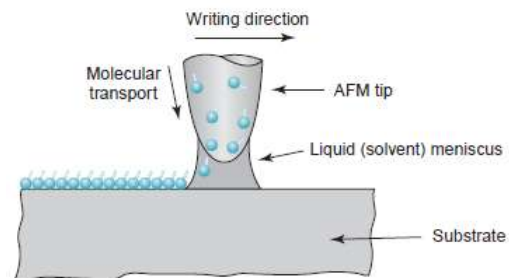
Sol:

- Another form of weighted moving average is the exponential smoothed average. This method keeps a running average of demand and adjusts it for each period in proportion to the difference between the latest actual demand and the latest value of the forecast.
- The quickness of forecast adjustment to error is determined by smoothing constant α . The closer its value is to zero, the slower the forecast will be to adjust to forecast errors (i.e., the greater the smoothing). Conversely, the closer the value of α is to 1.00, the greater the responsiveness and the less the smoothing.

34. Ans: (a)

35. Ans: (a)

Sol: Dip-pen nanolithography, in which the tip of an atomic force microscope is used to deposit molecules through the water meniscus that forms naturally between the tip and the substrate, as shown in figure below.





36. Ans: (b)

Sol: Given data:

Grey cast iron block thickness

$$(t) = 100 \text{ mm,}$$

Diameter of drill (D) = 40 mm

Cutting speed (V_c) = 20 m/min

Feed (f) = 0.5 mm/rev

Approach (AP) = 8 mm

Over run (OR) = 6 mm

$$\text{Speed (N)} = \frac{1000V}{\pi D} = \frac{1000 \times 20}{\pi \times 40} \approx 160 \text{ rpm}$$

$$\text{Time/cut} = \frac{L}{f N} = \frac{100 + 6 + 8}{0.5 \times 160} = 1.4 \text{ min}$$

37. Ans: (a)

38. Ans: (d)

Sol: The shortest average flow time is possible with SPT rule.

Job	Processing time	Flow time (F_j)
E	4	4
B	5	9
D	6	15
C	7	22
A	12	34
		$\Sigma F_j = 84$

$$\bar{F} = \frac{\Sigma F_j}{n} = \frac{84}{5} = 16.8$$

39. Ans: (c)

Sol:

- *Process Annealing—Eliminating Cold Work:* The recrystallization heat treatment used to eliminate the effect of cold working in steels with less than about 0.25% C is called a process anneal.
- *Normalizing:* Normalizing allows the steel to cool more rapidly, in air, producing fine pearlite.
- *Spheroidizing—Improving Machinability* Steels that contain a large concentration of Fe_3C have poor machining characteristics. It is possible to transform the morphology of Fe_3C using spheroidizing.
- *Age hardening, or precipitation hardening,* is produced by a sequence of phase transformations that leads to a uniform dispersion of nanoscale, coherent precipitates in a softer, more ductile matrix.

40. Ans: (d)

41. Ans: (d)

Sol: In grinding, the specific energy is much greater than in conventional machining.

There are several reasons for this.

- *First* is the size effect in machining. The chip thickness in grinding is much smaller than for other machining operations, such



as milling. According to the size effect, the small chip sizes in grinding cause the energy required to remove each unit volume of material to be significantly higher than in conventional machining roughly 10 times higher.

- *Second*, the individual grains in a grinding wheel possess extremely negative rake angles. The average rake angle is about -30° , with values on some individual grains believed to be as low as -60° . These very low rake angles result in low values of shear plane angle and high shear strains, both of which mean higher energy levels in grinding.
- *Third*, specific energy is higher in grinding because not all of the individual grits are engaged in actual cutting. Because of the random positions and orientations of the grains in the wheel, some grains do not project far enough into the work surface to accomplish cutting.

42. Ans: (b)

43. Ans: (b)

Sol:

- Qualitative forecasting methods are used for intermediate or long range decision. Examples of qualitative forecasting methods

are Delphi method, Collective opinion and Judgement, Market survey, etc.

- Time series analysis is a quantitative method of forecasting which is used for short or intermediate range decisions. Examples of quantitative methods are moving average, exponential smoothing and trend projection, etc.

44. Ans: (d)

45. Ans: (c)

Sol:

- Ductility can be tested by tension test.
- Toughness is determined by impact testing.
- Endurance limit can be determined by fatigue test.
- Resistance to penetration is for hardness test.

46. Ans: (d)

Sol: Alligatoring is a rolling defect. Wrinkle is a deep drawing defect.

47. Ans: (d)



48. Ans: (d)

Sol: The problem is balanced. There are five allocations. A basic feasible solution will have a maximum of $m + n - 1 = 4$. Hence the solution is not basic feasible. There is a loop and breaking it can decrease cost. It is therefore not optimum.

49. Ans: (d)

50. Ans: (c)

Sol: Maximum reduction = $\mu^2 R$
 $= 0.1^2 \times 200 = 2 \text{ mm}$

51. Ans: (b)

52. Ans: (c)

Sol: Automated manufacturing systems can be classified into three basic types:

1. Fixed automation.
2. Programmable automation, and
3. Flexible automation.

Fixed Automation: Fixed automation is a system in which the sequence of processing (or assembly) operations is fixed by the equipment configuration. Each of the operations in the sequence is usually simple, involving perhaps a plain linear or rotational motion or an uncomplicated combination of the two; for example, the feeding of a

rotating spindle. It is the integration and coordination of many such operations into one piece of equipment that makes the system complex. Typical features of fixed automation are:

- High initial investment for custom-engineered equipment
- High production rates
- Relatively inflexible in accommodating product variety

53. Ans: (a)

54. Ans: (c)

Sol: EBM application:

Electron beam machining is used for a variety of high-precision cutting applications on any known material. Applications include *drilling of extremely small diameter holes down to 0.05 mm diameter*, drilling of holes with very high depth to-diameter ratios more than 100:1, and cutting of slots that are only about 0.025 mm wide.

These cuts can be made to very close tolerances with no cutting forces or tool wear. The process is ideal for micromachining and is generally limited to cutting operations in thin parts in the range 0.25 to 6.3 mm thick.



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55. Ans: (a)

56. Ans: (d)

57. Ans: (c)

Sol: If the primal and dual have feasible solution with same value of objective function then both have optimal solutions with same value of the objective function.

58. Ans: (d)

Sol: The core is anchored by core prints, which are geometric features added to the *pattern to locate and support the core* and to provide vents for the escape of gases (Fig. a).

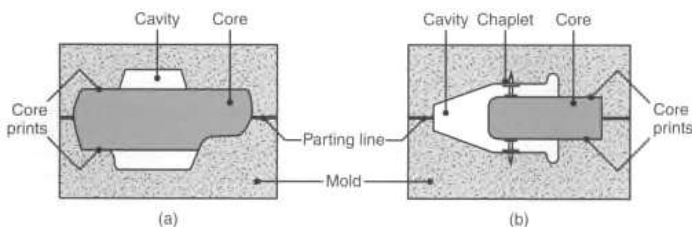


Fig: Examples of sand cores, showing core prints and chaplets to support the cores.

Note: A common problem with cores is that, for some casting requirements, as in the case where a recess is required, they may lack sufficient structural support in the cavity. To keep the core from shifting, metal supports (*chaplets*) may be used to anchor the core in place (Fig:b).

59. Ans: (a)

60. Ans: (a)

Sol:

- MRP is a technique for determining the quantity and timing for the acquisition of dependent demand items needed to satisfy master schedule requirements.
- Master production Schedule dictates gross or projected requirements for end items to the MRP system.

61. Ans: (d)

62. Ans: (a)

Sol: Brittle materials having internal flaws have much higher compressive strength values than tensile strength values because cracks propagate much readily from these internal flaws under tensile stresses but with much difficulty under compressive stresses. In fact compressive stress tends to close the crack.

63. Ans: (c)

Sol:

- *Clearance angle* is essentially provided to avoid rubbing of the tool (flank) with the machined surface which causes loss of energy and damages of both the tool and the



job surface. Hence, clearance angle is a *must and must be positive* ($3^\circ \sim 15^\circ$ depending upon tool-work materials and type of the machining operations like turning, drilling, boring etc.) So given statement (I) is correct.

- *Rake angle* is provided for ease of chip flow and overall machining. Rake angle may be positive, or negative or even zero. So given statement (II) is incorrect. Hence given option (d) is correct.

64. Ans: (b)

65. Ans: (c)

66. Ans: (b)

Sol: Materials that can have more than one crystal structure are called allotropic or polymorphic. The term **allotropy** is normally reserved for this behavior in pure elements, while the term **polymorphism** is used for compounds. Some metals, such as iron and titanium, have more than one crystal structure. At room temperature, iron has the BCC structure, but at higher temperatures, iron transforms to an FCC structure. These transformations result in changes in properties of materials and form the basis for the heat treatment of steels and many other alloys.

67. Ans: (a)

Sol: In deep drawing, because of the radial flow of material, the side walls increase in thickness as the height is increased as shown in below figure.

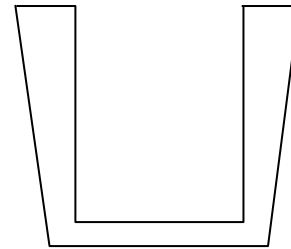


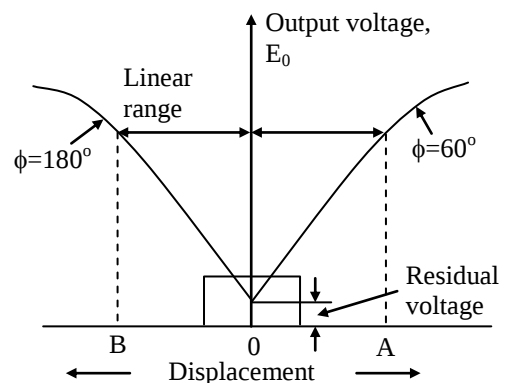
Fig: Side wall taper

Note: There would be a slight thinning of metal at the bottom corners for applications requiring uniform side walls, an operation called "Ironing" is carried out on drawn cups.

68. Ans: (a)

69. Ans: (b)

Sol:





The above figure shows LVDT output voltage and input displacement relation. The residual voltage shown is always exist for all LVDTs. So we can say that null voltage of an LVDT cannot be reduced to an insignificant value.

In Hall Effect transducer the magnitude of the develop voltage depends on the density of flux. So we can say that both statements are true and they are related.

70. Ans: (c)

Sol:

- *Stainless steels* are selected for their excellent resistance to corrosion. All true stainless steels contain a minimum of about 11% Cr, which permits a thin, protective surface layer of chromium oxide to form when the steel is exposed to oxygen. The chromium is what makes stainless steels stainless. Chromium is also a *ferrite stabilizing element*.
- Nickel (Ni) is a silver-white metal and an alloying element that imparts strength, toughness, and corrosion resistance.

71. Ans: (c)

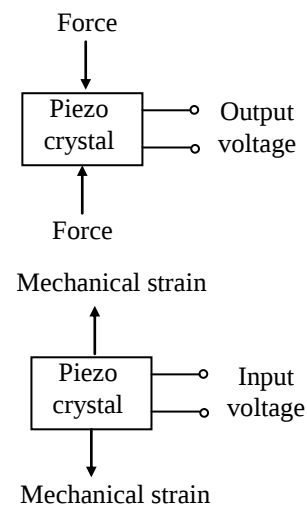
72. Ans: (b)

Sol: Piezo electric transducer T.F =
$$\frac{1}{\sqrt{1 + \left(\frac{1}{\omega T}\right)^2}}$$

At $\omega = 0$ TF = 0

At $\omega = \infty$ TF = 1

From this we can say that piezo transducer used for static pressure measurement.



From above two figures we can say short piezo electric effect is a reversible phenomenon.

73. Ans: (a)

Sol:

- The “light metals” include low-density alloys based on aluminum, magnesium, and beryllium. Aluminum alloys have a high specific strength due to their low density and, as a result, find many aerospace applications. The excellent corrosion



resistance and electrical conductivity of aluminum also provide for a vast number of applications.

- Aluminum and magnesium are limited to use at low temperatures because of the degradation of their mechanical properties as a result of overaging or recrystallization.

74. Ans: (b)

75. Ans: (b)

Sol: Surface texture alone does not completely describe a surface. There may be metallurgical or other changes in the material immediately beneath the surface that can have a significant effect on its mechanical properties. *Surface integrity is the study and control of this subsurface layer and any changes in it because of processing that may influence the performance of the finished part or product.*



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in Top 10

34

E & T
TOP 10
10

E
TOP 10
10

C
TOP 10
8

M
TOP 10
6

and many more...