ACE Engineering Academy

Head Office : Sree Sindhi Guru Sangat Sabha Association, # 4-1-1236/1/A, King Koti, Abids, Hyderabad – 500001.

Ph: 040-23234418, 040-23234419, 040-23234420, 040 - 24750437

Hyderabad | Delhi | Bhopal | Pune | Bhubaneswar | Lucknow | Patna | Bengaluru | Chennai | Vijayawada | Vizag | Tirupati | Kukatpally | Kolkata | Ahmedabad

ESE- 2019 (Prelims) - Offline Test Series Test – 7

MECHANICAL ENGINEERING

SUBJECT: THERMODYNAMICS, HEAT TRANSFER AND RENEWABLE SOURCES OF ENERGY - SOLUTIONS

01. Ans: (a)

Sol: Given $A_c = 5\ cm^2$

$A_s = 15\ cm^2$, $\in = 2.5$

Effectiveness of the fin $(\in) = \eta \times \dfrac{P \times L}{A_c}$

$$(\in) = \eta \times \frac{A_s}{A_c}$$

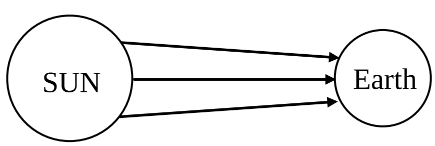
$$2.5 = \eta \times \frac{15}{5}$$

$$\eta = 0.833$$

$$= 83.33\ \%$$

02. Ans: (d)

Sol:



$Q_E = G_{SC} \times R^2_{earth}$, where G_{sc} is solar constant

$= 1367 \times \pi(6371 \times 10^3)^2$

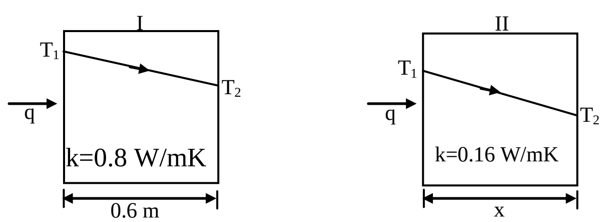
$= 1.74 \times 10^{17}$ W $\approx 1.8 \times 10^{17}$ W

03. Ans: (d)

Sol: Wind energy, biomass energy and wave energy all of them are indirect methods of solar energy utilization.

04. Ans: (b)

Sol:



For Case: I

Heat flux (q) = $\dfrac{T_1 - T_2}{\left(\dfrac{L}{k}\right)} = \dfrac{T_1 - T_2}{\dfrac{0.6}{0.8}}$ --------(1)

For Case: II

Heat flux (q) = $\dfrac{T_1 - T_2}{\left(\dfrac{x}{0.16}\right)}$ -------------(2)

From (1) and (2)

$$\frac{0.6}{0.8} = \frac{x}{0.16}$$

$x = 0.12$ m

05. Ans: (b)

Sol: As the gas is heated the pressure remains constant (equal to atomospheric pressure) and the temperature of the gas goes on increasing.

Now, PV = mRT

So, as temperature increases the volume will increase and hence pistons will move to right. (As distance moved by pistons are same, so volume swapped by right side piston is more because its cross sectional area is larger).

06. Ans: (b)

Sol: Process AB $\rightarrow$ constant P, increasing V $\therefore$ increasing T

Process BC $\rightarrow$ isothermal process and increasing volume $\therefore$ decreasing pressure.

Process CD $\rightarrow$ constant V, decreasing P $\therefore$ decreasing T

Process DA $\rightarrow$ isothermal process and decreasing volume.

07. Ans: (b)

Sol: For cylinder,

$$T_{max} - T_{wall} = \frac{q_G R^2}{4k}$$

08. Ans: (d)

Sol: Energy balance:

Heat released by hot oil = heat gained by cold water

$$\dot{m}_o \times c_{po} \times (T_{hi} - T_{he}) = \dot{m}_w \times c_{pw} \times (T_{ce} - T_{ci})$$

$1000 \times 4.18 \times (80 - 40) = 5000 \times 4.18 \times (T_{ce} - 30)$

$T_{ce} = 38°C$

The exit temperature of cold fluid (38°C) is less than that of hot fluid (40°C). Therefore, it may be counter, parallel or cross flow heat exchanger.

09. Ans: (a)

Sol: Surfaces should face equator to get maximum insolation.

10. Ans: (c)

Sol:

- If a selective coating is put on a flat plate collector, its collection efficiency improves.
- Also, by evacuating the space above the absorber plate, the collection efficiency of the flat plate collector improves.

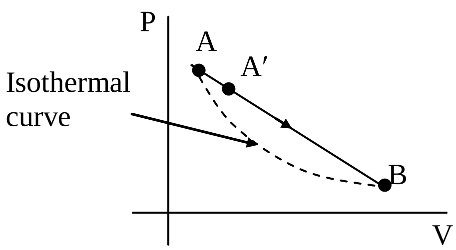
11. Ans: (b)

Sol: Emissive power = $\pi \times$ intensity of radiation

Intensity of radiation = $\frac{\text{Emissive power}}{\pi}$

12. Ans: (c)

Sol:



- The straight line AB has negative slope.
- Just after the start (point A) of process, the temperature at point (say A′) is more than point A and finally the temperature at point B (say T_B) is equal to that of point A. So the temperature first increases and then decreases.

13. Ans: (b)

Sol: At higher temperature heat losses increase. Thus, the efficiency of collector decreases with increasing temperature.

14. Ans: (d)

Sol: When a comparison is made in terms of maximum efficiency of different types of collector, it is found that paraboloid dish collector has the maximum.

15. Ans: (c)

Sol: $\eta_{th} = \frac{W_{actual}}{\text{Heat supplied}}$ ----------- (i)

$\eta_{2nd\ law} = \frac{W_{actual}}{W_{reversible}}$ ----------- (ii)

Now, $W_{reversible}$ < Heat supplied

$\Rightarrow \quad \eta_{2nd\ law} > \eta_{th}$

16. Ans: (b)

Sol:

- Thermal conductivity of fin material should be large.
- Fins should be used on the side where heat transfer coefficient is small.

17. Ans: (b) **18. Ans: (b)**

19. Ans: (c)

Sol: Number of transfer units

- A measure of heat exchanger size

Periodic flow heat exchangers

- Regenerators

Phase change

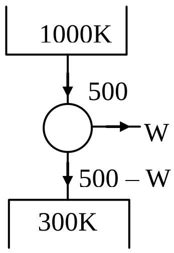
- Condensers

Deposition on heat exchanger surface

- Fouling factor

20. Ans: (b)

Sol:



For W_{max} , system should be reversible

$$\frac{-500}{1000}+\frac{500-W}{300}=0$$

$\Rightarrow W = 350$ kW

21. Ans: (a)

Sol: The angle made by the Sun's rays with normal to a horizontal surface is called azimuth angle.

22. Ans: (d)

Sol: The range of variation of azimuth angle is $-\pi$ to π.

23. Ans: (c)

Sol: By using steady flow energy equation between starting and end of the duct.

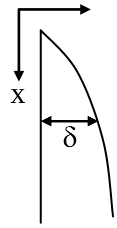
$$\dot{m}h_1+\dot{Q}=\dot{m}h_2$$

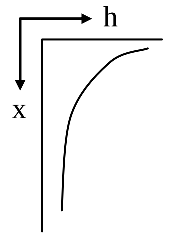
$3 \times 1 \times 40 + 10 = 3 \times 1 \times T_2$

$T_2 \approx 43.3\ ^oC$

24. Ans: (a)

Sol:





$$\delta \propto (x)^{1/4}$$

$$h \propto \frac{1}{(x)^{1/4}}$$

$$h \propto \frac{1}{\delta}$$

25. Ans: (b)

Sol: Tilt factor is the ratio of the beam radiation flux falling on a tilted surface to that falling on a horizontal surface.

26. Ans: (b)

Sol: The standard emf of the hydrogen-oxygen fuel cell is 1.23 V.

27. Ans: (d)

Sol: Black body - $\rho = \tau = 0$

Gray body - Emissivity is independent on wave length.

Opaque body - $\alpha + \rho = 1$

White body - $\rho = 1$

28. Ans: (d)

Sol: The specific heat C_P and C_V are zero at absolute zero temperature.

29. Ans: (a)

Sol: Light weight is the main factor due to which oxygen fuel cells are used for the space crafts.

30. Ans: (b)

31. Ans: (a)

Sol: $P + F = C + 2$

$1 + F = 2 + 2$

$\Rightarrow F = 3$

32. Ans: (b)

Sol: From steady flow energy equation

$h_1 + Q = h_2 + W$

$h_1 = h_2 \quad (\because Q = W = 0)$

$T_1 = T_2$

Entropy change can be calculated as,

$$s_2 - s_1 = c_p \ell n \frac{T_2}{T_1} - R \ell n \frac{P_2}{P_1}$$

$$s_2 - s_1 = R \ell n \frac{P_1}{P_2} \qquad (\because T_1 = T_2)$$

Irreversibility $= T_0[\Delta s_{gen}]$

$$= T_0 \times \dot{m} \times R \ell n \frac{P_1}{P_2}$$

$$= 300 \times 1 \times R \times \ell n \left(\frac{P_1}{0.75 P_1} \right)$$

$$= 300 R \ell n \left(\frac{4}{3} \right)$$

33. Ans: (b)

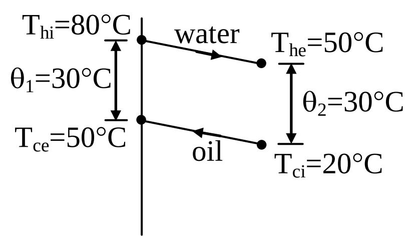
Sol: Anaerobic oxidation of biomass produces methane.

34. Ans: (c)

Sol: Distillation of the vegetable oil produces bio diesel.

35. Ans: (b)

Sol:



For water, $C_w = \dot{m}_w . C_{p_w}$

$$= \rho A v \times C_{p_w} = 1000 \times \left(\frac{0.02}{60} \right) \times 4$$

$$C_w = \frac{80}{60} \text{ kW/K}$$

For oil, $C_o = \dot{m}_o . C_{p_o}$

$$= \rho A v \times C_{p_w} = 800 \times \left(\frac{0.05}{60} \right) \times 2$$

$$C_o = \frac{80}{60} \text{ kW/K}$$

When, $C_{min} = C_{max} \Rightarrow C = \frac{C_{min}}{C_{max}} = 1$ (every where the temperature difference will be same)

LMTD $= \theta_1 = \theta_2 = 30°C$

$T_{ce} = T_{hi} - LMTD = 80 - 30$

$T_{ce} = 50°C$

36. Ans: (c)

Sol: **Local** Nusselt number for laminar free convection, $Nu_x = C(Gr.Pr)^{1/4}$

$$Nu_x = C\left(\frac{g\beta\Delta T x^3}{\nu^2}.Pr\right)^{\frac{1}{4}}$$

$$\frac{h_x.x}{k} \propto x^{\frac{3}{4}}$$

$$h_x \propto x^{-1/4}$$

$$h_x = c_1 x^{-\frac{1}{4}}$$

$$h_{x=L} = c_1 L^{\frac{-1}{4}}$$

Average heat transfer coefficient

$$(\bar{h}) = \frac{1}{L}\int_0^L h_x\, dx$$

$$= \frac{1}{L}\int_0^L c_1 x^{-\frac{1}{4}} dx$$

$$= \frac{c_1}{L} \times \frac{4}{3} \times L^{\frac{3}{4}}$$

$$= \frac{4}{3}.c_1.L^{\frac{-1}{4}}$$

$$\bar{h} = \frac{4}{3} h_x$$

37. Ans: (d)

38. Ans: (a)

Sol: $(dS)_{Surr} = \frac{\delta Q}{T} = \frac{I^2Rt}{T}$

$$= \frac{60^2 \times 5 \times 2}{300} = 120\, J/K$$

39. Ans: (d)

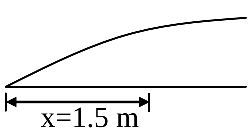
Sol: Thermodynamic properties are defined only when system is in complete thermal, mechanical and chemical equilibrium (i.e., thermodynamic equilibrium)

40. Ans: (d)

Sol: All of the factors mentioned, in the options do affect the distribution of wind energy.

41. Ans: (b)

Sol:



Dimensionless temperature gradient at the wall = Nusselt number = 1000

Nu = 1000

$$\frac{h \times x}{k} = 1000$$

$$\frac{h \times 1.5}{0.6} = 1000$$

$$h = \frac{1000 \times 0.6}{1.5} = 400 \text{ W/m}^2\text{.K}$$

42. Ans: (a)

Sol: Let $L_{e,h} \rightarrow$ hydrodynamic entrance length.

$L_{e,t} \rightarrow$ thermal entrance length.

$D \rightarrow$ diameter of the tube.

$$\frac{L_{e,h}}{D} = 0.05 Re_D$$

$$\frac{L_{e,t}}{D} = 0.05 Re_D .Pr$$

$$\frac{L_{e,t}}{L_{e,h}} = Pr$$

If Pr > 1

(thermal entrance length) > (Hydrodynamic entrance length)

If Pr < 1

Thermal entrance length < Hydrodynamic entrance length.

43. Ans: (b)

Sol: On P-v diagram triple point is a line.

44. Ans: (c)

Sol:

- Availability is a measure of work potential which can never be negative.
- Exergy of an isolated system will always decrease.

45. Ans: (a)

Sol: In forced connection

Nusselt number (Nu) = f(Re, Pr)

Heat transfer coefficient (h) = f(Re, Pr, k/*l*)

In free convection, Nu = f(Gr, Pr)

Heat transfer coefficient (h) = f(Gr, Pr, k/*l*)

46. Ans: (d)

Sol:

- Effectiveness of the fin ($\in$) = $\sqrt{\frac{Pk}{hA}}$

$$\in \propto \frac{1}{\sqrt{h}}$$

Fin will be more effective when it is provided in lower heat transfer coefficient environment.

So, in a liquid to gas heat exchanger, fins should be provided in gas side.

- Efficiency of the long fin

$$\eta = \frac{1}{mL} = \frac{1}{\sqrt{\frac{Ph}{kA_c}}.L}$$

$$\eta \propto \frac{1}{\sqrt{h}}$$


ACE
SUMMER
SHORT TERM BATCHES
GATE+PSUs - 2020
Admissions Open From 14th NOV 2018
HYDERABAD
29th April | 06th May | 11th May
18th May | 26th May | 02nd June 2019
DELHI
11th May | 23rd May 2019
SHORT TERM BATCHES
Start Early.. Gain Surely...
EARLY BIRD OFFER :
Register on or Before 31st December 2018 : 5000/- Off | Register on or Before 31st March 2019 : 3000/- Off


ACE
TEST YOUR PREP
IN A REAL TEST ENVIRONMENT
Pre GATE - 2019
Date of Exam : 20th January 2019
Last Date to Apply : 31st December 2018
Highlights :
* Get real-time experience of GATE-2019 test pattern and environment.
* Virtual calculator will be enabled.
* Post exam learning analytics and All India Rank will be provided.
* Post GATE guidance sessions by experts.
* Encouraging awards for GATE-2019 toppers.

47. Ans: (d)

Sol:

- Because of dissipative effects involved in irreversible processes the efficiency of reversible engines is more than that of irreversible engines.

  $\eta_{rev} > \eta_{irreversible}$

- The efficiency of all reversible heat engines operating between source (temperature T_H and sink temperature T_L) is given by $\frac{T_H - T_L}{T_H}$.
- All spontaneous processes are irreversible.

48. Ans: (c)

Sol: Work done by the system depends on the change in volume during the process. Since in this process the volume is continuously increasing, so work done by the system is positive

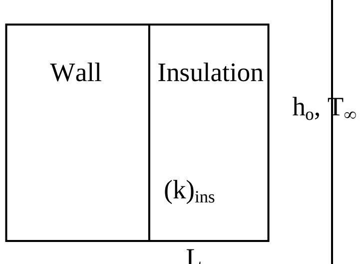
Also $PV = mRT$

As pressure and volume increase, temperature also increases.

49. Ans: (a)

Sol:

- For the plane wall:



Thermal resistance $(R_{th}) = \frac{L}{k_{ins}.A} + \frac{1}{h_o A}$

As, $L\uparrow \Rightarrow R_{th}\uparrow$

Adding more insulation on plane wall, will always increase the heat transfer rate.

- Critical radius of insulation $(r_c) \propto \frac{k_{ins}}{h_o}$

  if $h_o\uparrow r_c\downarrow$

  $(r_c)_{forced\ convection} << (r_c)_{free\ convection}$ [$\because$ $h_{forced\ convection} >> h_{free\ convection}$]

- For the cylindrical surface, heat transfer rate increases upto critical radius of insulation after critical radius of insulation, heat transfer rate decreases.

50. Ans: (c)

Sol: Thermal diffusivity of a substance is defined mathematically as

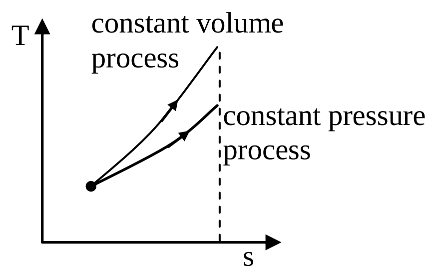
$$\alpha = \frac{k}{\rho c_p}$$

Thermal conductivity physically signifies the ability of substance to conduct heat, while ρc_p physically signifies the ability of a substance to store thermal energy. Therefore, thermal diffusivity of a substance physically signifies the ability of the substance to conduct heat relative to its ability to store thermal energy.

51. Ans: (c)

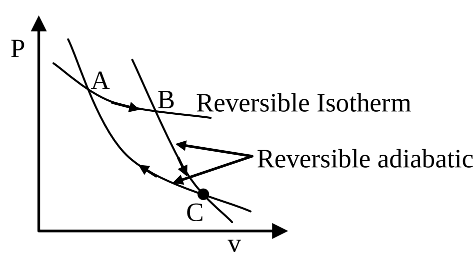
Sol:

- for an ideal gas enthalpy is a function of temperature only so during isenthalpic process temperature remains constant
- ΔT is greater for isochoric process (for same Δs) since constant volume process has greater slope than constant temperature process on T-s diagram



52. Ans: (b)

Sol:



- Let it be assumed that two reversible adiabatics AC and BC intersect each other at point C. Let a reversible isotherm AB be drawn in such a way that it intersects the reversible adiabatics at A and B. The three reversible processes AB, BC and CA together constitute a reversible cycle, and the area included represents the net work output in a cycle. But such a cycle is impossible, since net work is being produced in a cycle by a heat engine by exchanging heat with a single reservoir in the process AB, which violates the Kelvin-Plank statement of the second law of thermodynamics.
- It is impossible to construct a perpetual motion machine of the second kind.

53. Ans: (a)

Sol: Total emissive power = $\int E_\lambda d\lambda$

= Area under the diagram

= 100 × 5 + 200 × 5 + 100 × 5

= 2000 W/m^2

54. Ans: (d)

Sol: Overall heat transfer coefficient:

$$\frac{1}{U_c} = \frac{1}{h_c} + \frac{r_i}{r_o} \times \frac{1}{h_h}$$

$$= \frac{1}{8000} + \frac{10}{13} \times \frac{1}{200}$$

= 259.96 W/m^{2}K ≈ 260 W/m^{2}K

55. Ans: (b)

Sol: The desired fraction (f) is

$$f = \frac{\Delta U}{\Delta Q} = \frac{nC_v dT}{nC_p dT} = \frac{C_v}{C_p} = \frac{1}{\gamma}$$

$$f = \frac{3}{5} \qquad (\because \text{ for mono-atomic gas } \gamma = \frac{5}{3})$$

56. Ans: (b)

Sol: Properties are point functions because, change of property between two given state points independent of the path joining them.

57. Ans: (d)

Sol: AT critical point $h_{fg} = 0$, $s_{fg} = 0$, $v_{fg} = 0$, $u_{fg} = 0$

58. Ans: (c)

Sol: $F_{1\text{-}2} = 1$ (from the geometry)

$F_{1\text{-}1} = 0$

From reciprocity theorem:

$A_1F_{1\text{-}2} = A_2F_{2\text{-}1}$

$$F_{2\text{-}1} = \frac{A_1}{A_2} = \frac{4\pi r_1^2}{4\pi r_2^2} = \left(\frac{40}{50}\right)^2 = 0.64$$

Using summation rule:

$F_{2\text{-}1} + F_{2\text{-}2} = 1 \Rightarrow F_{2\text{-}2} = 1 - 0.64 = 0.36.$

59. Ans: (c)

Sol: Since any surface cannot store any thermal energy, the rate of heat that is transferred to the surface by conduction must be same as the rate of heat transferred to the air by convection and radiation. Heat transfer coefficient may vary with time and accordingly the temperature gradient will change.

60. Ans: (c)

Sol:

- Controlled or restricted expansion or compression can approach reversibility.
- Mixing of different substance, chemical reactions and application of brakes for stopping of vehicle are irreversible processes.

61. Ans: (d)

Sol: Addition of heat at constant pressure results in raising the temperature of gas and doing external work as volume is increased.

62. Ans: (a)

Sol: Wind energy is harnessed as mechanical energy using wind mill or turbine.

63. Ans: (d)

64. Ans: (b)

Sol: Clausius-Clapeyron equaion is applicable to any phase-change process that occurs at constant temperature and pressure and it is derived from Maxwell equation: $\left(\frac{\partial P}{\partial T}\right)_V = \left(\frac{\partial s}{\partial V}\right)_T$.

Since 1995
ACE
Launching
Spark Batches for
ESE / GATE - 2020
from Mid May 2019
Admissions from January 1st, 2019
@ DELHI
INDIA

Since 1995
ACE
Launching
Regular Batches for
ESE / GATE - 2020
from Mid May 2019
Admissions from January 1st, 2019
@ BHOPAL & LUCKNOW

65. Ans: (c)

Sol: In laminar forced convection through tubes, Nusselt number is constant and equal to 4.36 for constant heat flux condition.

66. Ans: (b)

67. Ans: (c)

Sol:

- At critical point of a pure substance there is no constant temperature vaporization process.
- The ice directly converts from solid phase to vapor phase at a pressure below the triple point value and the process is called sublimation.

68. Ans: (b)

Sol: Fourier Law of heat conduction is

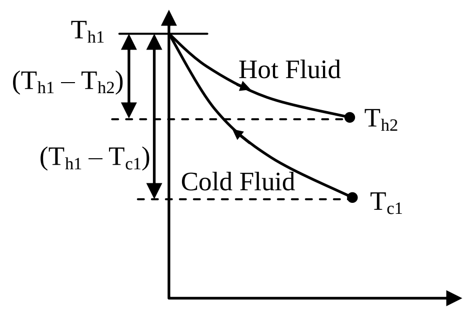
$$Q = -kA\frac{dT}{dx}$$

- It is applicable for all matters.
- It is a law based on experimental observations (No mathematical proof).

69. Ans: (d)

70. Ans: (a)

Sol:



Energy balance :

given, $\dot{m}_c C_{P_c} > \dot{m}_h C_{P_h}$

$$\dot{m}_c C_{P_c}\left(T_{c_2} - T_{c_1}\right) = \dot{m}_h C_{P_h}\left(T_{h_1} - T_{h_2}\right)$$

$$\left(T_{c_2} - T_{c_1}\right) < \left(T_{h_1} - T_{h_2}\right)$$

$$\left[\because \dot{m}_c C_{P_c} > \dot{m}_h C_{P_h}\right]$$

For $T_{c_2} = T_{h_1} \Rightarrow \left(T_{h_1} - T_{c_1}\right) < \left(T_{h_1} - T_{h_2}\right)$

but from the figure,

$T_{h1} - T_{c1} > T_{h1} - T_{h2}$

That's why, it is impossible that exit temperature of cold fluid be equal to inlet temperature of hot fluid.

71. Ans: (c)

72. Ans: (a)

Sol: For lumped capacity analysis:

- Internal conductive resistance is negligible as compared to the external convective resistance.
- Biot number < 0.1
- Smaller body with higher thermal conductivity.

73. Ans: (d)

74. Ans: (c)

Sol: The exergy of a system is zero when it is in complete thermal as well as mechanical equilibrium with the surroundings. Also it has no kinetic or potential energy relative to the environmental and it does not react with the environment.

75. Ans: (a)

ACE ENGINEERING ACADEMY
Since 1995
ACE
Engineering Academy
Leading Institute for ESE/GATE/PSUs
23
Years of Excellence
CONGRATULATIONS TO OUR
ESE - 2018 TOP RANKERS
AIR 1 SHASHANK E&T
AIR 1 CHIRAG JHA EE
AIR 1 VINAY PRAKASH CE
AIR 1 AMAN JAIN ME
AIR 2 CHERUKURI SAIDEEP E&T
AIR 2 SHADAB AHAMAD EE
AIR 2 PUNIT SINGH CE
AIR 2 CHIRAG SINGLA ME
AIR 3 RAMESH KAMULLA E&T
AIR 3 SRIJAN VARMA EE
AIR 3 PRAVEEN KUMAR CE
AIR 3 MAYUR PATIL ME
AIR 4 JAPJIT SINGH E&T
AIR 4 ANKIT GARG EE
AIR 4 AMIT KUMAR ME
AIR 5 NARENDRA KUMAR E&T
AIR 5 KARTHIK KOTTURU EE
AIR 5 RISHABH DUTT CE
AIR 5 VITTHAL PANDEY ME
AIR 6 KUMUD JINDAL E&T
AIR 6 RATIPALLI NAGESWAR EE
AIR 7 KARTIKEYA DUTTA E&T
AIR 7 TEKCHAND DESHWAL EE
AIR 7 ROHIT KUMAR CE
AIR 8 SURYASH GAUTAM E&T
AIR 8 RAVI TEJA MANNE EE
AIR 8 VIJAYA NANDAN CE
AIR 8 ROHIT BANSAL ME
AIR 9 SHANAVAS CP E&T
AIR 9 SOUVIK DEB ROY EE
AIR 9 ROOPESH MITTAL CE
AIR 10 PRATHAMESH E&T
AIR 10 MILAN KRISHNA EE
AIR 10 SRICHAND POONIYA CE
TOTAL SELECTIONS in Top 10 34
E&T TOP 10 10
EE TOP 10 10
CE TOP 10 8
ME TOP 10 6
and many more...
www.aceenggacademy.com