

POSTAL Book Package

2022

Mechanical Engineering

Objective Practice Sets

Power Plant Engineering

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Jet and Rocket Propulsion System

- Q.1** A jet engine works on the principle of conservation of
 (a) mass (b) discharge
 (c) energy (d) momentum
- Q.2** In the inlet to turbojet, air is slowed down and a part of the kinetic energy of air stream is converted into pressure. This type of compression is called
 (a) diffuser compression
 (b) primary compression
 (c) ram compression
 (d) jet compression
- Q.3** Ram compression manifests in
 (a) leakage loss
 (b) compression of inlet air
 (c) increase in speed of incoming air
 (d) slowing down of incoming air and conversion of a part of its kinetic energy into pressure energy
- Q.4** Compared to turbojet, a turbo prop has an additional feature in having
 (a) grid passages (b) inlet diffuser
 (c) intercooler (d) reduction gear
- Q.5** Which of the following propulsion units has reduction gear as one of its essential component?
 (a) turbo-jet (b) turbo-prop
 (c) pulse-jet (d) athodyd
- Q.6** Which of the following devices makes use of indirect reaction for propulsion?
 (a) Pulsejet (b) Turboprop
 (c) Turbojet (d) Ramjet
- Q.7** Which of the following devices utilize the principle of an aero-thermodynamic duct?
 (a) Ramjet (b) Pulsejet
 (c) Both a and b (d) Turbojet
- Q.8** In small rocket motors, the movement of cooling fluid is
 (a) Helical (b) Axial
 (c) Radial (d) None
- Q.9** The surrounding air is not used as oxidiser in
 (a) flying bomb (b) rocket propulsion
 (c) turbo jet (d) turbo prop
- Q.10** The propulsion system having highest efficiency at higher speed
 (b) Turbo jet (b) Reciprocating aircraft
 (c) Ram jet (d) Rocket
- Q.11** If v_j is the jet velocity & v_o is the vehicle velocity, the propulsive efficiency of a rocket is given by
 (a) $\frac{2(v_o/v_j)}{1 + \left(\frac{v_o}{v_j}\right)^2}$ (b) $\frac{v_o/v_j}{1 + \left(\frac{v_o}{v_j}\right)^2}$
 (c) $\frac{v_o}{v_o + v_j}$ (d) $\frac{v_j}{v_o + v_j}$
- Q.12** Which one of the following is incorrect about jet propulsion?
 (a) Plane is very noisy & has short life
 (b) Thermal efficiency is higher at low pressure
 (c) Neither lubrication nor radiators required
 (d) Delivery of power is continuous.
- Q.13** A rocket works with maximum overall efficiency when air-craft velocity is equal to the
 (a) jet velocity
 (b) half the jet velocity
 (c) double the jet velocity
 (d) no. such relationship with the jet velocity
- Q.14** Thrust of a jet propulsion power unit can be increased by
 (a) burning fuel after gas turbine
 (b) injecting water in the compressor
 (c) injecting ammonia into the combustion chamber
 (d) all of the above

- Q.15** Consider the following in turbojet
1. Compressor 2. Diffuser
3. Nozzle 4. Turbine
Correct sequence of above is
(a) 1 - 2 - 3 - 4 (b) 2 - 1 - 3 - 4
(c) 1 - 2 - 4 - 3 (d) 2 - 1 - 4 - 3
- Q.16** The relative jet exit velocity from a rocket is 2700 m/s. The forward flight velocity is 1350 m/s. What is the propulsive efficiency of the unit?
(a) 90% (b) 66.66%
(c) 50% (d) 33.33%
- Q.17** Lowest thrust per unit engine weight is developed by
(a) Ramjet (b) Piston engine
(c) Turbojet (d) Rocket
- Q.18** The power plant having highest specific fuel consumption
(a) Ramjet (b) Turbojet
(c) Piston (d) Rocket
- Q.19** The velocity of a gas flowing at 300 m/s at a temperature of 400 K through a duct having gas constant, $R = 0.25 \text{ kJ/kgK}$. Ratio of specific heat, $\gamma = 1.6$. The value of Mach number?
(a) 0.75 (b) 0.72
(c) 0.70 (d) 0.77
- Q.20** Air enters the jet engine with a velocity of 250 m/s (40 kg/s) relative to an aircraft moving at 83.33 m/s. Exhaust of the engine has a velocity of 700 m/s relative to moving aircraft. The thrust developed by the engine is (kN).
(a) 9 (b) 12
(c) 18 (d) 24
- Q.21** What is the propulsive efficiency of jet engine if absolute jet exit velocity is 2800 m/s and forward flight is 1400 m/s?
(a) 90% (b) 66.66%
(c) 40% (d) 33.33%
- Q.22** A plane travels at 400 km/h at sea level ($T = 15^\circ\text{C}$). The velocity of plane at the same mach number at an altitude where temperature is -25°C is
(a) 400 km/h (b) 371.2 km/h
(c) 350.4 km/h (d) 330.2 km/h
- Q.23** Plane moving horizontally at a speed of 1800 km/h is propelled by a jet leaving the nozzle at a speed of 600 m/s. The propulsive efficiency is
(a) 0.75 (b) 0.91
(c) 0.85 (d) 0.94
- Q.24** Reciprocating engines are not used in modern aircrafts due to
(a) high specific weight
(b) high speed requirement
(c) large drop in power with altitude
(d) all of the above
- Q.25** The compression of incoming air is accomplished by ram effect and during flow through grid passages opened and closed by V-shaped non-return valves in
(a) turbo-jet (b) turbo-prop
(c) pulse-jet (d) ram-jet
- Q.26** In rocket propulsion, the oxygen required for combustion of its fuel is taken from
(i) surrounding air
(ii) the rocket itself
(iii) compressed atmospheric air
(iv) surrounding air and compressed atmospheric air
Choose the correct option from the following:
(a) (ii) and (iii) only (b) (ii) only
(c) (i), (iii), (iv) only (d) (iii) only
- Q.27** Speed of sound in Helium is _____ m/s. ($T_0 = 300 \text{ K}$)
(a) 378 (b) 1019
(c) 934 (d) 342
- Q.28** The following are some characteristics of a Ram-Jet:
1. It is light-weight, less costly and requires no maintenance
2. The thrust produced per unit weight is less than most other propulsion systems
3. It is a self-starting system
4. The design of diffuser is quite difficult because of convergent-divergent passage.
Which of these are correct?
(a) 1, 3 (b) 2, 4
(c) 1, 4 (d) 3, 4
- Q.29** The thrust augmentation of turbojet engine can be effected by the following methods except
(a) Afterburning
(b) Injecting refrigerants between inlet and exit of air compressor
(c) Bleeding off excess air
(d) Supplying additional air

- Q.30** Chemical rockets use propellant which is
(a) solid (b) liquid
(c) free radical (d) all of the above
- Q.31** Consider the following statements pertaining to rocket engine:
1. It has no altitude limitation.
2. Rate of climb increases with altitude.
3. Engine ram increases with flight speed.
4. Low efficiency except at extremely high flight speed for small duration.
Which of the above are correct?
(a) 1, 2 and 3 (b) 1, 2 and 4
(c) 2, 3 and 4 (d) 1, 3 and 4
- Q.32** The efficiency of jet engine
(a) higher at higher speed
(b) lower at higher speed
(c) higher at high altitudes
(d) same at all altitudes
- Q.33** For maximum overall efficiency of a turbojet engine, the aircraft velocity and the jet velocity conform to the ratio
(a) 1 : 2 (b) 2 : 3
(c) 2 : 1 (d) 1 : 3
- Q.34** Only rocket engines can be propelled to space because they
(a) can generate very high thrust
(b) have high propulsion efficiency
(c) can work on several fuels
(d) are not air-breathing engines
- Q.35** If a stable chemical material is supplied with sufficient energy to break the energy bonds and if it is used for rocket propulsion, it is called
(a) nuclear propulsion
(b) free radical propulsion
(c) electrodynamic propulsion
(d) plasma rocket propulsion
- Q.36 Assertion (A):** The efficiency of a turboprop engine decreases at higher speed.
Reason (R): The use of turboprop engine is limited to medium speed application.
(a) Both A and R are individually true and R is the correct explanation of A.
(b) Both A and R are individually true but R is not correct explanation of A.
(c) A is true but R is false
(d) A is false but R is true
- Q.37 Assertion (A):** A rocket engine can operate even in vacuum & in any fluid medium.
Reason (R): Rocket engine is a pure reaction engine where in a propulsive thrust is obtained as a reaction of momentum of ejected matter.
(a) Both A and R are individually true and R is the correct explanation of A.
(b) Both A and R are individually true but R is not correct explanation of A.
(c) A is true but R is false
(d) A is false but R is true
- Q.38** The thrust power developed by a rocket is 4500 kW. The Kinetic energy lost in the exhaust is 1500 kW. The propulsive efficiency of the rocket is _____ percent.
- Q.39** A turbo jet flying at 250 m/s has an air mass flow rate of 50 kg/s. The exit velocity of gases from the nozzle is 600 m/s. The air fuel ratio is 100. The propulsive power of the given device is _____ MW.
- Q.40** A turbojet used a fuel of calorific value 40 MJ/kg and develops the propulsive power of 7527 kW. The fuel require is 1800 kg per hour. The thermal efficiency in percentage is _____.

Answers Jet and Rocket Propulsion System

1. (d) 2. (c) 3. (d) 4. (d) 5. (b) 6. (b) 7. (c) 8. (a) 9. (b)
10. (d) 11. (a) 12. (b) 13. (b) 14. (d) 15. (d) 16. (c) 17. (b) 18. (d)
19. (a) 20. (c) 21. (b) 22. (b) 23. (b) 24. (d) 25. (c) 26. (b) 27. (b)
28. (c) 29. (d) 30. (d) 31. (b) 32. (a) 33. (c) 34. (d) 35. (b) 36. (b)
37. (a) 38. (75) 39. (7.53) 40. (37.63)

Explanations Jet and Rocket Propulsion System**1. (d)**

A jet engine works on the principle of conservation of momentum.

2. (c)

In the inlet to turbojet, air is slowed down and a part of the kinetic energy of air stream is converted into pressure. This type of compression is called ram compression.

3. (d)

Ram compression manifests in slowing down of incoming air and conversion of a part of its kinetic energy into pressure energy.

4. (d)

Components of turbo prop engine:

Propeller, Reduction gear, Diffuser, Compressor, Combustion chamber, Turbine, Nozzle

Component of turbojet engine:

Diffuser, Compressor, Combustion chamber, Turbine, Nozzle

5. (b)

Components of turbo prop engine:

Propeller, Reduction gear, Diffuser, Compressor, Combustion chamber, Turbine, Nozzle

Component of turbojet engine:

Diffuser, Compressor, Combustion chamber, Turbine, Nozzle.

6. (b)

Turboprop makes use of indirect reaction for propulsion. Turboprop engine derives most of its propulsive thrust from the propeller and derive only a small portion from the exhaust nozzles.

7. (c)

Ramjets and Pulsejet power plants are called athodyds. At high ram pressure, there is no necessity of a mechanical compressor and no turbine to drive it.

8. (a)

In small rocket motors, the movement of cooling fluid is helical.

9. (b)

One major difference between the rocket engine power plant and other jet propulsion systems is

that the rocket carries its entire propellant (oxidiser and fuel) with it. Other jet propulsion systems depend upon atmospheric air.

10. (d)

$\eta_{\text{Turbojet}} \approx 30\%$ at 1600 kmph

$\eta_{\text{Ramjet}} \approx 33\%$ at 1600 kmph

$\eta_{\text{Rocket}} \approx 44\%$ at 1600 kmph

11. (a)

Propulsive efficiency of a rocket,

$$\eta_{\text{prop}} = \frac{2 \left(\frac{v_o}{v_j} \right)}{1 + \left(\frac{v_o}{v_j} \right)^2}$$

12. (b)

At low pressure, thermal efficiency is reduced.

13. (b)

A rocket works with maximum overall efficiency when aircraft velocity is equal to half the jet velocity.

14. (d)

Thrust augmentation of turbojet engine can be effected by the following method:

- Burning of additional fuel i.e. after burning.
- Injecting refrigerants, water or water alcohol mixture at some point.
- Bleeding off air in excess of that required for stoichiometric combustion.

15. (d)

- Diffuser convert kinetic energy of the entering air into static pressure rise which is achieved by ram effect.
- Compressor compresses the air which is injected into combustion chamber where fuel is added.
- Hot combustion gas enters the gas turbine where partial expansion takes place.
- Exhaust gases from turbine are expended in nozzle, and a very high velocity of jet is produced which gives forward motion to the aircraft by jet reaction.
So, the sequence is 2-1-4-3.

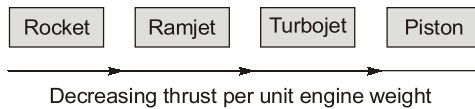
16. (c)

$$\begin{aligned}
 C_j - C_a &= 2700 \text{ m/s} \\
 C_a &= 1350 \text{ m/s} \\
 C_j &= 2700 + 1350 \\
 &= 4050 \text{ m/s}
 \end{aligned}$$

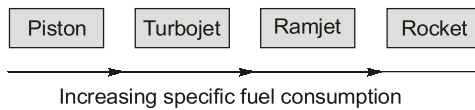
Propulsive efficiency

$$\begin{aligned}
 h_p &= \frac{2C_a}{C_j + C_a} = \frac{2 \times 1350}{4050 + 1350} \\
 &= 0.5 = 50\%
 \end{aligned}$$

17. (b)



18. (d)



19. (a)

$$M = \frac{V}{C} = \frac{V}{\sqrt{\gamma RT}} = 0.75$$

20. (c)

$$\begin{aligned}
 \text{Thrust} &= \dot{m}_a [V_e - V_i] = 40(700 - 250) \\
 &= 18 \text{ kN}
 \end{aligned}$$

21. (b)

$$\begin{aligned}
 \eta_p &= \frac{2C_i}{C_i + C_j} \\
 &= \frac{2 \times 1400}{2800 + 1400} = 0.667 \\
 \therefore &= 66.67\%
 \end{aligned}$$

22. (b)

$$\begin{aligned}
 M_1 &= M_2 \\
 \frac{400 \times \frac{5}{18}}{\sqrt{\gamma R(273 + 15)}} &= \frac{V \times \frac{5}{18}}{\sqrt{\gamma R(273 - 25)}} \\
 \Rightarrow V &= 371.2 \text{ km/h}
 \end{aligned}$$

23. (b)

$$\begin{aligned}
 V_{\text{plane}} &= 1800 \text{ km/h} = 500 \text{ m/s} \\
 \therefore \eta_p &= \frac{2 \times 500}{600 + 500} = 0.91
 \end{aligned}$$

26. (b)

Rocket carries its own oxidizer, hence no oxygen is taken from surroundings.

27. (b)

For helium, $\gamma = 1.667$

$$R = \frac{\bar{R}}{4} = 2.0785 \text{ kJ/kgK}$$

$$\therefore C = \sqrt{\gamma R T_0} = 1019.5 \text{ m/s}$$

28. (c)

Ramjet produces greater thrust per unit weight than any other propulsion device at supersonic speeds except the rockets.

The system is not self-starting and requires a launching device.

29. (d)

Thrust augmentation of turbojet engine can be effected by the following method:

- Burning of additional fuel i.e. after burning.
- Injecting refrigerants, water or water alcohol mixture at some point.
- Bleeding off air in excess of that required for stoichiometric combustion.

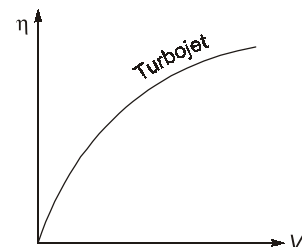
30. (d)

Chemical rockets use propellant which is solid, liquid or free radical.

31. (b)

Rocket engine has no ram drag and constant thrust with speed.

32. (a)



34. (d)

Since rocket do not require external oxygen and carries its own oxygen. So they can be propelled to space.

35. (b)

Free radial propulsion used stable chemical material which supplies energy to break the bonds.

36. (b)

Both statement are individually correct.

In turboprop engine, at high speeds, due to shocks and flow separations, the propeller efficiency decreases rapidly, thereby putting up a maximum speed limit on the engine. Hence its use is limited to medium speed application.

37. (a)

Rocket engine can operate in vacuum or any other medium because it carries its own oxidiser.

38. (75)

Propulsive efficiency

$$\eta_P = \frac{TP}{PP} = \frac{TP}{TP + KE \text{ loss}}$$

$$= \frac{4500}{4500 + 1500} = 75\%$$

39. (7.53)

Velocity of aircraft = $V_0 = 250 \text{ m/s}$

Velocity of exhaust gases = $V_e = 600 \text{ m/s}$

Mass flow rate of air = $\dot{m}_a = 50 \text{ kg/s}$

Mass flow rate of fuel = $\dot{m}_f = \frac{\dot{m}_a}{AFR} = \frac{50}{100} = 0.5 \text{ kg/s}$

Propulsive Power = $PP = \frac{1}{2}(\dot{m}_a + \dot{m}_f)V_e^2 - \frac{1}{2}\dot{m}_a V_0^2$

$$= \frac{1}{2000}(50 + 0.5) \times 600^2 - \frac{1}{2000} \times 50 \times 250^2 \text{ kW}$$

$$= 7527.5 \text{ kW} = 7.527 \text{ MW}$$

40. (37.63)

$$\text{Thermal efficiency} = \frac{PP}{\dot{m}_f \times C_V} = \frac{7.527}{0.5 \times 40}$$

$$= 0.3763 = 37.63\%$$

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