MADE EASY PUBLICATIONS

POSTAL BOOK PACKAGE 2024

CONTENTS

MECHANICAL ENGINEERING

Objective Practice Sets

Internal Combustion Engines

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1 CHAPTER
Basic and Air Standard Cycles

MCQ and NAT Questions

Q.1 In an air standard Otto cycle, r is the volume compression ratio and γ is an adiabatic index (c_p/c_v), the air standard efficiency is given by

(a) $\eta = 1 - \frac{1}{r^{\gamma-1}}$ (b) $\eta = 1 - \frac{1}{r^{\gamma}}$

(c) $\eta = 1 - \frac{1}{r^{\frac{\gamma-1}{\gamma}}}$ (d) $\eta = 1 - \frac{1}{r^{\frac{\gamma-1}{2\gamma}}}$

Q.2 In an air-standard Diesel cycle, r is the compression ratio, r is the fuel cut-off ratio and γ is the adiabatic index (c_p/c_v). Its air standard efficiency is given by

(a) $\eta = 1 - \left[\frac{1}{\gamma r^{\gamma}} \cdot \frac{(\rho^{\gamma} - 1)}{(\rho - 1)}\right]$

(b) $\eta = 1 - \left[\frac{1}{\gamma r^{\gamma-1}} \cdot \frac{(\rho^{\gamma-1} - 1)}{(\rho - 1)}\right]$

(c) $\eta = 1 - \left[\frac{1}{\gamma r^{\gamma-1}} \cdot \frac{(\rho^{\gamma} - 1)}{(\rho - 1)}\right]$

(d) $\eta = 1 - \left[\frac{1}{\gamma r^{\gamma}} \cdot \frac{(\rho^{\gamma-1} - 1)}{(\rho - 1)}\right]$

Q.3 The function of piston rings in internal combustion engines is to
(a) dissipate heat to cylinder walls
(b) seal the cylinder
(c) prevent piston from wear
(d) all of the above

Q.4 Advantage of two stroke engine over a four stroke engine is
(a) more uniform turning moment on crankshaft
(b) reduced friction loss
(c) more power for same cylinder dimensions
(d) all of the above

Q.5 The power to weight ratio of diesel engine compared to petrol engine is
(a) high
(b) low
(c) same
(d) high in some cases and low in other cases

Q.6 Besides mean effective pressure, the data needed for determining the indicated power of an engine would include
(a) piston diameter, length of stroke & calorific value of fuel
(b) piston diameter, specific fuel consumption & calorific value of fuel
(c) piston diameter, length of stroke & speed of rotation.
(d) specific fuel consumption, speed of rotation & torque

Q.7 An engine has four cylinders of 68 mm bore and 75 mm stroke. The cubic capacity of the engine is
(a) 1089.5cm^3 (b) 1289.5cm^3
(c) 1489.5m^3 (d) 1689.5cm^3

Q.8 A certain engine produces 10 kW indicated power & mechanical efficiency is 80%. The friction power is
(a) 12 kW (b) 8 kW
(c) 4 kW (d) 2 kW

Q.9 Fuel consumption of a engine is 0.35 kg/kW-hr and heating value of fuel is 43000 kJ/kg. The brake thermal efficiency is
(a) 20.1% (b) 23.9%
(c) 28.29% (d) 32.21%

Q.10 The relative efficiency of a engine will be equal to if air standard efficiency & brake thermal efficiency of engine are 53.4% & 24.4% respectively.
(a) 40.7% (b) 45.7%
(c) 13.1% (d) 53.4%

Q.11 Gudgeon pin forms the link between
(a) piston and big end of connecting rod
(b) piston and small end of connecting rod
(c) connecting rod and crank
(d) big end and small end

Q.12 Engines used for ships are normally
(a) four-stroke SI engines of very high power
(b) two-stroke CI engines of very high power
(c) four-stroke CI engines of high speed
(d) two-stroke SI engines of high power

Q.13 In a SI engine very high compression ratio cannot be used because
(a) the engine efficiency would be unmanageable high
(b) the power required for compression would be high
(c) cylinders will required very thick walls
(d) self-ignition may takes place before the spark occurs

Q.14 In a four stroke IC engine cam shaft rotates at
(a) same speed as crankshaft
(b) twice the speed of crankshaft
(c) half the speed of crankshaft
(d) none of the above

Q.15 Thermal efficiency of CI engine is higher than that of SI engine due to
(a) fuel used
(b) higher compression ratio
(c) constant pressure heat addition
(d) none of the above

Q.16 The area of P-V diagram can be measured by
(a) anemometer
(b) clinometer
(c) planimeter
(d) graphometer

Q.17 If clearance volume is 10% of swept volume, the compression ratio will be equal to
(a) 9 (b) 10
(c) 11 (d) 12

Q.18 In an engine working on Otto cycle, the compression ratio is 5.5. The work output per cycle is $23.625 \times 10^5\ V_c$ joule where V_c is the clearance volume in m^3, the mean effective pressure (in bar) is
(a) 3.25 bar (b) 5.25 bar
(c) 7.25 bar (d) 9.25 bar

Q.19 For the same maximum pressure and temperature
(a) Otto cycle is more efficient than diesel cycle
(b) Diesel cycle is more efficient than Otto cycle
(c) Dual cycle is more efficient than Otto and diesel cycle
(d) Dual cycle is less efficient than Otto & diesel cycle

Q.20 The thermal efficiency of diesel engines is in the range of
(a) 10 to 20 percent (b) 20 to 35 percent
(c) 35 to 50 percent (d) 65 to 80 percent

Q.21 The order of values of thermal efficiency of Otto, diesel and Dual cycle, when they have equal compression ratio and heat rejection, is given by
(a) $\eta_{Otto} > \eta_{diesel} > \eta_{dual}$
(b) $\eta_{diesel} > \eta_{dual} > \eta_{Otto}$
(c) $\eta_{dual} > \eta_{diesel} > \eta_{Otto}$
(d) $\eta_{Otto} > \eta_{dual} > \eta_{diesel}$

Q.22 Which of the following process is not a part of the dual cycle ?
(a) Adiabatic compression
(b) Constant volume expansion
(c) Isothermal expansion
(d) Constant pressure expansion

Q.23 Match **List-I** (details of the processes of the cycle) with **List-II** (name of the cycle) and select the correct answer using the codes given below the lists:

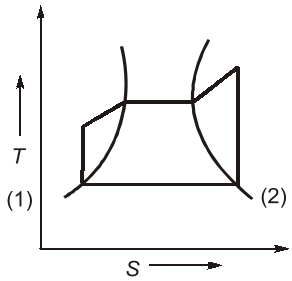
List-I
A. Two isothermals and two adiabatics
B. Two isothermals and two constant volumes
C. Two adiabatics and two constant volumes
D. Two adiabatics and two constant pressure

List-II
1. Otto
2. Joule
3. Carnot
4. Stirling

Codes:

	A	B	C	D
(a)	4	3	1	2
(b)	4	3	2	1
(c)	3	4	1	2
(d)	3	4	2	1

Q.24

1.


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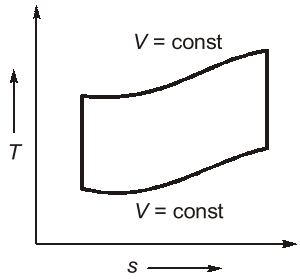

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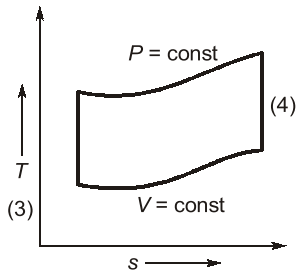

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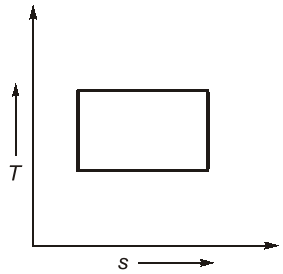


The correct sequence of the given four cycles on T-s plane in Figure (1), (2), (3), (4) is

(a) Rankine, Otto, Carnot and Diesel
(b) Rankine, Otto, Diesel and Carnot
(c) Otto, Rankine, Diesel and Carnot
(d) Otto, Rankine Carnot and Diesel

Q.25 For an engine working on air standard Otto cycle has a clearance volume of 10 percent of swept volume. The efficiency of engine will be

(a) 56.4% (b) 61.6%
(c) 67.8% (d) data insufficient

Q.26 The stroke and bore of a four stroke spark ignition engine are 250 mm and 200 mm respectively. The clearance volume is 0.001 m^3. If the specific heat ratio $\gamma = 1.4$, the air-standard cycle efficiency of the engine is

(a) 46.40% (b) 56.10%
(c) 58.20% (d) 62.80%

Q.27 A diesel engine is usually more efficient than a spark ignition engine because

(a) diesel being a heavier hydrocarbon, releases more heat per kg than gasoline
(b) the air standard efficiency of diesel cycle is higher than the Otto cycle, at a fixed compression ratio
(c) the compression ratio of a diesel engine is higher than that of an SI engine
(d) self ignition temperature of diesel is higher than that of gasoline

Q.28 In combustion process, the effect of dissociation is to

(a) reduce the flame temperature
(b) separate the products of combustion
(c) reduce the proportion of carbon monoxide in gases
(d) reduce the use of excess air

Q.29 The most perfect method of scavenging is

(a) cross scavenging
(b) uniform scavenging
(c) loop scavenging
(d) reverse flow scavenging

Q.30 As compared to air standard cycle, in actual working the effect of variation in specific heats is to

(a) increase maximum pressure and maximum temperature
(b) reduce maximum pressure and maximum temperature
(c) increase maximum pressure and decrease maximum temperature
(d) decrease maximum pressure and increase maximum temperature

Q.31 For same power output and same compression ratio, as compared to two-stroke engines, four-stroke S.I. engines have

(a) higher fuel consumption
(b) lower thermal efficiency
(c) higher exhaust temperatures
(d) higher thermal efficiency

Q.32 Two stroke SI engines suffer from
(a) fuel loss
(b) idling difficulty
(c) both (a) and (b)
(d) none of the above

Q.33 With dissociation the exhaust gas temperature
(a) decreases
(b) increases
(c) no effect
(d) increases upto certain air-fuel ratio and then decreases

Q.34 Dissociation can be considered as
(a) disintegration of combustion products at high temperature
(b) reverse process of combustion
(c) heat absorption process
(d) all of the above

Q.35 For a given compression ratio, as the mixture is made progressively rich from lean, the mean effective pressure
(a) increases
(b) decreases
(c) initially increases and then decreases
(d) remains more or less same

Q.36 Which one of the following events would reduce the volumetric efficiency of a vertical compression ignition engine?
(a) The inlet valve closing after bOttom dead centre
(b) Inlet valve closing before bOttom dead centre
(c) Inlet valve opening before top dead centre
(d) Exhaust valve closing after top dead centre

Q.37 Keeping other parameters constant brake power of a diesel engine can be increased by
(a) decreasing the density of intake air
(b) increasing the temperature of intake air
(c) increasing the pressure of intake air
(d) decreasing the pressure of intake air

Q.38 Most high speed compression engines operate on
(a) Diesel cycle
(b) Otto cycle
(c) Dual combustion engine
(d) Gas turbine

Q.39 This is considered as the first link in transmitting the gas forces to the output shaft
(a) cylinder block
(b) inlet and exhaust valves
(c) piston
(d) connecting rod

Q.40 The purpose of balance weight in crankshaft is to
(a) balance the rotating system
(b) time the valve train
(c) improve the net torque
(d) control the mean speed

Q.41 Consider the following parts of IC Engine:
1. Rocker arm
2. Follower
3. Cams
4. Camshaft
5. Crankshaft

Which among the above constitutes the part of valve train system?
(a) 1, 2 and 3
(b) 1, 2, 3 and 4
(c) 2, 3 and 4
(d) All of the above

Q.42 Consider the following statements pertaining to volumetric efficiency:
1. The normal range of volumetric efficiency at full throttle for SI engines is more than that of CI engines.
2. Volumetric efficiency is maximum at inlet mach number of 0.5.
3. Inlet valve mach index is related volumetric efficiency.

Which of these statements are correct?
(a) 2 only
(b) 2 and 3
(c) 1, 2 and 3
(d) 1 and 3

Q.43 Consider the following statements:
1. Mean piston speed is given by $\bar{V}_P = LN$.
2. Automobile engines operate at higher end of mean piston speed near to 15 m/s.
3. Large marine diesel operate at lower end of mean piston speed near to 8 m/s.

Which of these are correct?
(a) 1, 2 and 3
(b) 1 and 2
(c) 2 and 3
(d) 1 only

Q.44 All of followings are correct except:
Inlet-valve mach index is dependent on
(a) mean piston speed
(b) bore
(c) inlet sonic velocity
(d) fuel consumption

(For air take, c_p = 1.005 kJ/kgK, c_v = 0.718 kJ.kgK, γ = 1.4)

(a) Temperature after the compression process in 750 K.

(b) Compression ratio of the cycle is 6.72.

(c) Heat added in the cycle is 807.75 kJ/kg

(d) Network output from the cycle is 430.76 kJ/kg

Q.133 Which of the following statements is(are) correct with respect to air standard cycles?

(a) In Otto cycle, heat addition takes place at constant volume.

(b) In diesel cycle, heat addition takes place at constant pressure.

(c) In dual cycle, heat addition takes place first at constant volume and then at constant pressure.

(d) In dual cycle, heat addition takes place first at constant pressure and then at constant volume.

Q.134 Which of the following statements is(are) true for Dual cycle?

(a) The heat addition at constant pressure is 2-3 times more than the heat addition at constant volume.

(b) The dual cycle engine is more compact in size with respect to diesel cycle.

(c) The sound pollution for dual cycle engine is higher than that of the diesel cycle engine.

(d) The maintenance is easier and maintenance cost is less for dual cycle engine than that of the diesel cycle engine.

■■■■

Answers Basic and Air Standard Cycles

1. (a)	2. (c)	3. (d)	4. (d)	5. (b)	6. (c)	7. (a)
8. (d)	9. (b)	10. (b)	11. (b)	12. (b)	13. (d)	14. (c)
15. (b)	16. (c)	17. (c)	18. (b)	19. (b)	20. (b)	21. (d)
22. (c)	23. (c)	24. (b)	25. (b)	26. (c)	27. (c)	28. (a)
29. (b)	30. (b)	31. (d)	32. (c)	33. (a)	34. (d)	35. (c)
36. (b)	37. (c)	38. (c)	39. (c)	40. (a)	41. (b)	42. (b)
43. (c)	44. (d)	45. (b)	46. (d)	47. (a)	48. (b)	49. (b)
50. (c)	51. (c)	52. (c)	53. (a)	54. (b)	55. (d)	56. (a)
57. (a)	58. (d)	59. (c)	60. (c)	61. (c)	62. (a)	63. (d)
64. (d)	65. (d)	66. (c)	67. (d)	68. (a)	69. (d)	70. (d)
71. (b)	72. (c)	73. (d)	74. (b)	75. (a)	76. (c)	77. (c)
78. (a)	79. (a)	80. (b)	81. (a)	82. (b)	83. (b)	84. (c)
85. (a)	86. (b)	87. (d)	88. (a)	89. (b)	90. (c)	91. (d)
92. (c)	93. (d)	94. (c)	95. (d)	96. (c)	97. (b)	98. (b)
99. (a)	100. (6.075)	101. (75)	102. (168)	103. (0.34)	104. (25)	105. (264)
106. (5.328)	107. (2)	108. (1.78)	109. (53.9)	110. (45.45)	111. (5.34)	112. (50)
113. (535.96)	114. (1554.97)	115. (8.92)	116. (154.6)	117. (83.9)	118. (6.94)	119. (a, c)
120. (b, c, d)	121. (a, b)	122. (a, d)	123. (b, d)	124. (a, d)	125. (a, d)	126. (a, b, c)
127. (a, d)	128. (a, b, c)	129. (a, c)	130 (a, c, d)	131. (b, c)	132. (a, c)	133. (a, b, c)
134. (a, b, d)						

Explanations Basic and Air Standard Cycles

1. (a)

$$\eta_{otto} = 1 - \frac{1}{r^{\gamma - 1}}$$

2. (c)

$$\eta_{diesel} = 1 - \frac{\rho^{\gamma} - 1}{r^{\gamma - 1} \cdot \gamma \cdot (\rho - 1)}$$

3. (d)

Function of piston rings:

(i) Improves heat transfer from the piston to the cylinder wall.

(ii) Seals the combustion chamber so that there will be minimal loss of gases to the crank cases.

(iii) Prevent piston from wear.

(iv) Regulating oil consumption by scraping oil from the cylinder walls back to the sump.

(v) Maintain proper oil quantity between piston and cylinder wall.

4. (d)

Advantages of 2-stroke over 4-stroke.

- For same power developed, 2-stroke engine is lighter, less bulky and occupy less floor area.
- More uniform turning moment so lighter weight of flywheel is required.
- More power for same cylinder dimension.
- The work required to overcome the friction and the exhaust strokes is saved.
- Little maintenance because of fewer parts.

5. (b)

The power of weight ratio of diesel is lower than petrol engine because of bulky and robust construction required for its higher compression ratio.

6. (c)

$$\text{I.P} = P_{imep} \times \frac{A.L.N}{60}$$

7. (a)

Capacity of engine = $4 \times V_s$

$$= 4 \times \frac{\pi}{4} (6.8)^2 \times 7.5 = 1089.5 \text{ cm}^3$$

8. (d)

b.p.(brake power)

$$= \eta_m \times ip = 0.80 \times 10 = 8 \text{ kw}$$

$$\therefore \quad F.p = ip - bp = 10 - 8 = 2 \text{ kw}$$

9. (b)

$$\eta_{bt} = \frac{1kW - hr}{m_f/hr \times CV}$$

$$= \frac{3600}{0.35 \times 43000} = 23.9\%$$

10. (b)

Relative efficiency

$$= \frac{\text{Brake thermal efficiency}}{\text{Air thermal efficiency}} = \frac{24.4}{53.4} = 45.7\%$$

11. (b)

In I.C. engines the gudegeon pin is used to connect piston and small bearing end of connecting rod.

12. (b)

Due to low weight, compactness and high power output two-stroke CI engines are useful in ship propulsion.

13. (d)

A very high compression ratio is SI engines is avoided because self ignition may occur before spark occurs.

14. (c)

In a four stroke IC engine cam shaft rotates at half the speed of crank shaft.

15. (b)

Thermal efficiency of CI is higher than SI engines because of its higher compression ratio (16 - 24).

16. (c)

Planimeter or platometer is used to measure area (2-D shape) of P-V diagram.

17. (c)

$$r = \frac{V_1}{V_2} = \frac{V_s + V_c}{V_c} = \frac{V_s + 0.1V_s}{(0.1V_s)} = 11$$

18. (b)

We know that compression ratio

$$r = \frac{V_c + V_s}{V_c}$$

$$5.5 = 1 + \frac{V_c}{V_c} \Rightarrow \frac{V_s}{V_c} = 4.5 \text{ or,}$$

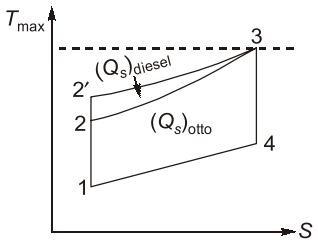
$$V_s = 4.5\ V_c$$

$$\therefore \quad P_m = \frac{W_{net}}{V_s} = \frac{23.625 \times 10^5}{4.5\ V_c} V_c$$

$$= 5.25 \times 10^5\ \text{N/m}^2 = 5.25\ \text{bar}$$

19. (b)

For same maximum pressure and temperature.



$$(Q_s)_{diesel} > (Q_s)_{otto}$$

So, $$\eta_{diesel} > \eta_{otto}$$

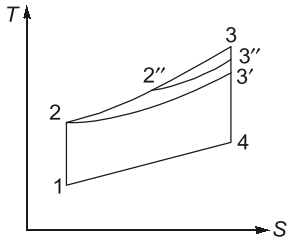
20. (b)

The thermal efficiency of diesel engine practically lies in range of 21% to 33%.

21. (d)

For same compression and heat rejection.

Process 1-2 same compression ratio for all three cycles.



1-2-3-4 = Otto cycle

1-2-3′-4 = Diesel cycle

1-2-2″-3″-4 = Dual cycle

$$(Q_s)_{otto} > (Q_s)_{dual} > (Q_s)_{diesel}$$

$$\Rightarrow \quad \eta_{otto} > \eta_{dual} > \eta_{diesel}$$

22. (c)

Isothermal expansion is not a part of the dual cycle.

23. (c)

Otto cycle - Two adiabatics and two constant volume

Joule cycle - Two adiabatic and two constant pressure

Carnot cycle - Two adiabatic and two isothermal

Stirling cycle - Two isothermal and two constant volumes

24. (b)

The correct order is Rankine, Otto, Diesel and Carnot.

25. (b)

Given

$$V_c = 10\%\ V_s$$

we know that

$$r = 1 + \frac{V_s}{V_c} = 1 + \frac{1}{0.1} = 11$$

$$\eta = 1 - \frac{1}{(r)^{\gamma-1}} = 1 - \frac{1}{(11)^{1.4-1}}$$

$$= 0.616 = 61.6\%$$

26. (c)

$$V_c = 0.001\ \text{m}^3$$

$$V_s = \frac{\pi}{4} \times 0.200^2 \times 0.250\ \text{m}^3$$

$$\therefore \quad \eta = 1 - \left(\frac{V_c}{V_c + V_s}\right)^{r-1}$$

$$= 1 - \left(\frac{0.001}{0.001 + \frac{\pi}{4} \times 0.200^2 \times 0.250}\right)^{1.4-1}$$

$$= 58.2\%$$

27. (c)

For same compression ratio and the same heat supplied, Otto cycle is most efficient and diesel cycle is least efficient.

In practice, however, the compression ratio of the Diesel engine ranges between 14 and 25 whereas that of the Otto engine between 6 and 12. Because of which its efficiency, is higher than that of the Otto engine.

28. (a)

The effect of dissociation is to reduce T_{max} and P_{max} of cycle and hence efficiency and work output of cycle reduces.

29. (b)

Uniflow is the most efficient scavenging system.

30. (b)

Except for monoatomic gases, C_p and C_v increase with increase in temperature and $\gamma\downarrow$. Thus P_{max} and T_{max} reduces.

31. (d)

Thermal efficiency is higher and part load efficiency is better for 4-stroke engine than 2-stroke engine.

32. (c)

2-stroke engines suffer from fuel loss and idling difficulty.

33. (a)

With dissociation the exhaust gas temperature decreases.

34. (d)

Dissociation can be considered as heat absorption process in which there is disintegration of combustion products at high temperature. It is reverse process of combustion.

35. (c)

For same compression ratio, as mixture progresses from lean to rich, the mean effect pressure initially increases and then decreases.

36. (b)

When inlet value closes before the BDC, the charge inhaled will reduce thereby reducing the volumetric efficiency.

37. (c)

Keeping other parameter constant, the brake power of CI engine can be increase by increasing the pressure of intake air.

38. (c)

Dual combustion engine is most high speed compression engines operated.

39. (c)

Cylinder block: It is the main supporting structure for the various components.

Inlet and exhaust valve: Regulate the incoming and outgoing charge to and form the cylinder.

Piston: It acts as moving boundary of the combustion system and forms the first link to transmit the gas force through connecting rod.

40. (a)

The balance weights are provided for static and dynamic balancing of the rotating system.

41. (b)

Valve train controls the amount of air and fuel entering the combustion chamber at any point of time. It consists of valves, rocker arms, cam, cam shaft, push rods and lifters.

42. (b)

η_v (for SI engine at full throttle) = 80 – 85%
η_v (for CI engine at full throttle) = 85 – 90%

43. (c)

Mean piston speed, $\bar{V}_P = \dfrac{2LN}{60}$ m/s

44. (d)

$$Z = \frac{u}{\alpha} = \left(\frac{b}{D_i}\right)^2 \frac{V_p}{C_i \alpha}$$

where, u = gas velocity through the inlet valve at smallest flow area
α = inlet sonic velocity
b = bore
D_i = inlet valve diameter
V_p = mean piston speed
C_i = inlet valve average flow coefficient

45. (b)

The leakage of gases between the walls of piston and cylinder is prevented by means of three to six cast iron rings which may be square or rectangular in cross-section.

46. (d)

The holes in the oil ring groove allows excess cylinder wall oil to return to the crank case by way of the inside of the piston.