2019

RANK IMPROVEMENT WORKBOOK

Mechanical Engineering

Internal Combustion Engine

Answer Key of Objective & Conventional Questions

MADE EASY Publications

1 Air Standard Cycles

LEVEL 1 Objective Questions

1.	(d)
2.	(a)
3.	(b)
4.	(c)
5.	(525)
6.	(a)
7.	(b)
8.	(d)
9.	(a)

LEVEL 2 Objective Questions

10.	(b)
11.	(a)
12.	(d)
13.	(c)
14.	(a)
15.	(d)
16.	(1409.6)
17.	(d)
18.	(a)
19.	(b)

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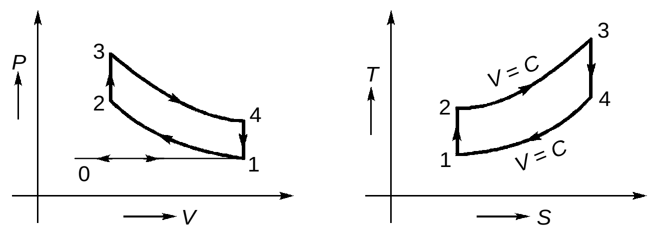
LEVEL 3 Conventional Questions

Solution : 20

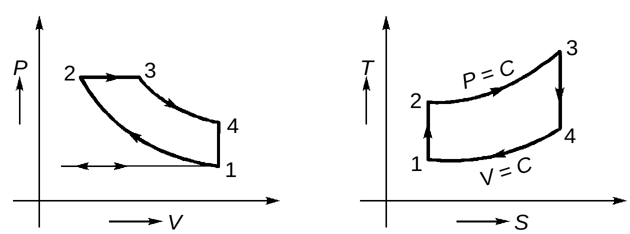
Otto cycle:



The processes:

1. 0 - 1 and 1 - 0 on the p-v diagram represents suction and exhaust processes and their effect is nullified.
2. 1 - 2 represents isentropic compression
3. 2 - 3 represents constant volume heat addition
4. 3 - 4 represents isentropic expression
5. 4 - 1 represents constant volume heat rejection

Diesel cycle:



1. 0–1 suction
2. 1 - 2 represents isentropic compression
3. 2 - 3 represents constant pressure heat addition
4. 3 - 4 represents isentropic expansion
5. 4 - 1 represents constant volume heat rejection
6. 1–0 exhaust

Given: $d = 20$ cm, $L = 30$ cm, $V_c = 0.10 \times V_s$

r_c (cut-off) takes place at 10% of the stroke

$$V_s = \frac{\pi}{4} d^2 L = \frac{\pi}{4}(0.20)^2 (0.30) = 9.42 \times 10^{-3} \text{ m}^3$$

$$r = \text{compression ratio} = \frac{V_c + V_s}{V_c} = 1 + \frac{V_s}{V_c}$$

$$r = 11$$

$$\eta = 55.135\%$$

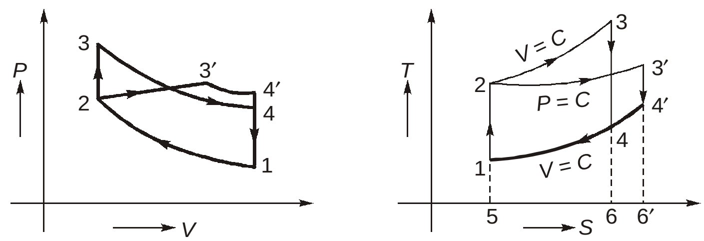
Solution : 21

Same compression ratio and heat addition:

The otto cycle and diesel cycle are shown in the *P*-*V* and *T*-*S* diagram for the same compression ratio and heat input.

1 - 2 - 3 - 4 otto cycle

1 - 2′ - 3′ - 4′ diesel cycle



All the cycles start from the same initial state point 1 and the air is compressed from state 1 to state 2 as the compression ratio is same. From the T-s diagram, it can be seen that for the same heat input, heat rejection in diesel cycle (514′6′) is maximum and more than that in otto cycle (5146). Consequently, the otto cycle has the highest work output and efficiency.

$$r = 19.373$$
$$\eta_{diesel} = 64.132\%$$
$$\text{SFC} = 0.3356 \text{ kg/kW-hr}$$

Solution : 22

$$\eta_{air\text{-}std} = 56.47\%$$
$$P_m = 14.24 \text{ bar}$$

Solution : 23

Solving by iteration, $\rho = 2.38$

$$\eta = 54.66\%$$

Solution : 24

% increase in efficiency of diesel cycle = **1.236%**

Solution : 25

(i) $$P_{max} = P_3 = \frac{T_3}{T_2} \times P_2 = 66.365 \text{ bar}$$

Percentage cut-off = 2.64%

Solution : 26

$$P_m = 7.017 \text{ bar}$$
$$= \frac{p_2}{p_m} = 6.49$$
$$\eta_{cycle} = 0.6048 \text{ or } 60.48\%$$

Fuel consumption per kWh; m_f

$\eta_{th(I)} = 0.5\,\eta_{cycle} = 0.5 \times 0.6048 = 0.3024$

or, 30.24%

$$\eta_{th(B)} = \frac{B.P.}{m_f \times C} = \frac{1}{\frac{m_f}{3600} \times 42000} = \frac{3600}{m_f \times 42000}$$

or,

$$0.242 = \frac{3600}{m_f \times 42000}$$

or,

$$m_f = 0.354 \text{ kg/kWh}$$

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2 Combustion & Knocking in SI and CI Engines

LEVEL 1 Objective Questions

1. (c)
2. (c)
3. (c)
4. (d)
5. (c)
6. (d)
7. (a)

LEVEL 2 Objective Questions

8. (a)
9. (d)
10. (c)
11. (d)
12. (c)
13. (a)
14. (d)
15. (b)
16. (b)

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3 Analysis and Injection of Fuel and Fuel Emissions

LEVEL 1 Objective Questions

1. (c)
2. (d)
3. (c)
4. (c)
5. (d)
6. (a)
7. (a)
8. (d)
9. (c)
10. (b)

LEVEL 2 Objective Questions

11. (d)
12. (a)
13. (a)
14. (d)
15. (b)
16. (d)
17. (b)
18. (b)
19. (d)
20. (c)
21. (b)
22. (b)
23. (b)
24. (d)
25. (a)
26. (b)
27. (d)

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LEVEL 3 Conventional Questions

Solution : 28

$$d = 0.9612 \text{ mm}$$

Solution : 29

$$\text{Time for injection} = 1.736 \times 10^{-3}$$

$$\text{Fuel flow rate/cylinder/cycle} = 5.241 \times 10^{-5} \text{ m}^3\text{/cycle}$$

Solution : 30

$$\text{Volume of fuel injected per cycle} = 0.05447 \text{ c.c.}$$

Solution : 31

$$d_0 = 0.813 \text{ mm}$$

Solution : 32

$$\text{Fuel consumption in kg/kWh} = 0.278 \text{ kg/kWh}$$

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4 Testing and Performance of I.C. Engine

LEVEL 1 Objective Questions

1.	(b)
2.	(a)
3.	(c)
4.	(a)
5.	(b)
6.	(a)
7.	(d)
8.	(c)
9.	(a)
10.	(b)

LEVEL 2 Objective Questions

11.	(d)
12.	(d)
13.	(a)
14.	(b)
15.	(c)
16.	(c)
17.	(a)
18.	(c)
19.	(c)
20.	(a)
21.	(a)

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LEVEL 3 Conventional Questions

Solution : 22

$$p_{bmep} = 7.21 \text{ bar}$$

Solution : 23

$$\eta_{th} = 25.85\%$$

(ii) Brake mean effective pressure, P_{bmep} = 4 bar

Volumetric efficiency, η_V = 85.68%

Solution : 24

Mechanical efficiency at full load = 85.94%

Mechanical efficiency at half load = 75.34%

Mechanical efficiency at quarter load = 60.44%

Volume flow rate of fuel = 6.984×10^{-6} m^3/s

η_{ith} = 29.09%

Solution: 25

(i) Heat in B.P = 12.57 kW

(ii) Heat carried away by cooling water = 7.46 kW

(iii) Heat carried away by exhaust gases = 6.55 kW

(iv) Heat lost by radiation or unaccounted losses = 1.545 kW

Heat input	kW	%	Heat Expenditure	kW	%
Heat supplied by fuel	28.125	100	1. B.P. 2. cooling water 3. exhaust gas 4. unaccounted losses	12.57 7.46 6.55 1.545	44.7 26.52 23.29 5.49
			Total	28.125	100%

Heat Balance Sheet

Solution : 26

(i) bp = 62.83 kW

(ii) Indicated power, ip = 73.92 kW

P_{bmep} = 6.67 bar

(iv) Friction power, fp = 73.92 – 62.83 = 11.09 kW

(v) Brake work from one cylinder in one cycle,

W_b = 0.629 kJ

(vi) $\dot{m}_f$ = 0.00501 kg/s

(vii) Brake thermal efficiency

η_b = 30.5%

(viii) Volumetric efficiency,

η_v = 90%

(ix) Brake specific fuel consumption

$$bsfc = 0.287 \text{ kg/kWh}$$

Solution : 27

$$\eta_m = 91.96\%$$
$$\eta_{ith} = 29.58\%$$

Heat input (per minute)	(kJ)	Heat expenditure (per minute)	(kJ)	%age contr.
Heat supplied by fuel	57333.33	1. Heat equivalent to BP	15600	27.2
		2. Heat lost to cooling medium	14295.6	24.934
		3. Heat lost to cooling oil	2380.5	4.152
		4. Heat carried away by steam	5132	8.95
		5. Heat lost in dry exhaust	9824.1	17.135
		6. Unaccounted losses	10101.13	17.618
		Total	57333.33	100

Solution : 28

$$\eta_v = 77.36\%$$
$$\left(\frac{A}{F}\right) = 16.85$$
$$\Rightarrow \quad P_{bmep} = 6.81 \text{ bar}$$
$$\text{Brake thermal efficiency, } \eta_{\text{Bth}} = 28.80\%$$
$$\text{Relative efficiency, } \eta_{\text{relative}} = 56.28\%$$

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