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Thermodynamics

Problem C

HEAT-ENGINE EFFICIENCY

PROBLEM

If a gasoline engine has an efficiency of 33 percent and receives 660 J of energy as heat from combustion during each cycle, how much work is done by the engine?

SOLUTION

Given: $eff = 0.33$ $Q_h = 660\ \text{J}$

Unknown: $W_{net} = ?$

Choose the equation(s) or situation: Rearrange the equation for efficiency.

$$W_{net} = eff\, Q_h = (0.33)\ (660\ \text{J}) = \boxed{220\ \text{J}}$$

ADDITIONAL PRACTICE

1. A steam engine of a locomotive has an efficiency of 17 percent and receives 5.5×10^9 J of energy by heat from its boiler. How much work is done by the engine?
2. A coal-burning power plant has an efficiency of 35 percent. If the power plant uses 7.37×10^8 J of energy as heat, how much work is done by the power plant?
3. A geothermal power plant has an efficiency of 15 percent. If the power plant takes in 9.36×10^8 J of energy as heat, how much work is done by the power plant?
4. If a gasoline engine has an efficiency of 29 percent and receives 693 J of energy by heat during each cycle, how much work is done by the engine?
5. Suppose an engine has an efficiency of 11 percent and performs 1150 J of work each cycle. How much energy is taken in as heat?
6. Suppose a steam engine has an efficiency of 19 percent and performs 998 J of work each cycle. How much energy is received by the steam engine as heat?
7. A certain propane engine performs 544 J of work in each cycle with an efficiency of 22.25 percent. How much energy is received from the engine to the exhaust and cooling system as heat?
8. Find the efficiency of a gasoline engine that, during one cycle, receives 365 J of energy from combustion and loses 223 J as heat to the exhaust.

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9. Find the efficiency of an engine that, during one cycle, receives 571 J of energy and loses 463 J of energy as heat.

10. A test model for an experimental engine that uses a new clean-burning fuel does 128 J of work in one cycle and receives 581 J of energy as heat from combustion. What is the engine's efficiency?

Additional Practice C

Givens	*Solutions*
1. $eff = 0.17$ $Q_h = 5.5 \times 10^9\ \text{J}$	$W_{net} = eff\, Q_h = (0.17)(5.5 \times 10^9\ \text{J}) = \boxed{9.4 \times 10^8\ \text{J}}$
2. $eff = 0.35$ $Q_h = 7.37 \times 10^8\ \text{J}$	$W_{net} = eff\, Q_h = (0.35)(7.37 \times 10^8\ \text{J}) = \boxed{2.6 \times 10^8\ \text{J}}$
3. $eff = 0.15$ $Q_h = 9.36 \times 10^8\ \text{J}$	$W_{net} = eff\, Q_h = (0.15)(9.36 \times 10^8\ \text{J}) = \boxed{1.4 \times 10^8\ \text{J}}$
4. $eff = 0.29$ $Q_h = 693\ \text{J}$	$W_{net} = eff\, Q_h = (0.29)(693\ \text{J}) = \boxed{2.0 \times 10^2\ \text{J}}$
5. $eff = 0.11$ $W_{net} = 1150\ \text{J}$	$Q_h = \dfrac{W_{net}}{eff} = \dfrac{1150\ \text{J}}{0.11} = \boxed{1.0 \times 10^4\ \text{J}}$
6. $eff = 0.19$ $W_{net} = 998\ \text{J}$	$Q_h = \dfrac{W_{net}}{eff} = \dfrac{998\ \text{J}}{0.19} = \boxed{5.3 \times 10^3\ \text{J}}$
7. $W_{net} = 544\ \text{J}$ $eff = 0.2225$	$Q_h = \dfrac{W_{net}}{eff} = \dfrac{544\ \text{J}}{0.2225} = \boxed{2.44 \times 10^3\ \text{J}}$
8. $Q_h = 365\ \text{J}$ $Q_c = 223\ \text{J}$	$eff = 1 - \dfrac{Q_c}{Q_h} = 1 - \dfrac{223\ \text{J}}{365\ \text{J}} = 1 - 0.611 = \boxed{0.389}$
9. $Q_h = 571\ \text{J}$ $Q_c = 463\ \text{J}$	$eff = 1 - \dfrac{Q_c}{Q_h} = 1 - \dfrac{463\ \text{J}}{571\ \text{J}} = 1 - 0.811 = \boxed{0.189}$
10. $W_{net} = 128\ \text{J}$ $Q_h = 581\ \text{J}$	$eff = \dfrac{W_{net}}{Q_h} = \dfrac{128\ \text{J}}{581\ \text{J}} = \boxed{0.220}$