

Question 1: For the following engines:

2 cylinder, 4-cycle;	2 cylinder 2-cycle;	3 cylinder, 4-cycle;
4 cylinder, 4-cycle;	6 cylinder, 4-cycle;	8 cylinder 4-cycle;

(a). Determine the average firing interval (AFI).

2 cylinder, 4-cycle; = $180 \times 4 / 2 = 360$ (Note: This engine does not fire every 360 deg)
 2 cylinder 2-cycle; = $180 \times 2 / 2 = 180$ (Note: This engine does fire every 180 deg)
 3 cylinder, 4-cycle; = $180 \times 4 / 3 = 240$ (Note: This engine does fire a cylinder at the AFI)
 4 cylinder, 4-cycle; = $180 \times 4 / 4 = 180$ (Note: This engine does fire a cylinder at the AFI)
 6 cylinder, 4-cycle; = $180 \times 4 / 6 = 120$ (Note: This engine does fire a cylinder at the AFI)
 8 cylinder 4-cycle; = $180 \times 4 / 8 = 90$ (Note: This engine does fire a cylinder at the AFI)

(b). Identify those engines with an uneven power strokes.

2 cylinder, 4-cycle;	Uneven Power strokes (both within 360 deg, none for second 360)
2 cylinder 2-cycle;	Even Power strokes (both within 360 deg)
3 cylinder, 4-cycle;	Even Power strokes (Fires every 240 degree, with power stroke lasting 180 deg)
4 cylinder, 4-cycle;	Even Power strokes (Fires every 180 degree, with power stroke lasting 180 deg)
6 cylinder, 4-cycle;	Even Power strokes (Fires every 120 degree, with power stroke lasting 180 deg)
8 cylinder 4-cycle;	Even Power strokes (Fires every 90 degree, with power stroke lasting 180 deg)

(c). Identify those engine with power strokes that overlap. Assuming engines of equal power were available for each of the engine types determine the order of relative size of flywheel required for each engine. (i.e. From largest flywheel to smallest flywheel).

2 cylinder 4-cycle;	No overlap	Largest Flywheel
2 cylinder, 2-cycle;	No overlap	
3 cylinder, 4-cycle;	No overlap	
4 cylinder, 4-cycle;		
6 cylinder, 4-cycle;	Overlapping power cycles	
8 cylinder 4-cycle;	Overlapping power cycles	Smallest Flywheel

(d). For a 5cylinder, 4 cycle engine, determine the crank angle degrees when intake and exhaust valves would open and close for any 3 of the five cylinders. Assume that a crank angle of 0 degrees corresponds with the piston 1 at TDC at the beginning of the intake stroke. Assume that intake valve opens 15° before TDC and closes 45° after BDC; and that exhaust valve closes 15° after TDC and opens 45° before BDC. The firing order of the engine is 1,5,2,4,3

$AFI = 180 \times 4 / 5 = 144$

Piston 1: Intake Valve Opens = $0 - 15 = -15$ degrees or 705 degrees

Intake Valve Closes = $180 + 45 = 225$ degrees

Exhaust Valve Opens = $540 - 45 = 495$ degrees

Exhaust Valve Closes = $720 + 15 = 735$ degrees or 15 degrees

Piston 5: All delayed by 144 degrees

Intake Valve Opens = $705 + 144 = 129$ degrees

Intake Valve Closes = $225 + 144 = 369$ degrees

Exhaust Valve Opens = $495 + 144 = 639$ degrees

Exhaust Valve Closes = $15 + 144 = 159$ degrees

Piston 2: All delayed by 288 degrees

Intake Valve Opens = $705 + 288 = 273$ degrees

(Compared to Piston 1)

Intake Valve Closes = $225 + 288 = 513$ degrees

Exhaust Valve Opens = $495 + 288 = 63$ degrees

Exhaust Valve Closes = $15 + 288 = 303$ degrees

Piston 4: All delayed by 144×3 degrees

Piston 3: All delayed by 144×4 degrees

Question 2:

(a). Is the minor diameter (Measured parallel to the piston pin) and the major diameter (measured perpendicular to the piston pin) of a piston the same when the piston is cold? If not, explain the reasons for this difference.

No! The area around the piston pin (minor axis) contains much more material than perpendicular to the piston pin. Therefore, when the piston heats up the minor diameter increases more than the major diameter. The goal is to have both diameters equal when the piston is at its operating temp.

(b) If the exhaust valve clearance is too small, would this cause the valve to prematurely fail? If this is the case, give two different reasons this could cause valve failure.

If clearance is too small the valve will open early and and close late (or not close at all). This will cause the valve to overheat and could cause heat fatigue. Another possibility is that the valve will still be open when the piston reaches TDC and the piston may hit the valve, causing impact damage

(c). After an engine is dismantled the following observations were made on only one of the four engine cylinders (other 3 appeared to have no damage). (1). The front top and back bottom edges of the piston were badly worn in a plane parallel to the crankshaft. Give potential causes for this uneven wear and explain how the wear occurred.

Incorrectly installed bearings.

Bent connecting rod.

Worn piston pin.

Question 3: The stoichiometric A/F ratio for gasoline engines is 15.05 for complete combustion, producing carbon dioxide and water.

(a). If the A/F ratio was decreased to 12.04, would the air/fuel mixture be considered a rich or a lean mixture, and would complete combustion occur.

Rich Mixture

(b). Name two additional combustion products that may be produced under these conditions.

Carbon Monoxide, Carbon, Unburnt Hydrocarbons

(c) Determine the mass of all combustion products at the A/F ratio of 12.04, for gasoline (C₈H₁₈)

The final combustion equation will be



or



Use these equations and molecular mass to find mass of products

(d). An engine is tested with the following A/F ratios, (10, 15, 20, 25, 50, and 75). It was found that the engine would run satisfactorily at A/F ratios above 25. Is this a SI engine or diesel engine? Explain your answer.

Diesel Engine. A gasoline engine will not run when A/F ratio is greater than 20:1 (or less than 8:1)

(d). When would you use a high cetane fuel in a gasoline engine? Explain your answer.

Never. Cetane is used to rate diesel fuels which make very poor gasoline fuel.

Question 4: The point's T10, T20, and T90 refer, respectively to the temperatures on the fuel distillation curve at which 10, 50 and 90 % of the fuel has been distilled.

(a). Why is it important that the T10 temperature is not too high? What would the effect of increasing the T10 temperature be on starting an engine in cold weather?

T10 temperature is a measure of the cold start characteristics of the fuel. (i.e. How much of fuel will vaporize in the carburetor) If T10 is too high it will be difficult to start the engine in cold weather.

(b). Engines' warm time up depends on the T50 temperature of the fuel. For gasoline would the T50 temperature be increased or decreased during winter. Explain your reasoning.

Decreased in winter to cause the engine to warm up faster. In addition vapor lock is not a problem in winter so a lower T50 is not a problem.

(c). A fuel is found to cause dilution of the crankcase oil. Which of the three distillation temperature points are associated with this phenomenon How does the fuel enter the crankcase?

T90. If the T90 is too high a significant portion of the fuel may condense on the cylinder walls and eventually find its way into the crankcase.

(d). Gasoline volatility is adjusted by petroleum refiners to suit the season. Give one reason why the volatility of gasoline is

increased in winter, and a second reason why the volatility is lower in summer.

In winter, temperatures are lower and cold starting is a problem. In summer starting is not such a problem but vapor lock may cause problem. The volatility is also decreased in summer to prevent evaporation from the fuel tank of the lighter components to prevent smog and air pollution.

Question 5: The ignition delay of a fuel after the self-ignition temperature is reached, has important effects on the speed of the flame front, rate of combustion and rate of pressure rise in the engine cylinder.

(a). Why would you tend to use a fuel with a relatively long ignition delay in a spark ignition engine?

A long ignition delay gives the flame time to progressively burn from the spark to the extremes of the cylinder walls before auto ignition occurs.

(b). What would be the effect of using fuel with a long ignition delay in a diesel engine?

This will allow most of the fuel to mix with the air before combustion occurs, resulting in a very high percentage of pre-mix combustion which will result in very high rates of pressure rise in the cylinder, (and most likely very high maximum pressure in the cylinder, depending on timing).

Question 6: The timing of start and end of injection for an in-line injector pump and a rotary distributing type pump are very different

(a). For an in-line injection pump, does the start of injection change with the mass of fuel per injection? Explain your answer

No. The start of injection is constant since the scroll blocks the inlet port at the same time irrespective of the injection volume.

(b). For an in-line injection pump, explain the effect of increasing the injection volume on the start and end of injection.

Increasing the injection volume, by rotating the scroll, increases the effective stroke of the plunger, opening the spill port later and delaying the end of injection

(c). For a rotary injection pump, Does the timing of the end of injection change as fuel delivery increases? Explain your answer

No. The end of injection is constant since the end of injection occurs when the plungers move past the highest point on the cam lobe.

(d). For a rotary injection pump, explain why the start of injection for a rotary pump changes in proportion to the volume of fuel per injection

When the injection volume decreases, less fuel is metered into the space between the plungers resulting in the plunger only being forced out a small distance. Therefore, the plungers do not hit the cam lobe as soon as the lobe begins to rise and the start of injection is delayed when injection volume decreases. (Easiest way to answer this question is to draw a diagram and then explain)

Question 7: The dwell angle is important in a spark ignition engine

(a). Define the dwell angle.

Dwell angle is the angle of rotation of the distributor shaft while the points remain closed (for one cylinder only)

(b). What is the effect of decreasing the dwell angle on the spark voltage?

A decrease in dwell angle reduces the dwell time which in turn reduces the amount of energy stored in the magnetic fields of the coil and reduces the spark voltage.

(c). Explain the effect of points gap on dwell angle.

Increasing the points gap decreases the dwell angle, reducing points gap increases dwell angle.

(d). Does engine speed affect the dwell angle? What effect does engine speed have on dwell time and how does this affect spark voltage.

Engine speed does not change dwell angle but will reduce dwell time and therefore reduce spark voltage.

Question 9: You are fitting a turbocharger to a 7.2 litre engine. You wish to develop 250 Hp at 2100 rpm and run at an A/F ratio of 30:1. The brake specific fuel consumption is .027 kg/kWhour.

(a). Find the required fuel consumption

(b). Find the required air consumption

(c). Find the required volumetric efficiency

(d). Determine the Pressure Ratio required if the turbocharger compressor has an efficiency of 0.70.

Follow steps in notes