EXERCISES 1

Review questions

1 Define the terms 'brake power' and 'indicated power' as applied to a motor vehicle engine.

2 Explain the reason for the difference between the brake power and the indicated power of an internal combustion engine.

3 The mechanical efficiency of an engine is given by

4 Three factors which affect the mechanical efficiency of a spark-ignition engine are:
(1) ..... (2) ..... (3) .....

5 State what is meant by 'engine torque'.

6 The units of engine torque are .....

7 A device which measures engine torque is .....

8 The equation which gives the relationship between engine torque and brake power is .....

9 Sketch typical torque and brake power curves on a base of engine speed. Explain briefly why they are of the shape shown.

10 Distinguish between 'indicated mean effective pressure' and 'brake mean effective pressure'.

11 Three factors which affect the value of the brake mean effective pressure of a spark-ignition engine are:
(1)..... (2)..... (3).....

12 Define the term 'specific fuel consumption'.

13 Complete the following equations:
(a) i.p. - b.p. = ...
(6) b.m.e.p. = i.m.e.p. x .....

14 The thermal efficiency of an engine is the ratio ...../.....

15 Three factors which affect the thermal efficiency of a spark-ignition engine are:
(1)..... (2)..... (3).....

16 Describe a laboratory test on a four-cylinder, spark-ignition engine to determine the torque delivered by the crankshaft and the brake power at various speeds.

17 (a) Describe an experiment to find the approximate indicated power of a four-cylinder internal combustion engine, using the Morse test.(b) Show a typical formula used to find (i) brake power, (ii) indicated power, and (iii) mechanical efficiency. (c) Indicate on a base of engine speed the types of graph which may be plotted as a result of this experiment.

18 Describe how an engine is tested under laboratory conditions for power and fuel consumption. State the equipment and calculations required to obtain the final conclusions. Show a typical fuel consumption and power curve.

19 State how the brake thermal efficiency of the engine can be deter-mined from the results obtained in the experiment of Question 18above.

EXERCISE 2

Problems

1 An engine is tested against a dynamometer at 3300 rev/min and exerts a force of 200 N at the end of a torque arm of length 0.35 m. Calculate:
(a) the torque transmitted by the engine (70 N m)
(b) the brake power developed by the engine at this speed. (24.2 kW)

2 Calculate the torque of an engine which develops 22 kW at a speed of 21 rev/s. (166.7 N m)

3 Using the values given in the table below, plot the graph for engine torque against speed.

Engine torque (N m)	450	492	500	490	453	410	360
Speed (rev/min)	1200	1500	1800	2100	2400	2700	3000

(a) From the graph, obtain the maximum torque and the speed at which it occurs. (500 N m, 1800 rev/min)
(b) Calculate the power at that speed. (94.25 kW)

4 (a) Plot torque and brake power curves for both spark and compression-ignition engines from the following data:

Petrol engine

Speed (rev/min)	600	1200	1800	2400	3000	3600	4200	4800
Torque (N m)	90	110	104	90	74	59	44	26
Brake power (kW)	14	22	29	35.5	41	45	46	38

Compression-ignition engine

Speed (rev/min)	600	1200	1800	2400	3000	3600
Torque (N m)	95	98	97	95	90	83
Brake power (kW)	10	22	32	41	47	46

(b) In what way may these graphs be used in putting forward an argument in favor of the compression-ignition engine?

5 A six-cylinder, four-stroke petrol engine, having a cylinder bore diameter of 82 mm and a stroke of 80 mm, develops maximum power at a speed of 4800 rev/min. The i.m.e.p. at this speed was found to be 1100 kPa, the engine being coupled to a hydraulic dynamometer having a value of K = 16. The load on the dynamometer was 290 N. Calculate the indicated power, brake power and mechanical efficiency of the engine. (111.6 kW; 87kW; 78%)

6 A single-cylinder engine has a bore of 70 mm and a stroke of 76 mm. The average pressure during each working stroke is 620 kPa. Calculate:
(a) the average force on the piston
(6) the work done on the piston during one working stroke
(c) the power developed in the cylinder if the piston makes 2000 working strokes per minute
(d) the power available at the flywheel if the engine has a mechanical efficiency of 85 per cent.

7 The average pressure acting on each piston crown of a four-cylinder, four-stroke engine on test was 850 kPa, the piston diameter being 60 mm, and piston stroke 75 mm.
(a) Calculate the power developed by the engine, the crankshaft speed being 4200 rev/min
(b) If the mechanical efficiency of the engine is 80 per cent, calculate the torque developed at the output shaft of the engine.

8 A single-cylinder, two stroke diesel engine develops 7 kW at 2800 rev/min. Calculate the work done on the piston, in joules, in one stroke. If the piston is 100 mm diameter and the stroke is 150 mm, calculate the average pressure on the piston in kPa.

9 The following results were obtained from an engine tested with a dynamometer having a b.p. formula WN/20 000 kilowatts.

Speed, N (rev/min)	1000	1500	2000	2500	3000	3500	4000	4500
Load, W (N)	104	108	110	110	105	96	86.5	77.2

On a base of rev/min, plot the engine load and b.p. curves. Make comments on these curves and indicate the speed at which maximum torque occurs.

10 A four-cylinder, four-stroke engine produces an indicated power of 61 kW when rotating at 50 rev/s. The compression ratio is 8.5 to 1 when using a clearance volume of 66.4 cm3 Calculate:
(a) the swept volume of the cylinder
(6) the indicated mean effective pressure at 50 rev/s.

11 A single-cylinder, four-stroke engine of bore 120 mm and stroke 150 mm overcomes a resistance of 140 N at a radius of 0.5 m when running at 600 rev/min. Calculate the brake power developed by the engine and the brake mean effective pressure.

12 Calculate the diameter of the cylinder bore of a six-cylinder, four-stroke engine which develops a brake power of 46 kW at 3500 rev/min. The brake mean effective pressure is 700 kPa and the engine bore and stroke have the same dimension.

13 A six-cylinder engine is to develop an output power of 30 kW at 2500 rev/min, at which speed the b.m.e.p. is expected to be 840 kPa. If the ratio of stroke to bore is to be 1.4, determine the bore and stroke of the engine.

14 A vee-eight, four-stroke compression-ignition engine has a bore of 119 mm and a stroke of 89 mm, and the clearance volume is 58 cm). The engine develops its maximum torque of 450 N m at1900 rev/min and its maximum brake power of 250 kW at 3800 rev/min. Calculate:

(a) the compression ratio
(b) the brake power at maximum torque
(c) the b.m.e.p. at maximum power
(d) the i.m.e.p. and friction power at maximum power if the mechanical efficiency is 90 per cent.

15 During a Morse test on a four-cylinder engine the following results were recorded.

Cylinder cut out	None	No. 1	No.2	No.3	No.4
Brake power developed (kW)	33.6	23.1	23.2	23.0	23.1

For normal running at test speed the engine used 0.23 kg/min of petrol of calorific value 44000 kJ/kg. Calculate:

(a) the indicated power
(b) the mechanical efficiency
(c) the indicated thermal efficiency.

16 Using a dynamometer having a torque arm length of 0.6 m, the following brake loads were obtained during a Morse test on a four-cylinder engine at a test speed of 2250 rev/min.

Cylinder firing	A11 4	2,3,4	1,3,4	1, 2, 4	1, 2, 3
Brake force (N)	135	90	89.5	91.5	91

From the above data calculate:

(a) the brake power
(b) the indicated power
(c) the friction power
(d) the mechanical efficiency of the engine.

17 Calculate the brake thermal efficiency of an engine which uses fuel at the rate of 0.003 kg/s of 40 000 kJ/kg calorific value to produce 36 kW.

18 A petrol engine develops an indicated power of 43.5 kW while consuming 8.6 kg of fuel per hour. Given that the calorific value of the fuel is 42 200 kJ/kg, and that friction and pumping losses account for 9.25 kW, calculate:

(a) the brake power
(b) the brake specific fuel consumption
(c) the mechanical efficiency
(d) the indicated thermal efficiency
(e) the brake thermal efficiency.

19 Calculate the brake power of an engine which uses 15 kg of fuel per hour, the fuel having a calorific value of 44 MJ/kg. It is known that only 25 per cent of the energy in the fuel will be converted into brake power.

20 A petrol engine develops an indicated power of 30 kW and uses fuel having a calorific value of 43 MJ/kg. If the indicated thermal efficiency is 32 per cent, determine the number of litres of fuel consumed by the engine per hour. (1 litre of the fuel used has a mass of 0.74 kg.)

21 During a test on a compression-ignition engine of 25.5 kW (brake), 7.5 kg of oil were used in one hour. If the mechanical efficiency was 80 per cent, determine the brake thermal efficiency and the indicated thermal efficiency. The calorific value of the fuel was 45 MJ/kg.

22 A six-cylinder, four-stroke engine developing 100 kW at 42 rev/s has a bore and stroke of 100 mm. The thermal efficiency is 30 per cent and the calorific value of the fuel 40 000 kJ/kg. Calculate:

(a) the brake mean effective pressure
(b) the specific fuel consumption.

23 The following are the mean values of observations made during a series of tests on a four-cylinder petrol engine coupled to a dynamometer. The speed of the engine was kept constant throughout the tests at 2500 rev/min. Readings were obtained with all cylinders working and then each cylinder was cut out in turn. The calorific value of the fuel used was 43 MJ/kg.

Cylinder cut out	None	No. 1	No.2	No.3	No.4
Fuel consumption (kg/h)	5.45	5.5	5.61	5.58	5.48
Brake power (kW)	13.05	9.25	9.32	8.95	9.0

Calculate:
(a) the indicated power
(b) the friction power
(c) the brake thermal efficiency
(d) the mechanical efficiency of the engine.

24 A four-cylinder, two-stroke cycle petrol engine has a cylinder bore diameter of 76 mm and a piston stroke of 90 mm. When running at 2400 rev/min, the engine develops a brake mean effective pressure of 725 kPa and uses 9.2 kg of fuel per hour of calorific value 44 MJ/kg. Calculate:
(a) the brake power
(b) the specific fuel consumption, in kg/kW h
(c) the brake thermal efficiency.

25 In a test on a small petrol engine the fuel used had a calorific value of 44 MJ/kg, and the power was absorbed by a brake through which water circulated. When the output of the engine was 41 kW, petrol was used at the rate of 12 kg/h. Calculate the brake thermal efficiency of the engine. Also calculate the rate of flow of water required by the brake, in kg/min, assuming that all the power is converted into heat, for the rise in water temperature to be 45 K. (Take the specific heat capacity of water as 4.2 kd/kg K.)

26 A four-cylinder, four-stroke engine developing 78.5 kW at 50 rev/s has a fuel consumption of 0.25 kg/kW h and a bore and stroke of 100 mm. Calculate:
(a) the brake mean effective pressure
(b) the thermal efficiency assuming the calorific value of the fuel is 45 000 kJ/kg.

27 The following results were obtained during a test using a spark-ignition engine under varying load, to determine the fuel consumption at various speeds.

Speed (rev/min)	1000	1500	2000	2500	3000	3500	4000	4500
Brake power (kW)	11	15.4	19.4	23	26.3	28.8	29	27.3
Fuel consumption (kg/kW h)	0.45	0.375	0.346	0.34	0.347	0.36	0.39	0.46

Using a base of speed, plot curves for brake power and fuel consumption and determine:
(a) the maximum brake power developed and the speed at which it is produced
(b) the speed at which minimum specific fuel consumption occurs.

28 The following results were obtained during tests on a four-cylinder petrol engine using fuel having a calorific value of 45 MJ/kg.

Brake power (kW)	10	15	20	25	30
Fuel consumption (kg/kW h)	0.371	0.347	0.337	0.337	0.353

From the above results, calculate the brake thermal efficiency in each case and plot curves on a base of brake power of (a) fuel consumption and (b) brake thermal efficiency. From these curves, estimate the most economical power of the engine. (CGLI)(Modified)