

should be made for expansion and efficient draining of the pipes. State the type of steam-valve fitted to the boilers and bulkheads and the material used for pipes, valve chests, and valve seats.

8. Explain what is meant by "open" and "crossed" eccentric rods and state the type of valve with which each is associated. With valve gear in mid position an engine will stop with either arrangement of eccentric rods. What is the reason for this?
9. Sketch and describe a water-gauge suitable for a water-tube boiler working at 450 lb. per square inch. Why is protection necessary between the water and glass and how is this accomplished?

ENGINEERING KNOWLEDGE

AFTERNOON PAPER. MOTOR CANDIDATES

Time allowed : Three hours.

1. Sketch an exhaust-gas boiler of the thimble tube type and state the increase of efficiency claimed by fitting this boiler. Illustrate how the tubes are fitted and explain how oil firing of this boiler is accomplished.
2. Make a diagrammatic sketch of a two-stage manoeuvring air-compressor, and mark thereon the approximate pressures and temperatures. Draw a set of cards you would expect to obtain from such a compressor.
3. Explain what factors govern the quantity of starting air that must be carried in motor-vessels. Sketch a large air-receiver, showing method of construction and all fittings.
4. There have been many failures of crankshafts of internal-combustion engines as compared with steam-engines. What, in your opinion has been the cause of this, and what measures should be adopted to minimize the possibility of failure?
5. Sketch in detail the complete link of a roller chain used for camshaft drive. What is the approximate factor of safety of these chains? How is adjustment provided for and what dangers are present when chain is (a) too tight and (b) too slack?
6. Serious explosions have occurred in the crankcases of internal-combustion engines. Discuss the possible cause of these disastrous occurrences, and set out suggestions of design and management which would reduce the possibility of an explosion taking place.
7. Describe with the aid of a diagrammatic sketch the double-acting two-stroke cycle engine of the Burmeister and Wain type. At what angle to the main crank are the eccentrics driving the exhaust pistons set? What power, if any, is derived from the exhaust pistons?
8. Sketch a pressure-operated starting air valve, stating the type of engine with which it is associated. What provision is made to prevent the products of combustion passing back into starting air line whilst manoeuvring?
9. Describe the various methods of supercharging a four-stroke-cycle internal-combustion engine. What effect has supercharging on (a) power; (b) economy; (c) maximum pressure; (d) mean pressure; (e) maximum temperature; (f) mean temperature?

EXAMINATION OF ENGINEERS. IN THE MERCANTILE MARINE

Specimen Set of Examination Papers for a First-class Certificate

Exn. 1B

These Examination Papers relate to Examinations held under the Regulations published in 1939 (Exn. IA (1939))



WELLINGTON, N.Z.

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1949

NOTE.—Data to be used in working the problems will be found on the first sheet of the answer-book.

GENERAL ENGINEERING SCIENCE

Six questions ONLY to be attempted

Time allowed: Three hours

1. A uniform ladder 30 ft. in length weighs 100 lb. and rests against a rough wall with which it makes an angle of 30° . The coefficient of friction between the ladder and the ground is 0.28. Assuming the ladder is just on the point of slipping, find the coefficient of friction between the wall and the ladder.
2. A steel bolt is 4.5 in. in diameter and 2 ft. 2 in. in length over-all, the head being 6 in. in diameter and 4 in. long. A loose steel collar is placed on the bolt, the diameter and length of the collar being the same as that of the bolt head. If the centre of gravity of the bolt and collar is 13.5 in. from the point of the bolt, find the position of the collar.

3. The following observations were taken during an experiment on a Weston pulley block having pulleys 11 in. and 10 in. in diameter:—

Load (lb.)	40	80	120	160	200	240	280
Effort (lb.)	6.5	11	15.3	19.4	23.3	27.4	31.4

Plot curves on a load base showing efficiency and load lost due to friction in the machine and read off the loss of load due to friction when the efficiency is 32 per cent.

Use the following scales:—

- 1 in. = 40 lb. load.
- 1 in. = 10 per cent. efficiency.
- 1 in. = 100 lb. loss of load.

4. A cylindrical tank 18 ft. in diameter and 16 ft. high stands on a platform with its axis vertical and its base 20 ft. above the ground. The tank is to be filled with fresh water by a pump placed on the ground and delivering by a 3-in.-diameter pipe through the bottom of the tank. Find the approximate time to fill the tank when the pressure at the pump discharge is 50 lb. per square inch.
5. Define simple harmonic motion. Show that the periodic time of a simple pendulum $= 2\pi\sqrt{\frac{l}{g}}$ where l is length of pendulum in feet and $g = 32.2$, and state what assumptions are made. Find the length of a simple pendulum which has a periodic time of 1.75 seconds.
6. A beam 18 ft. in length carries a uniform load of 1 ton per foot run, a concentrated load of 6 tons at 4 ft. from left-hand support, and a concentrated load of 7 tons at 3 ft. from right-hand support. Determine the bending moment at the centre and at 5 ft. from the left-hand support, also find the position and

amount of maximum bending moment. State the shearing force acting at each end and at the centre and draw the shearing force and bending moment diagrams.

Use the following scales:—

- 1 in. = 4 ft. length of beam.
- 1 in. = 5 tons shearing force.
- 1 in. = 20 ft. tons bending moment.

7. Find the maximum and minimum stresses in a cylindrical bar 4.5 in. in diameter which carries a tensile load of 28 tons acting along a line 0.625 in. from the centre line of the bar.
8. Two circular beams are made of the same material, one being solid 5 in. in diameter, and the other hollow having an external diameter of 7 in. Find the internal diameter of the hollow section so that it shall have the same area as the solid section. Denoting the moment of resistance of the solid section by I , determine the number which will represent the moment of resistance of the hollow section.
9. A pressure cylinder is 6 ft. 6 in. internal diameter, the shell being constructed of four plates 1.375 in. thick. The plates are cut obliquely and butt welded, the butt welds making spiral angles of 45 degrees with the circumferential joints, which are also welded. If the working pressure is 380 lb. per square inch, what is the normal stress at (1) the circumferential weld; (2) the oblique weld?

HEAT AND HEAT ENGINES

Six questions ONLY to be attempted

Time allowed: Three hours

1. Define co-efficient of apparent expansion.
 - A cylindrical steel petrol-tank is 9.5 in. in diameter and 30 in. long. It is accidentally filled to the top of the filling pipe with petrol at 0° c. The temperature of the petrol then rises to 16° c. Calculate the amount of petrol which will overflow.
 - Co-efficient of linear expansion of steel = 0.0000065 per $^\circ$ Fahrenheit.
 - Co-efficient of cubical expansion of petrol = 0.0004 per $^\circ$ Fahrenheit.
2. The clearance volume of a gas-engine cylinder is 5,800 c.c. The cylinder diameter and stroke is 245 mm. and 550 mm. respectively. If gas and air is drawn in at 15 lb. per square inch absolute, find the pressure at the end of the compression stroke. The law of the compression is $PV^{1.35} = \text{constant}$.
3. An evaporator is supplied from an exhaust steam range at a pressure of 21 lb. per square inch absolute (temperature, 230° Fahrenheit) having a dryness fraction of 0.92. The dry vapour

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under a vacuum of 15 in. of mercury (temperature, 180° Fahrenheit) is passed to a distiller. The feed to the evaporator is raw water at a temperature of 80° Fahrenheit and the drain from the evaporator coils has a temperature of 190° Fahrenheit. Assuming that losses by radiation amount to 5 per cent. of the heat supplied, calculate the amount of steam required per hour to produce 40 tons of distilled water per day of twenty-four hours.

4. A boiler consumes 1,500 lb. of oil fuel per hour. The analysis of the oil is 84 per cent. carbon, 13 per cent. hydrogen, and 3 per cent. oxygen. Find—

- (a) The theoretical amount of air required per pound of fuel for perfect combustion; and
 (b) If the actual amount of air supplied is 60 per cent in excess of the theoretical quantity, find the weight of flue gases passing up the chimney per hour.

NOTE.—Atomic weight of carbon is 12, of hydrogen 1, of oxygen 16.

5. A heavy-oil internal-combustion engine is undergoing test-bed trials and it is found that the consumption of fuel per b.h.p. per hour is 0.48 lb., the calorific value of the fuel being 19,200 B.T.U.s per pound. The mechanical efficiency of the engine is 82 per cent. Find the percentage loss of heat in the exhaust gases and cooling water if the former carry away 8 per cent. more of the heat supplied than the latter.
6. The clearance volume of a cylinder 10 in. diameter is such that 4.8 lb. of water just fill it when the piston is at the end of its stroke. If the crank radius is 13 in., express the clearance as a fraction of the working volume. Steam at a pressure of 65 lb. per square inch absolute is admitted for 0.2 of the stroke, the back pressure being 2 lb. per square inch absolute. Calculate the mean effective pressure. (1) neglecting clearance; (2) taking clearance into account.
7. A carbon-dioxide refrigerating-machine makes 0.6 tons of ice at 29° Fahrenheit from water at 54° Fahrenheit in one hour. The brine in the evaporator is at a temperature of 16° Fahrenheit and the latent heat of CO_2 at this temperature is 105.5 B.T.U.s per pound. On entering the evaporator coils the CO_2 vapour has a dryness fraction of 0.32 and on leaving the dryness fraction is 0.94. Estimate the weight of CO_2 passing through the machine per hour.
8. A slide valve has a travel of 7.5 in., the angle of advance being 35°. The steam-port opening when the crank has turned through an angle of 80° from top dead centre is 1.5 in. Find mathematically (a) the steam lap, and (b) the lead.
9. An internal-combustion engine has a stroke of 40 in., connecting-rod length of 70 in., and the centre-line of the cylinder is offset 2 in. from that of the crank-shaft. When the crank has moved 30° past the vertical position the piston load is 18 tons. Find the pressure per square inch on the guide at this instant if the area of the sliding face is 100 sq. in. Also find how far the piston has moved down the cylinder.

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ELECTROTECHNOLOGY

Three questions ONLY to be attempted

Time allowed for the question paper, together with the question paper on Naval Architecture, is 3 hours

1. Define the term "frequency" as applied to A.C.

A two-pole turbo alternator runs at a speed of 3,000 revolutions per minute. What is the frequency of the current?

The alternator supplies current to a 4-pole induction motor which has a full load slip of 3 per cent. What will be the actual rotor speed and the frequency of the rotor-induced E.M.F. at full load?

2. A uniform wire 1 metre long is connected in series with a coil of 1 ohm resistance and a second coil of unknown resistance. A battery is then connected to the ends of the wire so that the current divides between it and the two coils. One terminal of a galvanometer is then connected to a point between the two coils and to a point on the wire 40 centimetres from the end nearest the one ohm coil, in which position there is no deflection produced on the galvanometer. Calculate the resistance of the second coil. Sketch the arrangement.
3. A 220-volt shunt motor running at 700 revolutions per minute has an armature resistance of 0.5 ohm, and takes an armature current of 24 amps. Assuming the same torque to be maintained, at what speed would the motor run if a resistance of 3 ohm were placed in series with the armature?
4. State Kirchhoff's Laws.

Twelve similar cells are arranged in four rows of three, the four rows being joined in parallel. Each cell has an E.M.F. of 1.3 volts and an internal resistance of 0.9 ohms. This battery is used to send current through a resistance of 15 ohms. What is the value of the current?

NAVAL ARCHITECTURE

Three questions ONLY to be attempted

Time allowed for the question paper, together with the question paper on Electrotechnology, is 3 hours

1. A rectangular-shaped lighter 120 ft. long, 40 ft. broad, 12 ft. deep, floating in sea-water at 4 ft. draught, has a collision bulkhead 8 ft. from the forward end. If the side is broached before this condition? what would be the trim in the damaged condition?

2. A piece of machinery weighing 50 tons is lifted from the hold of a vessel by the heavy-lift derrick—the head of which is 60 ft. above the C.G. of the weight—and landed on deck in such a position that its centre of gravity has moved forward 40 ft. and upward 35 ft. If the displacement of the vessel is 12,200 tons, calculate (a) the change, if any, in metacentric height when the weight is first taken by the derrick; (b) the change when the weight has been lifted 20 ft.; (c) the total movement of C. of G. of vessel when weight is in its position on deck; (d) at what angle to the horizontal is the new C. of G. relative to the original one.
3. Briefly describe the correct procedure to adopt in an inclining experiment. What information is gained from the data obtained? How is G.M. effected by slack water in a tank?
4. The wetted surface of a vessel is 2.2 times that of a smaller vessel of similar form. The displacement of the larger is 4,100 tons more than the smaller. Find the displacements of the two vessels.

ENGINEERING KNOWLEDGE

MORNING PAPER. ALL CANDIDATES

Time allowed: Three hours

1. Make a diagrammatic sketch of a tensile testing-machine and describe the manner in which a specimen is prepared and tested. How are the minute extensions measured?
2. In oil-tankers where oil having a lower flash point than 150° Fahrenheit may be carried special requirements appertaining to the electrical equipment are necessary. What are these requirements regarding voltage for (a) power, (b) lighting and heating, with D.C. and A.C.? What system of current distribution must be employed and what are the requirements for portable lights and the lighting of pump-rooms? Is any type lamp permitted in a tank containing possible explosive mixtures?
3. Sketch the stern frame for a large single-screw vessel showing clearly how the connection to the shell plating is carried out. Describe the manner in which a part such as this is tested before being accepted.
4. In a vessel fitted with a cellular double bottom the structure underneath the engines is considerably stiffened to carry the machinery. Describe this additional strengthening and make a transverse sectional view of the arrangement showing clearly the method of attachment of the bedplate.
5. Sketch a moving coil instrument and explain its action. Illustrate the position in the circuit when used as (a) an ammeter, and (b) a voltmeter. Why is this instrument essentially a D.C. meter?

6. On many modern vessels mechanical ventilation is adopted for the living-quarters. Describe the arrangement and explain how the temperature of the air is regulated. What attention does the system require to ensure satisfactory performance?
7. Describe any apparatus installed on board ship to enable an outbreak of fire in the various compartments to be detected and dealt with.
8. Sketch and describe the Hel-Shaw pump usually incorporated with an electric hydraulic steering-gear.
9. Electric welding is extensively adopted in marine engineering. Describe this system of welding and state the care necessary to ensure a good weld. What are the advantages of this system as compared with the oxyacetylene method?

ENGINEERING KNOWLEDGE

AFTERNOON PAPER. STEAM CANDIDATES

Time allowed: Three hours.

1. Make a diagrammatic sketch of the Foster-Wheeler "D" type boiler showing the disposition of the tubes, headers, and superheater. What major factor has influenced the adoption of this boiler for marine work?
2. Turbine blading of the "end tightened" type is now fitted to reaction turbines. Sketch this type of blading and explain how a saving in steam consumption is effected. To what stages of a turbine is "end tightened" blading fitted, and what provision is made to enable blade clearance to be altered whilst turbine is running?
3. Modern high-pressure water-tube boilers require particular attention regarding the treatment and testing of the feed water. Fully describe this treatment and explain why the feed water for these boilers require so much more attention than the older-type marine boiler.
4. Sketch diagrammatically an independent dual air-pump and its connections. What are the advantages claimed for this type of pump and what are the approximate temperatures of the contents?
5. Describe how you would proceed to take an indicator card from the cylinder of a steam-engine. Sketch a normal card from the M.P. cylinder and indicate the effect on both top and bottom cards of the valve being low. The valve is of the piston type taking steam on the inside.
6. Describe the construction of an air preheater and explain (a) what advantages are derived by fitting a preheater; (b) what is the temperature of the air and flue gas going in and out of the heater; (c) what trouble is likely to follow if the outlet gas temperature falls below a certain figure?
7. Sketch a suitable main steam-pipe arrangement for a group of three water-tube boilers supplying steam at 450 lb. per square inch and 750° Fahrenheit to the main turbines. Provision