

1934

## Mathematics (4th Year): Technical School Examinations 1934

Department of Education: Technical Instruction Branch

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# COURSES IN MECHANICAL ENGINEERING.

(67)

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TECHNICAL SCHOOL EXAMINATIONS.  
1934.

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## MATHEMATICS. (Fourth Year.)

Friday May 25th—7 p.m. to 10 p.m.

Examiner—THOMAS GORMLEY, ESQ., A.R.C.S.C.I.

Co-Examiner—PEADAR A. MACCIONNAITH, M.SC., A.C.S.C.I.

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### GENERAL INSTRUCTIONS.

You are carefully to enter on the Answer Book and Envelope supplied your Examination Number and the subject of examination, but you are not to write your name on either. No credit will be given for any Answer Book upon which your name is written, or upon which your Examination Number is not written.

You must not have with you any books, notes, or scribbling-paper, except the book of logarithms supplied to you.

You are not allowed to write or make any marks upon your paper of questions.

You must not, under any circumstances whatever, speak to or communicate with another candidate; and no explanation of the subject of the examination may be asked for or given.

You must remain seated until your Answer Book has been taken up, and then leave the examination-room quietly. You will not be permitted to leave before the expiration of twenty minutes from the beginning of the examination, and will not be re-admitted after having once left the room.

If you break any of these rules, or use any unfair means, you are liable to be dismissed from the examination, and your examination may be cancelled by the Department.

Three hours are allowed for this paper. Answer Books, unless previously given up, will be collected at 10 p.m.

## INSTRUCTIONS.

Read the General Instructions on page 1.

- (a) You may attempt not more than six questions.  
 (b) Equal values are attached to the questions.  
 (c) Answers must be written in ink; diagrams may be drawn in pencil.  
 (d) Write the number of the question distinctly in the margin of your paper before the answer.  
 (e) Slide-rules, drawing instruments and tables may be used.

1. Expand the expression  $\left(1 + \frac{1}{n}\right)^n$  showing at least the first four terms. For the case where  $n$  is infinitely large, simplify the expansion, and hence find the numerical value of the expression correct to three decimal places.

If  $y = \frac{a}{2} \left( e^{\frac{x}{a}} + e^{-\frac{x}{a}} \right)$  and  $s = \frac{a}{2} \left( e^{\frac{x}{a}} - e^{-\frac{x}{a}} \right)$ , prove  $y^2 = s^2 + a^2$ .

2. Find from first principles the differential coefficient of  $\frac{1}{x^2}$ .

The radial tension  $P$ , in a rotating hollow cylinder at any distance  $x$  measured outwards from the axis, is given by:

$$P = A \left( R^2 + r^2 - \frac{R^2 r^2}{x^2} - x^2 \right)$$

where  $A$ ,  $R$  and  $r$  are constants. Show that the maximum value of  $P$  is  $A(R-r)^2$ .

3. A wheel of radius  $r$  moves along the ground at a constant angular velocity  $\omega$ . If a point on the rim has moved a horizontal distance  $x$ , and reached a vertical height  $y$ , after  $t$  seconds, then  $x = r(\omega t - \sin \omega t)$  and  $y = r(1 - \cos \omega t)$ .

Prove that the velocity of the point at this instant is  $2r\omega \sin \frac{1}{2}\omega t$ .

4. A mass of gas initially at pressure  $P_1$  and volume  $V_1$  expands according to the law  $PV^n = c$  where  $n$  and  $c$  are constants. If the final pressure is  $P_2$  and volume  $V_2$ , find an expression for the work done during the expansion in terms of  $P_1$ ,  $V_1$ ,  $P_2$ ,  $V_2$  and  $n$ .

5. Water escapes from a hole at the bottom of an upright cylindrical tank at a rate proportional to the square root of the depth of water in the tank. If the depth of the water falls from 4 feet to 2 feet in 5 minutes, how much longer will the tank take to empty itself.

6. A wash-basin has a spherically shaped side and a flat bottom. Its internal dimensions are:—diameter at top 24 ins., diameter at bottom 10 ins., depth 7 ins. Find the capacity of the basin in cubic inches.

7. The parallel sides of a trapezoidal section are of length  $a$  and  $b$  respectively, and the distance between them is  $h$ . Find the moment of inertia of the section about the side  $a$  as axis. Find also an expression for the perpendicular distance of the centroid from the side  $a$ .

8. Deduce the equation of the tangent to the rectangular hyperbola  $xy = a^2$  at any point  $x', y'$  on it.

Prove that the portion of the tangent intercepted by the asymptotes is bisected at the point of contact, and that the area of the triangle formed by the tangent and the asymptotes is independent of the position of the point of contact.

9. The excess  $\theta$  of the temperature of a body above that of its surroundings at time  $t$  seconds is given by the equation  $\theta = \theta_1 e^{-kt}$  where  $\theta_1$  and  $k$  are constants and  $e = 2.718$ . If  $\theta = 80^\circ$  when  $t = 0$ , and  $\theta = 10^\circ$  when  $t = 60$ , plot  $\theta$  against  $t$  for values of  $t$  from 0 to 60.