

EAST INDIA (ENGINEERS' ESTABLISHMENT, &c.)

RETURN to an Address of the Honourable The House of Commons,
dated 22 June 1865;—for,

“RETURNS of the Names of the EXAMINERS appointed to examine the CANDIDATES who presented themselves, since the last Return, for Admission to the ENGINEERS' ESTABLISHMENT and PUBLIC WORKS DEPARTMENT of *India* :”

“And, of the Names of the SUCCESSFUL CANDIDATES in Order of Merit, their Ages, and the Names of the CIVIL ENGINEERS to whom any such Candidates have been Articled Pupils ; and MARKS assigned on each Subject to every Candidate ; and EXAMINATION PAPERS on each Subject (in continuation of Parliamentary Paper, No. 499, of Session 1861, and of No. 76, of Session 1863).”

India Office, }
24 June 1865. }

E. P. A. THOMPSON,
Assistant Secretary, Public Works Department.

(*Mr. Longfield.*)

Ordered, by The House of Commons, to be Printed,
28 June 1865.

2 PAPERS RELATING TO EXAMINATION OF CANDIDATES FOR

CIVIL ENGINEER EXAMINATIONS.

NAMES OF EXAMINERS.

Rev. Jonathan Cape, A. M., F. R. S.
 Major General A. G. Goodwyn, late R. E.
 George Preston White, Esq., C. E.

SUCCESSFUL CANDIDATES in order of Merit.

NAME.	AGE.	Place of Education.	Engineer to whom Articled, or under whom Served.
1. Mr. John Campbell	22	Queen's College, Belfast -	A. Tait, Esq., C.E., Belfast.
2. „ John Paterson -	20	Dollar Institution - -	J. Mitchell, Esq., Inverness.
3. „ James W. Alexander.	21	Madras College, St. Andrews; The College, Chester.	J. Barton, Esq., Dundalk.
4. „ Charles W. Odling.	18	Queen's College, Galway	S. U. Roberts, Esq., C.E., Galway.
5. „ John A. Willmore.	21	Not stated - - -	Messrs. Easton, Amos & Sons, London.
6. „ Aloys Sprenger	21	Ecole Polytechnic, Zurich	Messrs. Platt, Brothers & Co., Oldham.

NUMBER of MARKS assigned to each Candidate.

	Mathematics.	Civil Engineering.	Surveying and Levelling.	TOTAL.		Mathematics.	Civil Engineering.	Surveying and Levelling.	TOTAL.
1	306	300	191	797	9	132	250	83	465
2	319	265	184	768	10	110	260	73	443
3	264	290	163	717	11	190	195	52	437
4	231	290	173	694	12	126	255	53	434
5	212	275	156	643	13	127	245	54	426
6	202	285	135	622	14	115	145	50	310
7	160	295	89	544	15	23	195	28	246
8	162	270	98	530	16	29	50	35	114

PUBLIC WORKS DEPARTMENT—INDIA.

CIVIL ENGINEER ESTABLISHMENT.

EXAMINATION PAPERS for June 1865.

June 1865.

EUCLID.—Rev. J. Cape.

1. Define a *superficies*, a *plane rectilineal angle*, a *circle*, and a *rhomboid*, and give the definition of *parallel lines*.

2. Show how to bisect a given rectilineal angle. Hence show also how to bisect a given straight line.

3. Parallelograms upon the same base, and between the same parallels, are equal to one another.

Prove that a square is greater than any other parallelogram of the same perimeter.

4. If a straight line be divided into any two parts, the square on the whole line is equal to the sum of the squares on the two parts together, with twice the rectangle contained by the parts.

If a straight line be trisected, show that the square on the whole line is equal to nine times the square on a third part of it.

5. The opposite angles of any quadrilateral figure inscribed in a circle, are together equal to two right angles.

If two sides AD , BC , of such a quadrilateral $ABCD$, be produced to meet in E , the circle described about ECD will have the tangent at E parallel to AB .

6. Prove that the angle in a semi-circle is a right angle.

If AC be the diameter of a circle, and if any other circle be described with the centre C , all chords of the latter circle, produced if necessary, and passing through A , are bisected by the former circle.

7. The angles in the same segment of a circle are equal to one another.

AB , BC , are two equal arcs in a circle; D , E , two points in the opposite circumference. If from the extremities of these arcs the chords AD , BE , be drawn and produced to meet in F ; and also BD , CE , be drawn and produced to meet in G ; the angles at F and G will be equal.

8. Inscribe an equilateral and equiangular hexagon in a given circle.

Inscribe an equilateral and equiangular hexagon in a given equilateral triangle, and compare the area of this hexagon with the area of the triangle.

9. Describe an isosceles triangle, having each of the angles at the base double of the third angle.

Prove that the rectangle contained by a side of the isosceles triangle and the base, together with the square of the base, is equal to the square of a side of the triangle.

4 PAPERS RELATING TO EXAMINATION OF CANDIDATES FOR

10. Prove that equiangular triangles are similar.

ABC is a triangle inscribed in a circle, BD is drawn parallel to the tangent of the circle at the point A , and meets AC in D ; prove that

$$AC : AB :: CB : BD \quad ($$

11. Triangles of the same altitude are to one another as their bases.

Point out how it may be proved in a similar manner that triangles with equal bases are to one another as their altitudes.

12. If two straight lines are parallel, and one of them is perpendicular to a plane, prove that the *other* is also perpendicular to the same plane.

June 1865.

ARITHMETIC, TRIGONOMETRY, and MENSURATION.—Rev. J. Cape.

1. Simplify $(\frac{2}{3} \times \frac{5}{6} + 3\frac{1}{2}) - 2\frac{1}{3} \times \frac{1}{2} \times 3\frac{1}{7}$;
multiply $(\frac{3}{5} + \frac{20}{39} - \frac{7}{117})$ by $(\frac{3}{7} + \frac{8}{8} - \frac{8}{77})$;

and reduce $\frac{1 - \frac{1}{25} + \frac{1}{3} + \frac{1}{7}}{1 - \frac{1}{7} \text{ of } (\frac{1}{1 - \frac{1}{25}} + \frac{1}{3})}$ to its lowest terms.

2. Divide $(.003)^3$ by $(.0002)^2$, and also $.07$ by $.35$; and extract the square root of 2313450.126009 .

3. Find the value of
 $.025$ of 50 shillings + $.063$ of 100 guineas - $3\frac{1}{2}$ of 13 s. 4 d.

4. A dishonest grocer sells 16 lbs. of butter at 1 s. 4 d. per lb.; each pound of butter being weighed out with weight half-an-ounce short. What does he gain by his fraud?

5. The goods' tariff on a railway 100 miles long, between two towns, is a halfpenny per ton per mile. A shorter line is afterwards made between the same towns, only 80 miles in length. What through-charge per ton may the second company make, so as to carry goods as cheaply as the old line?

6. What sum of money would amount to 2,460 l. in $3\frac{1}{2}$ years, at 2 l. 13 s. 4 d. per cent. per annum, simple interest?

7. Define the terms *sine*, *tangent*, and *cosecant* of an arc.

8. In any triangle ABC , prove that

$$AB + AC : AB - AC :: \tan \frac{ACB + ABC}{2} : \tan \frac{ACB - ABC}{2}.$$

Apply this formula to determine the angles ACB , ABC , in the triangle where $AB = 852$, $AC = 708$, and the angle $BAC = 49^\circ 16'$.

9. Explain the ambiguous case in plane triangles; and of the two triangles in which $AB = 516$, $AC = 329$, and the angle $ABC = 37^\circ 9'$; solve the smaller.

10. Determine

10. Determine the following quantities by means of the tables:—

- (α). Logarithm of .0573107.
- (β). Number corresponding to 1.318762.
- (γ). Numerical value of $\frac{.02631 \times 73.42813}{1562 \times .286009}$
- (δ). Log cosine of $42^\circ 17' 33''$.
- (ε). Arc, whose log cotangent is 9.833086.

11. A tower 170 feet high stands in the middle of a field, which is an equilateral triangle; and at the top of the tower each side of the field subtends an angle of $96^\circ 17'$. Find the length of a side of the field.

12. Show how to ascertain the height of an inaccessible object, situated on the top of a mound, the height of which is also unknown, the whole of the object being visible from every spot in a horizontal plane in front of it.

13. How many acres are there in a field, one diagonal measuring 950 yards, and the perpendiculars on it from the other two angles being 135 and 210 yards respectively?

14. How long will it take to fill a cylindrical vat, the height being 14 feet, and the diameter 12 feet, by means of a pipe discharging 20 gallons per minute? (277.3 cubic inches in one gallon nearly.)

15. What must the radius of a sphere be, the volume of which is three times that of a pyramid 50 feet high, standing on a hexagonal base, each side of which is 35 feet?

16. A cubical block of granite (its edges being each 8 feet) has a corner broken off of the shape of a pyramid, each of the edges of which (terminating in an angle of the cube) is 1 foot 9 inches. What is the weight of the portion left, it being known that 1 cubic foot of granite weighs 162.5 lbs.?

17. How many cubic yards of earth will come out of a cutting, the transverse sections perpendicular to the axis being trapeziums, whose dimensions are—

Hor. lines at top	33,	39.7,	42.4,	37.2,	43.5,	35.6,	32.4	}	feet.
,, do. bottom	20,	20,	20,	20,	20,	20,	20		
Perpendicular height	8,	11.3,	13.2,	10.1,	14.5,	9.2,	7.6		

and the distance between the sections 50 feet.

18. Find the area of a segment of a circle whose radius is 50 feet, and the angle at the centre $72^\circ 15'$.

June 1865.

ALGEBRA.—Rev. J. Cape.

1. Divide $\frac{x^4}{3} - \frac{11x^3}{12} + \frac{41x^2}{8} - \frac{23x}{4} + 6$ by $\frac{2x^2}{3} - \frac{5x}{6} + 1$; and find the continued product of $a + x$, $a^{\frac{1}{2}} - x^{\frac{1}{2}}$, and $a^{\frac{1}{2}} + a^{\frac{1}{2}}x^{\frac{1}{2}} + a^{\frac{1}{2}}x^{\frac{1}{2}} + a^{\frac{1}{2}}x^{\frac{1}{2}} + x^{\frac{1}{2}}$.

2. Find the greatest common measure, and least common multiple of $x^4 + a^2x^2 + a^4$ and $x^4 + ax^3 - a^2x - a^4$.

6 PAPERS RELATING TO EXAMINATION OF CANDIDATES FOR

3. Simplify the following expressions:—

$$\frac{1}{a(a-b)(a-c)} + \frac{1}{b(b-a)(b-c)} + \frac{1}{c(c-a)(c-b)} \dots\dots\dots (a)$$

$$\frac{\sqrt{18a^5b^3} + \sqrt{50a_3b^5}}{\sqrt{8ab^3} + \sqrt{2a^3b} - 8a^2b^2 + 8ab^3} \dots\dots\dots (b)$$

$$\frac{(1-xy)(1+xy) - (x-y)(x+y)}{(1+xy)^2 + (x-y)^2} \dots\dots\dots (\gamma)$$

4. Solve the following equations:—

$$\frac{\sqrt{4x+1} + \sqrt{4x}}{\sqrt{4x+1} - \sqrt{4x}} = 9 \dots\dots\dots (a)$$

$$x^2 + 5x + 4 = 5\sqrt{x^2 + 5x + 28} \dots\dots\dots (b)$$

$$\left. \begin{aligned} 53 - \frac{x}{2} - \frac{z}{2} &= y - 109 \\ \frac{x}{4} + \frac{y}{8} &= 26 \\ 5y &= 4z \end{aligned} \right\} \dots\dots\dots (\gamma)$$

5. Extract the square root of $58 - 14\sqrt{3}$; and reduce the expression

$$\frac{\sqrt{5} - 2\sqrt{2}}{\sqrt{5} + \sqrt{2}}$$

to its simplest form.

6. Sum the following series:

$$\frac{8}{9} + \frac{29}{63} + \frac{2}{63} \dots\dots\dots \text{to 7 terms} \dots\dots\dots (a)$$

$$\frac{1}{3} - \frac{1}{2} + \frac{3}{4} - \dots\dots\dots \text{to 8 terms} \dots\dots\dots (b)$$

$$\frac{1}{3} + \frac{5}{6} + \frac{4}{3} + \dots\dots\dots \text{to } n \text{ terms} \dots\dots\dots (\gamma)$$

Also insert an arithmetical, a geometrical, and an harmonical mean between 3 and 12.

7. There are eight clerks in a bank, and two have to remain every Sunday; if the selection is varied in every possible way, how often will the turn of any particular two recur?

8. Determine the middle term in the expansion of $(3a^2 - 5x^2)^8$, and find approximately, by means of the binomial theorem, the value of $\sqrt[7]{108}$.

9. A man asks me the time. I say it is between 7 and 8, and that the minute-hand of my watch is exactly over the hour-hand. What is the real time?

10. A person borrows 1,200*l.* 10*s.*; how much must he pay annually that the whole debt may be cleared off in 35 years, allowing *simple* interest at 4 per cent.?

11. A farmer buys 100 sheep for 210*l.*, and sells 70 of them at a gain of 5*l.* per cent.; what must each of the remainder be sold for to make his whole profit 10 per cent.?

12. *A* and *B* can together do a piece of work in 10 days; *A* and *C* in 12 days; and *B* and *C* in 15 days. Find what time each could do it in by himself.

June 1865.

MECHANICS and HYDROSTATICS.—Rev. J. Cape.

1. Enunciate the "*parallelogram of forces*," and prove it with reference to the *direction* of the resultant of two commensurate forces.

2. $ABCD$ is a parallelogram. If forces acting on a point be represented in magnitude and direction by AB , BD , CA , respectively, determine the direction and magnitude of their resultant.

3. Two forces of 3 and 4 pounds respectively act at the ends of a rigid weightless rod, 10 feet long, their directions being inclined at angles of 30° and 60° to the rod. Find the magnitude of the force which will keep the rod at rest, as well as the direction of it, and the point at which it must be applied.

4. Explain clearly the meaning of the term "centre of gravity," and distinguish between *stable* and *unstable* equilibrium.

Which equilibrium exists in the case of—

- (a) An egg balanced on an end ;
- (β) A cricket ball resting on the ground ;
- (γ) A weight hanging at the end of a rope.

5. If a piece of uniform wire be bent into the form of a triangle ABC , and be hung freely by the angular point A , show that it will only rest with the side BC horizontal when the angle ABC equals the angle ACB .

6. What is meant by the terms *friction* and *coefficient of friction*? State the actual process by which the *coefficients of friction* of different bodies are determined.

7. A body of 25 lbs. weight is placed on a rough plane inclined to the horizon at an angle of 30° . If the coefficient of friction be $\cdot 18$, show that the body cannot be drawn up the plane by a force (or weight) less than $16\cdot 397$ pounds.

8. A capstan is held by four men pressing similarly on arms at distances of six feet from the axis about which the capstan can move; and the cylinder, whose radius is 9 inches, has a chain coiled round it exerting a tension of 1 ton. What force does each man exert?

9. Determine the conditions of equilibrium in the case of the screw—

- (1) When the screw is smooth ;
- (2) When it is rough.

What means have been suggested for increasing indefinitely the power of the screw, and what disadvantages limit the use of such means?

A substance compressed by a screw-press exerts a reaction of 400 lbs. in the direction of the axis of the screw. The diameter of the screw is 8 inches, and the thread makes 3 turns in 2 inches. The power is applied at the distance of 2 feet from the axis, and perpendicular to the arm. The coefficient of friction of the screw being 2, find the limits between which the power must be limited when there is equilibrium.

8 PAPERS RELATING TO EXAMINATION OF CANDIDATES FOR

10. Enunciate the principle of *virtual velocities*, and illustrate it by the inclined plane, when it is perfectly smooth.

11. What is understood in "practical mechanics" by the terms *work* and *horse-power*, and what is taken as the unit of work?

What is the horse-power of an engine, when the diameter of the piston is 75 inches, the length of the stroke is 9 feet, when 11 strokes are made per minute, with a mean pressure of steam of 16 lbs. on the square inch?

A mine has 4 shafts, which are 250, 300, 350, and 400 feet deep respectively. It is required to raise from them 100, 70, 65, and 40 cubic feet of water per minute respectively. What horse-power must an engine possess to do all the pumping of the mine?

12. Show how to determine the amount and direction of the pressure of an isosceles roof without a tie-beam on the side walls which support it.

Find the thrust on a wall made by an isosceles roof weighing 20 lbs. per square foot, and having a pitch of 60° , the distance between the side walls being 30 feet, and the rafters being 4 feet apart.

13. Explain the meaning of the terms *velocity*, *accelerating force*, *centrifugal force*, *impulsive force*, and *mass*. Give any illustrations you can think of, tending to prove the truth of the first two *laws of motions*.

14. Find the space a body would move through from rest under the influence of a uniform accelerating force.

A body moves over 14 feet in the first second of time during which it is observed, and over 22 feet and 34 feet in the third and sixth seconds respectively. Is this consistent with the supposition of its being under the influence of a uniformly constant force?

15. Assuming the formula expressing the relation between the length of a pendulum and its time of oscillation, show by what fraction of its length a pendulum must be altered, which beats seconds at a place where the force of gravity is 32, so that it may continue to beat seconds when removed to a place where the force of gravity is 32.32064 .

16. Prove that the surface of every fluid at rest is horizontal, or perpendicular to the direction of gravity.

Hence apply this to the common practice of levelling; and show that the *depression* in 1 mile is 8 inches.

What is the depression in 3 miles?

17. Explain the construction of the thermometer; state how it is filled, and how the freezing point and boiling point are determined.

When Fahrenheit's thermometer registers 63° , what will the centigrade thermometer register?

18. What is meant by saying that the specific gravities of gold and mercury are 19.362 and 13.568 respectively? Find the weight of a cubic foot of gold, and also of a gallon of mercury, it being given that a gallon contains 277.3 cubic inches nearly.

EXAMINATION PAPERS for Competitive Examination of Candidates for Appointments in the Engineer Establishment of the Department of Public Works in India, held at the India Office, London, in June 1865.

George Preston White, C.E., Examiner.

[*Note.*—You are particularly requested to write legibly, and to answer the questions as concisely as possible. Prefix the number of the question to each answer. In those cases in which free-hand sketches or diagrams are used to illustrate the subject, it is requested that they may be carefully executed, in order to show the Candidate's proficiency in this style of drawing. Candidates must not, during the Examination, refer to any Book or MS., nor communicate with each other; their doing so will disqualify them. Candidates are required to produce *bond fide* finished drawings, with certificate, respecting which there will be a *viva voce* examination.]

Describe the course of education you have undergone; name the Engineer to whom you have been a pupil; the number of years articulated; the nature of the works on which you have been engaged, and state in what branch of the profession you have had most practical experience.

CIVIL ENGINEERING.

MATERIALS AND GENERAL CONSTRUCTION.

(*Building Materials, Masonry, Carpentry, Earthwork.*)

1. Name the principal stones employed in building, under the following heads:—

1. Siliceous. 2. Argillaceous. 3. Calcareous. 4. Stratified. 5. Unstratified.

2. Specify those stones which are most durable under ordinary circumstances, which are the easiest worked, and the means usually employed to test the quality of stone for building purposes.

3. Give a simple chemical test for ascertaining when stone is calcareous.

4. Describe some of the most successful processes employed for the preservation of stone. What is the nature of patent stone, and under what circumstances is it economical to employ it?

5. Describe, by diagram, the modes employed in practice for setting out the forms of arch stones for flat segmental arches, without using the centre of the circle of which the arch forms a part. Also describe the methods employed for elliptical arches of large span.

6. Describe how to set out for the workmen the lines of the courses for a skew bridge, make a diagram, and state at what angles it becomes unsafe or undesirable to build skew bridges.

7. Describe the means employed by Mr. Gibbs and others, to build skew bridges, the brickwork or masonry being coursed in the usual way; and state where examples exist.

8. Make free-hand sketches to illustrate the different modes adopted for scarfing and trussing timber.

9. Illustrate, by free-hand sketch, the means employed by Sir Christopher Wren, for framing and supporting the outer dome of St. Paul's Cathedral. Point out the chief advantages, ingenuity, and skill of this mode of construction.

10. Why is the employment of sea sand in mortar prohibited in specifications? and specify the conditions required for good sand.

10 PAPERS RELATING TO EXAMINATION OF CANDIDATES FOR

11. Explain the modes employed for calculating earthwork, and give the names of standard books of tables used for the purpose. Explain how the tab. numb. is obtained, and upon what principle the tables most employed are constructed.

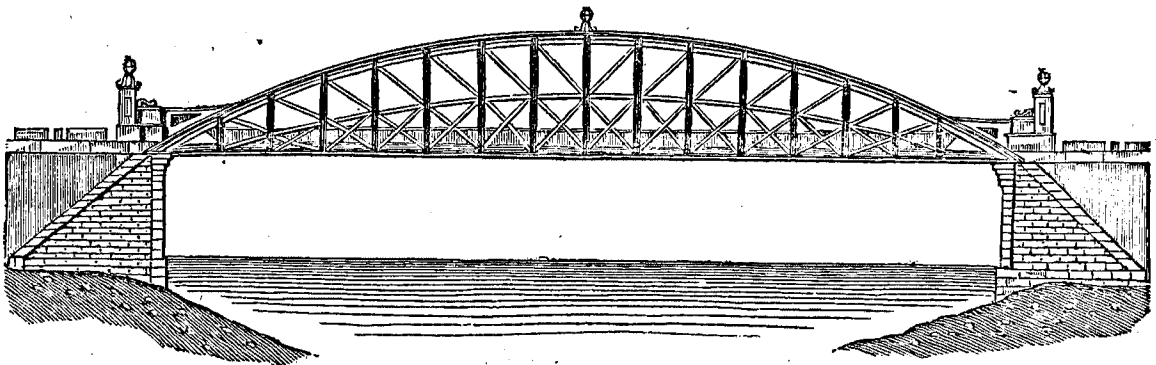
12. What are the best materials to employ for forming embankments? Specify those in which the least settlement takes place, and state what per-centage you would allow for settlement in your estimates in the different materials employed.

SPECIAL CONSTRUCTIONS.

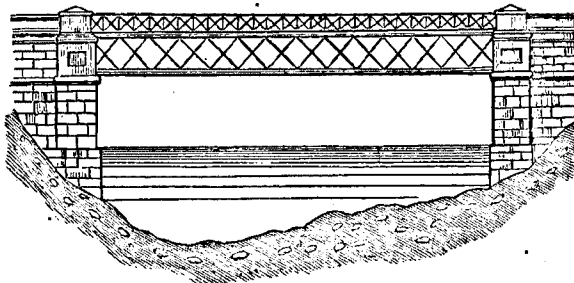
(Bridges, Roads, Railroads, Hydraulic Works, Architecture.)

13. In designing the proportions of a wrought-iron bridge, to what extent may iron of a fair average quality be strained per square inch, under compression and in tension respectively, under the effect of the maximum load that can possibly come upon the bridge?

14. What should be the net sectional areas in the arches and in the horizontal ties, for a bow-string girder bridge (*vide* drawing), the clear span of which is 220 feet, versed sine 28 feet; the weight of the structure being 320 tons, and the additional (traffic) load, equally distributed, 200 tons?



15. The accompanying sketch is a design for a lattice girder bridge, 100 feet span; width of roadway 18 feet; required to be constructed sufficiently strong to bear a load of ballast equal to about 84 lbs. per square foot, and a moving load of traffic of the same amount. State what depth you would make the beam in proportion to the span; give free-hand sketches of the details of the ironwork, distinguishing the parts subject to tension, from those liable to compression, and give an approximate estimate of the weight of iron, and of the cost of such a structure.



16. Make a design for an iron shed of simple construction, supported by cast-iron pillars 15 feet in height, 20 feet apart, connected at top by wrought-iron girders, to carry a segmental roof 40 feet span, versed sine 10 feet, and composed of ribs of T-iron, with purlins of angle-iron, covered with corrugated iron bolted on; make free-hand sketches of the different parts in detail, with dimensions figured on, and give an approximate estimate of the cost of such a structure per hundred square feet of ground covered.

17. Draw up a brief specification for the shed described in the foregoing question, and specify what wire gauge you would recommend for the corrugated iron, the structure to be sufficiently rigid to withstand a hurricane.

18. State what ruling gradient Mr. Telford considered desirable to obtain in laying out roads, and the form of cross section he adopted for the carriage-way.

When

When broken stone is employed for metalling, what sized ring should it pass through? In applying fresh metalling to roads, what precaution should be adopted to make the materials bind?

19. Describe and make free-hand sketches of some of the most approved and generally adopted forms of rails and chairs, the best means of fishing or securing the rails at the joint, and describe Mr. Dering's improvements; and name the most important points to attend to in the selection and construction of permanent way.

20. Explain some of the modes employed for ventilating buildings, and the best arrangements for roofs in warm climates.

21. What is the average cost per ton, at present price of iron, for ordinary wrought-iron lattice girders for bridges, and what would be a fair estimate per ton for cost of erection, the piers or abutments being already prepared to receive the girders?

22. When iron is used for the flooring of an iron bridge, to support the gravel and metalling, what is the best and most economical form in which to employ it?

23. Explain the uses and applications of Mallet's buckled plates.

24. Describe some of the most successful means employed for striking and easing bridge centres, and explain in what way sand has been used for the purpose.

25. In preparing a specification for a road or railway, state the general clauses desirable to introduce under the following heads:—

1. The bricks; the quality and description of the brickwork.
2. Stone; its character, colour, and quality.
3. Mortar; lime, cement, and concrete.
4. Tooled masonry.
5. Foundations.
6. Specify the precautions necessary in forming embankments, so as not to injure the bridges or culverts.
7. Removal of centres, and style of finishing earth round bridges.
8. Draining and metalling roads.
9. Ballast; state what materials are suitable, and why clay is not admissible.
10. Penal clauses.

26. Describe briefly, with free-hand drawing, the cylinders employed to form the Thames Embankment: and name other cases where iron-sheet piling has been used instead of timber.

27. Give the names of the different orders of Grecian and Roman architecture; name some buildings in each style, and state the chief features or characteristics which distinguish classic from the so-called Gothic or Christian architecture.

28. Make a free-hand drawing of a flying buttress; describe its objects and uses as a piece of skilful and scientific construction, independent of its advantages as a beautiful feature in architecture, and state upon what does its stability depend.

APPLIED MECHANICS.

(Strength of Materials, Mechanism, Hydraulic Machines.)

29. Give the names of some of the principal authorities who have experimented on the strength of the materials, wood, stone, mortars, cement, and wrought and cast-iron. State the general results arrived at, and name a few standard works of reference on the subject.

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30. Explain the nature and give the results of the experiments made by Mr. Grant, C.E., to test the quality of the cement supplied in the construction of the main drainage works of London; and state what are the characteristics of good cement, and how you would test it.

31. Explain and illustrate, with free-hand drawings, the action of Appold & Gwynne's centrifugal pump and of Fourneyron's turbine.

32. Make a free-hand sketch of the sun and planet and ex-centric motions, and explain their uses.

33. Explain the difference between spur gear and bevel gear, and make a free-hand sketch illustration.

34. Explain the principle of the atmospheric and pneumatic railway. What advantage does the latter system possess over the former; what are the steepest gradients which have been worked by it, and what are its advantages over the system of ordinary locomotive propulsion? State what pressure has been obtained in practice per square inch.

Miscellaneous.

35. Describe briefly the principal inventions and improvements in the manufacture of iron and steel by the following:—D. Dudley, Andrew Yarranton, Abraham Darby, Richard Reynolds, Benjamin Huntsman, Henry Cort, John Roebuck, David Mushet, James Beaumont Neilson.

36. How is Bessemer steel manufactured, and what are its advantages?

37. What are the advantages of employing steel in the construction of girders, bridges, and rails for permanent way?

38. State the advantages of Swedish iron and steel, and to what are they attributable?

39. What is the meaning of the terms—steam possessing an atmosphere of tension, of superheated steam, and of steam at its maximum density?

40. What is the meaning of the term horse-power as applied to the steam engine; upon what calculation is it founded, and by whom was the term introduced.

41. Name the principal mechanical inventions of the following eminent engineers:—Joseph Bramah, Henry Maudsley, Sir Marc Isambard Brunel, Joseph Clement, Richard Roberts, James Naysmith, William Fairbairn.

42. Explain the meaning of the following terms used in mining:—Back of a lode, counter lode, champion lode, cross course, cross cut, costeaning, dialling, driving, elvan.

43. It is proposed to carry out docks, piers, harbour works, and other improvements in a tidal harbour, and for this purpose it is required to obtain an accurate section of the bottom of the harbour, the nature of its bed, its capabilities as holding ground for anchorage, &c., &c. Describe how to fix the position of the soundings, whilst being taken, so as to mark them on the accompanying map, and how to reduce them to a common datum; as, for example, the low water of "ordinary spring tides."

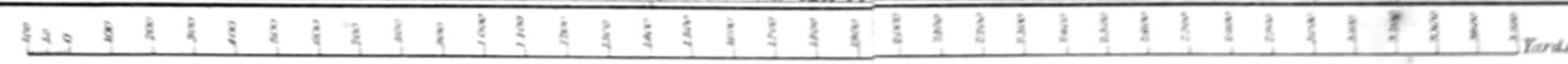
The river flowing into the harbour discharges and throws up a considerable amount of silt; describe some of the means usually employed at Ramsgate and elsewhere to counteract and remove impediments of this kind.

Also, mark on plan lines of intercepting and thorough drainage, and describe the conventional signs used on maps to denote geological, mineralogical, and other physical features. Print title, and colour map.



Ranipoor River

RANIPPOOR RIVER



SURVEYING.

Examiner, Major General *A. G. Goodwyn*.

1. Accompanying is the field book of a traverse survey which you are required to plot. The measurements are in feet. The plan should be appropriately headed.

If a sheet of foolscap paper be opened out, and the meridional line be drawn on it parallel to its longer sides, the starting point may advantageously be fixed in the lower left-hand corner, 4 inches from the bottom, and $2\frac{1}{2}$ inches from the side. If, as is recommended, a scale of 12 inches to the mile be adopted, the work will be conveniently contained within the sheet. No scale smaller than 9 inches to the mile can be allowed.

The work will be valued as to—

- Coming to a close correctly on the starting point ;
- Intelligent reading of the field book, and general accuracy ;
- Correct fixing of position of Shirley Mansion ;
- Good drawing and printing. (Colours may be used at discretion. Their absence, however, will not be deemed a defect) ;
- Completeness.

2. The accompanying plan represents ground, of which it is supposed you have to make a trigonometrical survey, and may be drawn over and lettered in any way you may deem necessary.

You are required to—

(a) Exhibit, in red ink, the scheme of triangulation you would adopt, specially marking the base, and not cumbering the plan with the less trustworthy observations, which, in the field, you might record.

(b) Give in a field book recording the measurement of the base as now to be got by scale ; and the theodolite readings at, at least, three of the points to be trigonometrically fixed, as now to be measured with a protractor.

(c) Hand in a field book of a supposed traverse survey of at least three miles of the course of the dry watercourse represented, including in its length at least two changes of direction of the lines to be chained. (*N.B.*—The scale at the bottom of the plan may be cut off, and used in measurements, if desired.)

(d) State how, after taking observations with a theodolite at your several trigonometrical stations, their correctness may be checked ; and, similarly, after making a traverse survey, in a circuit, and coming to a close on your starting point, the correctness of the work with the theodolite may be tested.

(e) State how, in the event of slight error, in either of the above cases, it should be disposed of.

(f) State how you would, in the field, ascertain the variation of the compass.

(g) Sketch freely, in any style you please, and as a specimen of your ability to do such work, features of the country, including the south-eastern loop of the dry watercourse. Not less than 9 square inches of the plan before you should be embraced by the sketch, and the copy should be on the same scale as, or in due proportion to, the original.

(h) Compute the area bounded on the north and west by the two branches of the watercourse, and on the south and east by the limits of the plan.

LEVELLING, SURVEYING, and GEOMETRICAL DRAWING.

Examiner, Major General *A. G. Goodwyn.*

3. Having to construct an embankment, level at top, straight across the valley of the Rooprail, along the course of which a stream flows, and 15 feet above the surface of the water, I drive pins flush with the ground, at the uniform distance of 100 feet apart, marking the central alignment of the work, and, having numbered them from (1) to (25) inclusive, I set my level over Nos. (4), (10), (16), and (22), and take the following readings :—

FIELD BOOK OF LEVELS.

Bearings.	BACK SIGHTS.			Height of Instrument, and Number of Pin.	FORE SIGHTS.			Bearings.	REMARKS.
	Number of Pins, and their Staff Readings.				Number of Pins, and their Staff Readings.				
	<i>Fl.</i>	<i>Pl.</i>	<i>Fl.</i>	<i>Fl.</i>	<i>Fl.</i>	<i>Fl.</i>	<i>Fl.</i>		
W. of S. 85°	(1) 0.59	(2) 1.67	(3) 2.91	(4) 4.52	(5) 5.81	(6) 7.04	(7) 8.35	E. of N. 85°	90 ft. east of Pin No. 12, you descend perpendicularly into the bed of the stream, which is 300 ft. wide. Eastern bank also precipitous. From Pin No. 10, the dry weather surface level of the water reads 10.60.
Ditto -	(7) 1.86	(8) 3.77	(9) 4.51	(10) 5.33	(11) 6.78	(12) 7.55	(13) 12.10	Ditto.	
Ditto -	(13) 11.75	(14) 11.60	(15) 10.53	(16) 5.01	(17) 4.62	(18) 2.84	(19) 1.11	Ditto.	
Ditto -	(19) 9.24	(20) 8.12	(21) 6.65	(22) 5.18	(23) 3.84	(24) 2.53	(25) 0.92	Ditto.	

From the above data it is required to draw sections both of the valley and of the embankment, marking the height of the top of each pin above a datum line 30 feet below No. 1, and the height of the embankment above each pin.

Work to be given in complete. It may be on any convenient horizontal scale— one-tenth of the vertical scale.

4. Starting from Ferozepore, the distance between that station and Loodianah was measured with a 100-foot chain, and found to be 423,000 feet. Also the intermediate station of Dhurrumkote was found to be 200,000 feet distant from Ferozepore. The chain, which was of the right length at starting, and so substantial as to forbid the idea of elongation in the *straight* portions of the links, nevertheless, at the termination of the work, was found to be six inches too long. What were the true distances between the three places?

5. Explain the principle of the vernier, and its mode of action.

6. In chaining, suppose a pond wider than the length of the chain to lie in your path, how would you continue your measurement beyond it?

7. Construct a scale of 13 feet to an inch, and show the method of dividing such a scale geometrically. Also state what methods are usually adopted in copying plans on a different scale.

8. An octagon of 200 feet side is surrounded by houses 70 feet high, extending back 50 feet. The roofing of the houses has a pitch of one-fourth its span, and where its continuity is broken the ends are finished off with hips (not in gables). The octagon lies square with the cardinal points, and streets 80 feet wide enter it from the north, south, east, and west, having houses on each side of them of the same description as those round the octagon.

Draw, in isometrical perspective, such a mass of buildings, on any scale not less than 50 feet to an inch; attaching the scale.

EAST INDIA
(ENGINEERS' ESTABLISHMENT, &c.)

RETURNS of the Names of EXAMINERS appointed to examine the CANDIDATES who presented themselves, since the last Return, for Admission to the ENGINEERS' ESTABLISHMENT and PUBLIC WORKS DEPARTMENT in *India*; of the Names of the SUCCESSFUL CANDIDATES in Order of Merit; of the MARKS which were assigned on each Subject to every CANDIDATE; and, of the EXAMINATION PAPERS of each SUBJECT (in continuation of Parliamentary Paper, No. 499, of Session 1861, and of No. 76, of Session 1863.)

(Mr. Longfield.)

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