

EAST INDIA (PUBLIC WORKS DEPARTMENT).

RETURN to an Address of the Honourable The House of Commons,
dated 25 July 1861;—for,

- “ RETURNS specifying 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* :”
- “ Of the Names of the SUCCESSFUL CANDIDATES in Order of Merit, their respective Ages, and the Names of the CIVIL ENGINEERS to whom any of such Candidates have been Articled Pupils :”
- “ And, of the MARKS assigned on each Subject to every Candidate ; and of the EXAMINATION PAPERS on each Subject (in continuation of Parliamentary Paper, No. 566, of Session 1860).”

India Office, }
30 July 1861. }

W. T. THORNTON,
Secretary, Public Works Department.

(*Mr. Adam.*)

Ordered, by The House of Commons, to be Printed,
31 July 1861.

2 PAPERS RELATING TO EXAMINATION OF CANDIDATES FOR

CIVIL ENGINEER EXAMINATIONS.

NAMES OF EXAMINERS.

Rev. Jonathan Cape, A. M., F. R. S.
 Lt. Col. John Ouchterlony (Madras Engineers).
 George Preston White, C. E.

Successful Candidates in order of Merit.

NAME.	AGE.	Civil Engineer to whom Articled, or under whom Served.
1. Mr. T. Hamilton - - -	20	Sharp, Stewart & Co., Manchester.
2. " J. M'Donald - - -	21	J. F. Beattie, Aberdeen.
3. " E. L. Asher - - -	22	J. Fowler, Westminster.
4. " G. C. Cooke - - -	22	{ W. Dargan, Dublin. J. Bower, Dublin.
5. " B. Black - - -	22	London, Brighton, and South Coast Railway.
6. " T. E. Owen - - -	19	Edwin Clarke, London.
7. " J. Sheldon - - -	22	E. Gibbs, Stratford-on-Avon.
8. " F. R. Butt - - -	22	{ John Penn, Greenwich. Joseph Cubitt, London.
9. " A. Fenner - - -	22	G. England & Co., London.
10. " J. M. Luff - - -	22	R. Stephenson & Co., Newcastle-on-Tyne.
11. " F. B. Doering - - -	22	{ John Stewart & Co., Blackwall. Fawcett, Preston & Co., Liverpool. J. Dickson Ikin, London.

NUMBER of MARKS assigned to each Candidate, whether successful or otherwise.

Number on Examiner's List.	Mathematics.	Surveying and Levelling.	Civil Engineering.	TOTAL.	Number on Examiner's List.	Mathematics.	Surveying and Levelling.	Civil Engineering.	TOTAL.
1	240	125	330	695	17	148	134	280	562
2	197	156	330	683	18	94	164	295	553
3	231	117	320	668	19	100	143	210	553
4	157	167	325	649	20	110	138	300	548
5	207	142	300	649	21	144	113	285	542
6	164	149	335	648	22	124	156	260	540
7	167	147	330	644	23	99	109	330	538
8	142	151	335	628	24	88	141	300	529
9	141	141	335	617	25	75	117	320	512
10	146	143	325	614	26	45	119	330	494
11	155	110	335	600	27	62	115	305	482
12	126	152	320	598	28	64	115	250	429
13	164	116	295	575	29	38	128	100	316
14	198	126	250	574	30	35	0	50	85
15	109	165	295	569	31	57	0	0	57
16	164	109	290	563	32	0	0	0	0

EXAMINATION PAPERS.

3d June 1861.

MECHANICS AND HYDROSTATICS.

1. If any number of forces in the same plane act upon a point, it is required to find a single force which shall be equivalent to them all. Find this both by construction and by analytical calculation.

Ex. Four forces represented by 1, 2, 3, and 4 act on a point; and the inclinations of the three last forces to the first are 60° , 90° and 150° . Find the magnitude and direction of the resultant.

2. A given weight is supported by two props situated upon a smooth horizontal plane; to find the pressure upon each. Also find the tension of the string which prevents the props from sliding outwards.

3. Find the centre of gravity of a triangular pyramid.

4. In toothed wheels it is required to find the proportion between the power and weight when they are in equilibrium.

5. A ladder 50 feet long weighs 120 lbs.; and a person wishing to raise it places one end against a wall, and then lifts it gradually upwards from the other end. Required the force which he will have to exert at any point of the ladder, supposing that his hands and feet are equally distant from the foot of the ladder; find also the pressure against the wall.

6. To determine the conditions of equilibrium on an inclined plane, when friction is taken into consideration.

7. Explain the principle of *virtual velocities*, and prove that it is true in the case of the lever.

8. It is required to calculate the conditions of equilibrium of any number of beams AB, BC, CD, DE, forming a framework in a vertical plane.

9. Explain the three laws of motion; and show by what experiments they are established.

10. When two imperfectly elastic bodies impinge upon each other directly with given velocities, and the force of compression is to the force of restitution as 1 to e ; it is required to determine their velocity after impact.

Ex. A is equal to 3 B, and A's velocity (60) is equal to half of B's velocity; required their velocities after impact, when they impinge upon each other directly in opposite directions, and the force of elasticity is to the force of compression as 3 to 4.

11. Two bodies are connected by an inextensible string passing over a fixed pulley; determine the motion of each body, and the tension of the string.

Ex. P=81 ounces, Q=80 ounces; how long would P be in descending 100 feet?

4 PAPERS RELATING TO EXAMINATION OF CANDIDATES FOR

12. Find the time of an oscillation in a small circular arc.

13. Explain the principle and uses of a fly-wheel; and find the limits within which the velocity of the wheel varies, the force acting in one direction only.

14. The pressure of a fluid on any surface is equal to the weight of a column of fluid, whose base is the surface pressed, and height equal to the depth of the centre of gravity of that surface below the surface of the fluid.

Ex. A cone whose height is 20 inches and the diameter of the base 20 inches, is filled with water; find the pressure (in lbs. avoirdupois) against the base, and the pressure upwards against the sides.

15. When a body is either partly or wholly immersed in a fluid, it is pressed upwards by a force equal to the weight of the fluid displaced.

16. Explain the method of determining the specific gravities of solid, fluid and gaseous bodies. How do you proceed when the solid is lighter than its bulk of water?

The specific gravity of *proof* spirit is .92, and the specific gravity of a cask of brandy is .90; how much per cent. is the brandy *over* or *under* proof?

17. Explain what is meant by stable and unstable equilibrium; and show that the equilibrium of a floating body is stable, unstable or indifferent, according as the *metacentre* is above, below, or coincident with, the centre of gravity of the body.

18. By what experiments is it proved that the density of the air is proportional to the force that compresses it?

19. Explain the principle of the siphon, and its mode of acting. To what height may it be constructed?

Hence explain the action of intermittent springs.

20. A diving bell of the form of a cube, each of whose sides is 8 feet long, is let down into the sea, its top being 100 feet below the surface of the water. Required the height to which the water will rise in the interior of the vessel.

4th June 1861.

ALGEBRA.

1. SIMPLIFY the following expressions:—

$$\frac{2a(x^2 - y^2)^2}{cx} \times \frac{x^3}{(x-y) \cdot (x+y)}, \left(x - y + \frac{y^2}{x+y}\right) \div \left(x + y + \frac{y^2}{x-y}\right),$$

$$\frac{x - \frac{1}{2}\left(x - \frac{2}{3}y\right)}{y - \frac{1}{3}\left(x + \frac{3}{2}y\right)}$$

2. Divide $x^3 + \frac{1}{x^2} - 3\left(\frac{1}{x^2} - x^2\right) + 4\left(x + \frac{1}{x}\right)$ by $x + \frac{1}{x}$; and extract the square root of the quotient of $x^4 + x^3y + xy^3 + y^4$ divided by $x^2 - xy + y^2$.

3. Solve

3. Solve the following equations :—

$$\frac{7x + 20}{8} - \frac{9x + 12}{16} = \frac{3x + 1}{10} - \frac{29 - 8x}{20} \dots \dots \dots (1)$$

$$(x - 1)(x - 2) = 2(x - 3)(x - 4) \dots \dots \dots (2)$$

$$\left. \begin{aligned} x^2 + xy &= 15 \\ y^2 + xy &= 10 \end{aligned} \right\} \dots \dots \dots (3)$$

$$(x + 5)x - 2 + 3\sqrt{x(x + 3)} = 0 \dots \dots \dots (4)$$

4. Change the fraction $\frac{7 - 2\sqrt{10}}{\sqrt{7 - 2\sqrt{10}} + 5 - \sqrt{10}}$ into one that has a rational denominator; and extract the square root of $38 - 12\sqrt{10}$.

5. Show that if $a : b :: c : d :: e : f :: \&c.$,
 then $a : b :: a + c + e + \&c. : b + d + f + \&c.$
 Also find a mean proportional between 709 and 320742.

6. A pipe of port (115 gallons) had 4 gallons drawn off, and was then filled up with water. After this had been repeated 7 times, how much wine was left in the cask?

7. Russian hemp being 30 *l.* a ton, a fibre is discovered such that a rope made of it lasts $\frac{3}{4}$ rds of the time that a hemp rope $\frac{1}{4}$ th as heavy again would, if exposed to the same wear and tear. What must this fibre fetch in order that ropes made of it may be as cheap in the end as those made of hemp?

8. Find an expression for the sum of a Geometrical Progression of n terms; and show what form this expression assumes when the number of terms becomes infinite.

9. Sum the series

- 11, 13 $\frac{1}{2}$, 16 to 25 terms,
- 1, $\frac{3}{4}$, $\frac{4}{9}$ to 5 terms,
- $\frac{1}{3}$, $\frac{2}{15}$, $\frac{4}{75}$ to infinity;

and insert 7 Arithmetical Means between 2 and -2 .

10. The sum of 5 numbers in Arithmetical Progression is 20, and the sum of their squares is 90. Required the numbers.

11. One horse takes 5 strides while another takes 4, but six strides of the latter are equal to 7 of the former; which is the swifter horse? and where will it be when the horse behind has travelled 20 miles?

12. A pound of tea and a pound of sugar cost together 5 *s.* 4 *d.*; but if the sugar were to rise in price 50 per cent., and the tea 10 per cent., they would cost 6 *s.*: find the prices of the tea and the sugar.

13. Find by duodecimals the number of square feet in a room whose length is 17 ft. 8 in. and the breadth 22 ft. 6 in.

14. What is the amount (simple interest) of 461 *l.* 10 *s.* for 6 $\frac{1}{2}$ years at 5 per cent. per annum.

15. On May the 1st Calcutta 5 $\frac{1}{2}$ per Cents. were at 100 $\frac{1}{8}$, while Consols were at 91 $\frac{1}{8}$. If 5,000 *l.* had been sold out of the former stock, and the proceeds invested in the latter, what effect would have been produced on the income?

6 PAPERS RELATING TO EXAMINATION OF CANDIDATES FOR

4th June 1861.

GEOMETRY.

1. DEFINE clearly the meanings of the terms *oblong*, *rhombus*, *rhomboid*, *trapezoid*, and *trapezium*; also enunciate the axiom on which the theorems concerning parallel lines are based.

2. The angles at the base of an isosceles triangle are equal to one another; and if the equal sides be produced, the angles upon the other side of the base shall be equal.

If an isosceles triangle has the vertical angle equal half a right angle, how many degrees are in each angle at the base?

3. To make a triangle of which the sides shall be equal to three given straight lines, but any two whatever of these must be greater than the third.

4. Triangles upon the same base, and between the same parallels, are equal to one another.

Hence show how to construct a triangle which shall be equal to a given triangle, and have one of its sides equal to a given straight line. Also show how to change any given rectilineal figure into a triangle of equal area; and explain the use of this transformation in surveying.

5. In any right angled triangle, the square which is described upon the side subtending the right angle, is equal to the squares described upon the sides which contain the right angle.

Show how to cut the corners off a square so as to form an equilateral and equiangular octagon.

6. If a straight line be bisected, and produced to any point, the square of the whole line thus produced, and the square of the part of it produced are together double of the square of half the line bisected, and of the square of the line made up of the half and the part produced.

Prove this Proposition also algebraically.

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

Given three points in a circle: show how we may find any number of other points, without knowing the position of the centre.

8. A segment of a circle being given, to describe the circle of which it is the segment.

Show that this, and the first Proposition in the third Book, are respectively the general and particular cases of the same Problem.

9. Assuming that the areas of circles are proportional to the squares of their radii, show how to divide a circle into three equal parts by concentric circles.

10. Enunciate and prove the Proposition on which the construction of "Proportional Compasses" depends.

11. Similar triangles are to one another in the duplicate ratio of their homologous sides.

Hence show how to bisect a given triangle by a line parallel to one of its sides.

12. If two straight lines be cut by parallel planes, they shall be cut in the same ratio.

INDIAN ENGINEER ESTABLISHMENT.

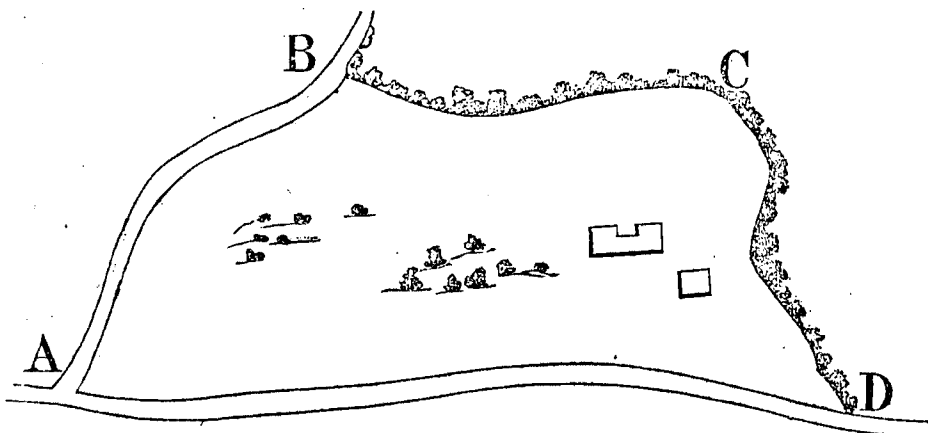
Competitive Examination, 3rd June 1861.

LAND SURVEYING.

1. THERE is a barrack cesspool on the slope of a hill, sunk 22 feet below the surface, which it is desired to render self-emptying by means of a sewer to discharge near the foot of the hill, to the eastward. Describe how you would proceed in driving a gallery or tunnel for this purpose, with a slope of 1 in 12. Draw a plan and section, illustrating your method, and assuming the angle of inclination of the hill to be 32° , dipping to the eastward.

2. In a survey, starting from a turnpike-gate, as my first station, I took the bearing of a sign-post along the road, with a circumferenter— $342^\circ 10'$ N. W., and measuring the distance found it to be 16 chains. I also took bearings to a church tower, $52^\circ 30'$ E, and to a conspicuous tree, $274^\circ 15'$ W. At the signpost I took the bearing of the tree, $243^\circ 40'$ W., and also a forward bearing to the angle of a cottage on the roadside, 11° E., measuring the distance which was 21 chains. From the cottage I got a bearing to the church tower, 130° E. Required the distance of the tree and church tower respectively, from the signpost. A plan to scale is required.

3. An irregular shaped piece of ground, as A, B, C, D, A,



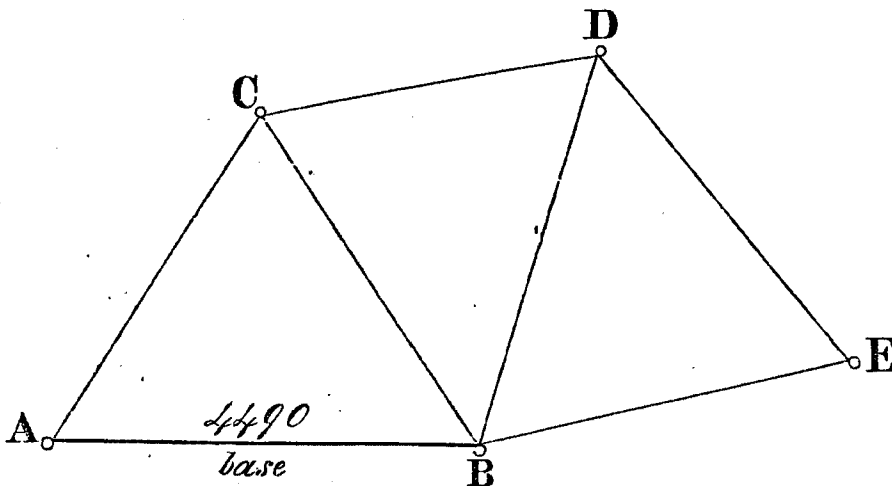
has to be surveyed and measured with the chain only. Draw a plan to scale of any figure preferred, and explain how it should be surveyed; also find the contents in square acres.

4. A survey plan of an estate is given. Describe how you would proceed to survey it with a circumferenter and chain, marking on the plan the stations you would establish, and prepare therefrom a field-book with sufficient accuracy to admit of a correct plan of the estate being plotted from its contents. Give also the content of the estate in square acres.

8 PAPERS RELATING TO EXAMINATION OF CANDIDATES FOR

TRIGONOMETRICAL SURVEYING.

1. A BASE line, A B, was measured and reduced, and found to be 4,490 yards.



Stations were established at C D and E, and angles were observed at A and B, with a theodolite as follows :

$$\angle C A B = 66^{\circ} 30' 5''$$

$$C B A = 57^{\circ} 9' 55''$$

$$C B D = 48^{\circ} 59' 50''$$

$$D B E = 65^{\circ} 1' 30''$$

Angles were also measured at C as follows,

$$\angle A C B = 56^{\circ} 20' 0''$$

$$B C D = 56^{\circ} 0' 30''$$

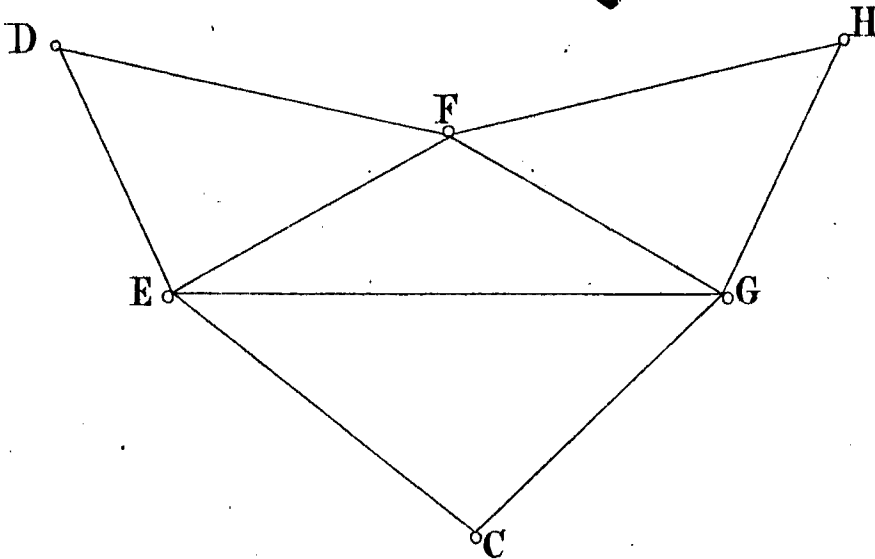
but as it appeared that B E was a side of a triangle of a former series, and the distance ascertained from records to be 3,910 yards, there was no necessity for measuring any angles at D.

The candidates are required to work out the above triangulation, resulting in ascertaining the distance D E.

2. Explain the method of measuring and reducing a base line, and of fixing the principal stations of a survey as practised in the Ordnance Survey of Great Britain, and in the Grand Trigonometrical Survey of India, and describe the mode of procedure to be adopted by a surveyor charged with the duty of extending a series of principal triangles, with sides of 25 to 40 miles in length, over a tract of country.

Trigonometrical Surveying.

Question 3. In conducting a series of Minor or Secondary Triangles, angular observations taken at E F and G were lost, and as it was inconvenient to resume the work at those stations, the angles E F and G of the Triangle EFG were found by computation. The following were the data which the records furnished...



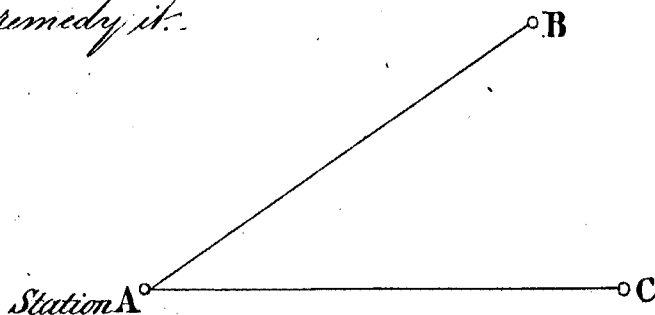
$$\begin{aligned} \text{In } \triangle DEF: DF &= 11,420 \text{ yards} \\ \angle D &= 33^\circ 52' 10'' \\ \angle E &= 83^\circ 5' 0'' \end{aligned}$$

$$\begin{aligned} \text{In } \triangle ECG: EC &= 9,881 \text{ yards} \\ \angle C &= 90^\circ 58' 5'' \\ \angle G &= 55^\circ 53' 10'' \end{aligned}$$

$$\begin{aligned} \text{In } \triangle FGH: FH &= 10,260 \text{ yards} \\ \angle H &= 56^\circ 10' 40'' \\ \angle G &= 66^\circ 42' 30'' \end{aligned}$$

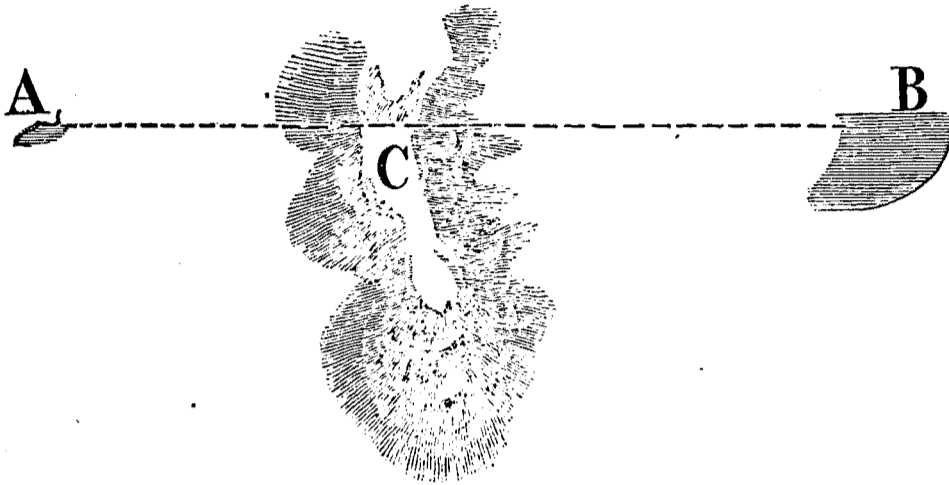
From these data it is required to compute the \angle s E F and G in the $\triangle EFG$

Question 4. At a Station A I measured the angular distance between two other Stations B & C, with a Theodolite, & found it to be $41^\circ 5' 10''$ but on measuring the same angle, viz. BAC, with a sextant, I obtained a different result, viz. $41^\circ 21' 30''$. Explain the cause of this discrepancy, both instruments being assumed as in perfect adjustment, and state what steps you would take to remedy it.



LEVELLING.

1. It was desired to ascertain if water could be brought from a spring (A) to a reservoir (B) by a channel to be carried round an intervening spur (C).



Levels were taken along the line A C B, and the result was that B was found to be 2·3 feet lower than A.

The candidates are required to prepare a field book from an imaginary profile (drawn to scale), involving six stations of the levelling instrument, exhibiting this result, assuming A C B to be 1853 yards in length.

2. Describe the dumpy level, its corrections and adjustments, and the method of using it.
3. Explain the use of the barometer (mercurial and aneroid) in preparing a section through an extended tract of hilly country.
4. How can the theodolite be used in levelling?
5. Describe the most expeditious and efficacious method to be adopted in carrying a series of trial levels for a contemplated line of railway over a tract of country.

PUBLIC WORKS DEPARTMENT—INDIA.

CIVIL ENGINEER ESTABLISHMENT.

EXAMINATION PAPERS for Appointments for June 1861,

George Preston White, C. E., Examiner.

Subject—Practical, Civil and Mechanical Engineering.

DESCRIBE the course of education you have undergone for the profession, 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.

Roads.

1. Describe the engineering features of any important line of communication, such as the great roads over the Simplon or St. Gothard; explain the means employed for obtaining easy gradients for drainage, and for preventing injury from floods, snow, avalanches, &c.

2. Draw transverse sections of a road, showing formation in sidelong ground, on level ground, through cutting, and long precipitous rocky ridges; show drains, culverts, fences, &c., and figure on dimensions, and state the quantity of metalling and other materials required per perch, with average cost.

3. Describe Mr. Telford's principles of road making, as adopted in his practice on the Caledonian and Holyhead roads; in what does it differ from Mr. M'Adam's system? and state the comparative advantages and cost.

4. Describe some of the plans which have been successfully employed for making foundations for roads over marshes and unstable ground.

5. What are the best materials for road metalling, and the best seasons of the year for repairing roads?

6. Give general specification and estimate, adopting your own prices and data, for one mile of road over level clay land, one mile over rough mountain and one mile in side cutting.

7. If required to lay out a road with a view, at a subsequent period, to use one portion of it for a tramway for cattle draft, or for light locomotives, state what gradients and curves you would consider necessary, the nature of the bridges and other works, the description of rail, and state what course you would adopt generally, so as to secure the utmost economy in construction.

8. What is the tractive power required per ton on a well-formed road, and on a railway on a level, also on gradients of 1 in 30, of 1 in 50, and of 1 in 100, at velocities of 5, 10 and 20 miles per hour?

Railways and Tramways.

9. Describe the different methods employed for setting out railway curves, and for laying out widths on sidelong ground.

10. What elevation should be given to the exterior rail for curves 500, 1,000 and 5,000 feet radius respectively, the gauge being 4 feet 8½ inches, and the average velocity of trains 20 miles an hour?

11. Give the weight per yard of the rails used on some of the principal railways in this country and abroad, and describe the different forms of rails, chairs, and sleepers, mode of fishing the joints; state the cost per mile of the different systems, and their comparative advantages.

12. Give the average cost per mile of some of the most important railways in the United Kingdom, on the Continent, in America and in India.

13. Give some particulars as to the steepest gradients used on railways, and explain the different modes adopted for working traffic over steep inclines.

14. Design a railway station of simple construction to accommodate a town of 10,000 inhabitants; give ground plan, elevation and sections, with sufficient detail to enable builders to execute the work therefrom, and give a specification and estimate of the cost.

15. In countries like America and India, of vast extent, where money bears a high rate of interest, and where it is necessary that the first cost of railways should be small, economy of construction being of the utmost importance consistent with safety and economy in working; describe the kind of railway and permanent way you would recommend, the nature of the bridges, the form and weight of rail per yard, the railway to be suitable either for light locomotives or cattle draft; give an estimate and general specification, and name any railway which illustrates your views.

16. Give a brief description of the locomotive engine, describing the most important improvements since its first introduction; and describe an economical light locomotive, suitable for moderate traffic on tramways or low-speed railways.

Canals.

17. Draw transverse sections of a canal in cutting, on the surface, and on an embankment. Figure on the dimensions and slopes, and show puddle lining, towing path, &c.

18. If required to lay out a line of canal, state the principal circumstances which would guide you as to the selection of the route, and the mode of obtaining the water supply.

19. Describe

19. Describe the various modes used for raising canal boats from one level to another.

20. Describe some of the most important aqueducts which have been constructed for carrying canals across valleys and ravines.

21. Describe the plan adopted by Mr. Roebling for using suspension bridges for canals, and explain why it is, in some respects, the most favourable strain to which a suspension bridge can be subjected.

22. State some of the circumstances which should determine the distance between canal locks.

23. Describe any canal, where great engineering skill has been displayed in its construction.

Irrigation.

24. Describe in detail the different methods employed in India and Lombardy for irrigating land.

Locks.

25. Make a design for a canal lock chamber, giving plan, elevation, section and specification, breadth 20 feet, length 80 feet, lift 10 feet, average depth of canal 10 feet. State what precautions you would take regarding the foundations, also describe the best form of sluice.

26. What are the circumstances which would determine you in adopting a small number of deep locks, or a large number of shallow locks, where a considerable difference of elevation is to be overcome?

27. Describe the best way of making puddle for lining canals, so as to prevent its cracking.

Foundations under Water.

28. Describe in detail the different methods employed for forming foundations under water, and give examples, stating the comparative merits and advantages of each system, and their applicability under the various circumstances met with in practice.

29. State which are the best, and which are the most difficult soils to form foundations in, and explain how you would ascertain the nature of the strata, if required, to execute an important work under water.

30. Describe the various uses and applications of Mr. Mitchell's screw piles.

31. Describe the method employed by Mr. Brunel, for forming the foundation for the centre pier of the Albert Bridge at Saltash; or by Sir William Cubitt, for Rochester Bridge.

Bridges and Viaducts.

32. Give the dimensions, span, cost, and peculiarities of construction of important examples of bridges and viaducts under the following heads:

1st. Those where the support of the structure depends on compression alone, as in the arch.

2nd. Those where the supporting material is subject to extension alone, as in the suspension bridge.

3rd. When the structure is subjected to both compression and extension, as in the girder.

33. Describe the different forms of girder, viz.:—The lattice or trellis, the Warren, the tubular, the bow and string, and Mr. Brunel's new girder; state the comparative advantages and applicability in practice of these different forms of construction.

34. Describe the mode adopted by Mr. Roebling for trussing the Niagara Suspension Bridge, to prevent vibration and undulation, so as to fit it for railway traffic.

35. Describe the principle of Bollman's Iron Suspension and Trussed Bridge.

36. What are the circumstances which would guide you in employing cast iron, wrought iron; stone, brick, timber or wire, in the construction of bridges and viaducts?

37. Design a railway viaduct to cross a river 200 feet wide, greatest depth of water 30 feet, and height from surface of water to formation level 50 feet.

38. In wrought iron trellis and boiler plate girder bridges, what proportion should the depth of the beam bear to the span?

39. What is the weight of a platform loaded with men per square yard? and what is the difference in effect between troops marching in order over a suspension bridge, and breaking step?

40. Describe the mode adopted for raising the chains of the Menai and Hungerford Suspension Bridges.

41. Make a design for a centre, of simple construction, for a brick semi-circular arch of 50 feet span.

42. Make a sketch, showing the principle of Mr. Mynes' centre for Blackfriars Bridge, or give any other important example of centering.

43. Explain the mode adopted by Sir Isambard Brunel, to build a bridge without centering, and describe the mode proposed by Mr. Robert Stephenson, to erect the bridge first designed for the Menai Straits without centering, so as not to interfere with the navigation.

44. Give transverse sections of the best forms for girders of cast, wrought and boiler plate iron; and state the proportion which should exist above and below the neutral axis; also the general results arrived at from the experiments of Messrs. Stephenson, Fairbairn, Hodgkinson and Barlow.

Retaining Walls.

45. Design retaining walls of stone and brick, 20, 30 and 40 feet in height; figure on the dimensions and batter, the strata being plastic clay.

Harbours.

46. Describe the plan adopted by Mr. Rendel for the formation of the Harbours of Portland and Holyhead; and explain the use of Beton and "Pierres Perdues."

Roofs.

47. Design a principal for a wrought iron roof of 60 feet span for a railway station; give working drawings with transverse sections of struts, tye-rods, &c., and figure on dimensions, and give sufficient detail to enable a contractor to execute the work.

48. Describe the different substances employed for roofing, and give comparative advantages, cost, and weight per 100 square feet superficial.

49. Describe the peculiarities and span of any important examples of roof construction, such as the roof over the central station, Birmingham, the King's Cross, Paddington, the Victoria Station, London, or the Lime-street Station, Liverpool.

50. Make sketches for simple and economical forms of roof of wood or iron, 20, 30 and 40 feet span.

Dams.

51. Design a dam for a river 100 feet wide, greatest depth of water 20 feet, head of water required five feet; give a plan of the superstructure, of the upper level, of the lower level, an elevation of a portion of the front of the dam, wall, and

and section of wing wall; state what precautions you would take to secure foundations, and prevent leakage; and give specification and estimate of the cost of the work.

Strength of Materials.

52. What proportion does the resisting power of cast and wrought iron bear to extension and compression?

53. In structures of cast and wrought iron, what proportion should the breaking weight bear to the maximum load?

54. State the result of the experiments of Messrs. Fairbairn and Hodgkinson on the average tensile strength of cast iron, its mean crushing weight per square inch, also the transverse strength of cast iron rectangular bars 1 inch wide, and 4 feet 6 inches between supports.

55. What is the cohesive strength of iron wire and iron bars per square inch for suspension chains? state the effect produced by drawing iron into wire and forging iron.

Machinery.

56. Describe the advantages of the slide rest principle, and mention some of its most important applications to machinery.

Limes, Mortars, and Cements.

57. Name the different kinds of lime and cement used in building; describe their properties, and specify those which are hydraulic.

58. What constitutes the chemical difference between ordinary and hydraulic limes, and explain how artificial hydraulic limes can be made, according to the experiments of Vicat and others, where natural hydraulic limes cannot be obtained.

59. What time does good hydraulic lime take to harden and set?

60. State the uses and application of concrete, and describe how it is made and the best proportions.

River Navigation.

61. Describe the various means employed for improving the navigation of rivers, and describe the engineering works on the Clyde, or any other river with which you may be acquainted, showing how the navigation has been improved.

Tunnels.

62. Describe how you would range out the centre line for a straight and also a curved tunnel.

63. Give a section of the best form of tunnel for a railway. Show the centerings, and explain how the heading is driven and the shafts sunk, and figure on dimensions.

64. Give the cost per lineal yard of some important examples of railway tunnels, and specify the nature of the strata; and if lined with brickwork, state the number of rings.

65. Describe the strata which are most favourable, and those which are most difficult to execute tunnels in, and specify where brickwork is required.

66. Before commencing a tunnel, what precautions would you take to satisfy yourself as to the nature of the strata, and with a view to make an estimate of the cost?

Water Supply.

67. Describe the different systems employed for supplying towns with water, and give the names of important works illustrating the subject.

68. Give the names and a short description of the different machines and engines employed for raising water.

Embanking Land from the Sea.

69. Describe the means employed in Holland and other countries for embanking land from the sea and from rivers.

Lighthouses.

70. Describe briefly the peculiarities of construction of the Eddystone Lighthouse; and give the names of important examples of lighthouse construction of wood, stone, and cast and wrought iron.

Miscellaneous.

71. Give the names of the eminent engineers of Great Britain in chronological order, and mention some of their most important and distinguished works.

72. Give the names of standard works of reference on engineering subjects.

73. Describe the various kinds of brick employed in building, and make a diagram, showing the different bonds used in brickwork, and state their comparative advantages; also explain the use of hoop iron.

74. Describe the various kinds of timber employed in building, their comparative advantages, cost and durability.

75. Explain the processes employed to preserve timber against decay, and against the ravages of marine and other insects, giving the names of those destructive to timber; and specify the timbers most durable for works under water.

76. Make a sketch, showing the best sectional forms for sewers and drains, and state the best materials for their construction.

77. What is the impulsive force of the wind per square foot during hurricanes, at a velocity of 150 feet per second.

78. How much does iron expand between 32° and 212° Fahrenheit? and explain the means employed in iron structures of magnitude to provide against expansion and contraction.

79. Mention the uses and most important practical applications of the hydraulic press.

80. What per centage of useful effect can be obtained respectively from overshot, breast, and undershot wheels, and from the turbine? and describe their comparative advantages, and the head of water required.

81. State the best kinds of stone for building purposes, and specify those most suitable for works under water.

82. If required to construct a physical atlas of India, state how you would proceed, and what subjects you would introduce.

83. Write a short essay, describing the engineering works you would recommend for India, of a reproductive character, with a view to increase the revenue of the country, by the development of its industrial resources.

EAST INDIA
(PUBLIC WORKS DEPARTMENT).

• RETURNS of the Names of EXAMINERS appointed to examine the CANDIDATES who presented themselves, since the last Return, for Admission to the ENGINEER'S ESTABLISHMENT and PUBLIC WORKS DEPARTMENT of *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.

(*Mr. Adam.*)

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