SYLLABUS

OF

A COURSE

OF

EXPERIMENTAL LECTURES

ON THE

PRINCIPLES OF MECHANISM.

BY

ROBERT WILLIS, M.A., F.R.S., &c.,

JACKSONIAN PROFESSOR.

CAMBRIDGE:

PRINTED AT THE PITT PRESS,

BY JOHN W. PARKER, PRINTER TO THE UNIVERSITY:

FOR J & J. J. DEIGHTON, TRINITY STREET.

M.DCCC.XLI.

SYLLABUS.

1. THE parts of Machines may be classed under three heads:—

Parts which receive and govern the action of the moving power.

Parts which do the work for which the machine is constructed.

Trains of mechanism which communicate and modify motion between the other two classes.

2. Of these classes it is most convenient to begin with the last, because its principles admit of being developed geometrically without reference to the powers employed or transmitted, or to the resistances or work to be done. The ordinary principles of Statics and Dynamics may be subsequently applied to the combinations thus obtained.

Of the second class of parts, numerous examples occur during this course in the machines selected for the elucidation of the general principles of the two other classes

Finally, the first class of parts form the subject of the second division of the course, entitled, "Machines considered with respect to Force."

PART I.

ON TRAINS OF MECHANISM.

---

3. MECHANISM may be defined to be a combination of parts, connecting two or more pieces, so that the motion of one compels the motion of the others, according to a law of connection depending on the nature of the combination. The motion of elementary combinations are *single* or *aggregate*.

SECTION I.

SINGLE MOTION.

4. THE motion of every piece in a machine is defined by path, direction, and velocity.

5. Of these, the path is assigned to it by its connection with the frame-work, but the direction and velocity are governed by the connection of the moving pieces with each other.

6. This connection is unaffected by the actual velocity and direction of the pieces, and therefore governs only the relation of their velocities and directions.

7. In a given path there are but two directions, and between the directions of two pieces there exist two relations: In the first, while one piece perseveres in the same direction, the other also retains a constant direction, and when one changes the other changes; in which cases the directional relation is said to be constant:

In the second, while one piece perseveres in the same direction, the other changes its direction, or *vice versâ*; in which case the directional relation is said to change.

8. The relations of velocity divide themselves also under two heads, according as the velocity ratio is constant or varies.

9. By combining these relations of direction and velocity, three classes are obtained, under which all the elementary combinations of mechanism may be conveniently arranged:

CLASS A. Directional relation and velocity ratio constant.

CLASS B. Directional relation constant, velocity ratio varying.

CLASS C. Directional relation changing, velocity ratio either constant or varying.

10. The pieces in a train of mechanism are connected in successive order either by contact or by intermediate pieces, so that when the first piece in the series is moved, it compels the second to

move, which again gives motion to the third, and so on.

11. The act of giving motion to a piece is termed *driving* it, and that of receiving motion from a piece is termed *following* it. Also, the piece or part of a piece which is appropriated to the transmission of motion to the next is the *driver*, and that which receives motion is the *follower*.

12. The law of motion of one piece in a train may differ in any way from the law of motion of another piece, and the change is effected by the mode of connection. The systematic examination of the different cases under which these changes may be arranged constitutes the principles of mechanism.

13. The path described by any point of a piece, with respect to the frame may always be considered as circular; for a rectilinear path is a portion of a circle of infinite radius; and curvilinear paths in practice are always effected by methods that fall under the head of aggregate motion.

14. The motion in a circular path may be either capable of continuation to an unlimited extent in one direction, or may be limited by the nature of the contrivance.

15. The methods of communicating motion from one piece to another, may be included under five heads:—

ROLLING CONTACT.
SLIDING CONTACT.
WRAPPING CONNECTORS.
LINKS.
REDUPLICATION.

16. If one piece move another by the actual contact of their surfaces, these surfaces are said to *slide* together when in passing from one position to another the distances of the consecutive points of contact, measured upon the two surfaces, are unequal; and they are said to *roll* together when those distances are equal.

17. If one piece move another by means of an intermediate piece, the latter is termed a *link* when its extremities are jointed to the two pieces, so as to turn on a given point of each in the changes of their relative positions.

18. The intermediate piece may be flexible, and apply itself to curve surfaces attached to the driving and following pieces; in which case it may be termed *a wrapping connector*.

(A connector may be a link at one end, and may wrap at the other.)

19. Reduplication is the principle of the pully, which, being principally employed for raising weights, is better studied as a modifier of force.

20. Axes of rotation may be: (*a*) parallel: (*b*) not parallel, but meeting in direction: (*c*) not parallel, and never meeting.

CLASS A. { DIRECTIONAL RELATION CONSTANT.
VELOCITY RATIO CONSTANT.

ELEMENTARY COMBINATIONS.

21. ***By Rolling Contact.*** Contact maintained by pressure and rough surfaces, or by teeth.

(*a*) Cylinders,
(*b*) Cones.
(*c*) Hyperboloids or Double Cones.
Spur Wheels.
Pinions.
Cogs.
Annular Wheels.
Racks.
Face Geer.
Crown Wheel.
Bevil Wheels.
Skew Bevils.
Hook's Geering.

22. ***By Sliding Contact.*** Forms of the individual Teeth of Wheels from Epicycloids, Involutes, &c.

Least numbers of Teeth.
Backlash.
Odontograph.
Ollivier's Property of Involute Teeth.
Cam-Plates.
Screws.

Endless screws.

Hindley's Screw.

Oldham's Coupling.

23. *By Wrapping Connectors.* Belts, Bands, &c.

Flat Belts always run to the highest part of a conical pully.

The advancing portion of the Belt is the only one that governs its position on the pully.

Management of Belts when the axes are not parallel, Geering Chains, Guide Pullies.

24. *By Links.*

Links in this class can only be employed when the angular velocities of the Driver and Follower are equal, unless the motions are limited in extent to a small arc.

Dead Points.

Three methods of passing the Link over the Dead Points.

Cranks.

Bell-Cranks.

25. EXAMPLES OF COMPLETE MACHINES.

Stationers' Ruling Machine.

Balling Machine.

Drawing Rollers.

Clark's Blower.

Covering Machine.

Piemont Silk Reel.
India Rubber Cutting.
Veneering Saw.
Self-Acting Lathe.

CLASS B. { DIRECTIONAL RELATION CONSTANT. VELOCITY RATIO VARYING.

ELEMENTARY COMBINATIONS.

26. *By Rolling Contact,*
Ellipses.
Logarithmic Spirals.
Rolling Curves in general.
Teeth applied to them.
Intermitting Teeth.
Eccentric Spur Wheels.
Roëmer's Wheels.
Eccentric Crown Wheel.
Rolling Levers.

27. *By Sliding Contact,*
Pin and Slit Lever.
Endless Screw with Varying Inclination.
Pinion of one Tooth,
Geneva Stop.
Oldham's Geering.

28. *By Links,*
Cam-Plate.
Hooke's Joint.

29. *By Wrapping,*
Curvilinear Pully.
Fusees.

30. EXAMPLES OF COMPLETE MACHINES.
Hooke's Sun-dial Machine.
Crab's Claw.
White's Lever Crane.

CLASS C. DIRECTIONAL RELATION CHANGING.

EXAMPLES OF ELEMENTARY COMBINATIONS.

31. *By Rolling Contact,*
Mangle Wheel,
Mangle Rack.
Escaping Geer.

32. *By Link Work,*
Cranks and Excentrics.
Complex motions by trains of Link-work.
Detent and Click.
Lever of Lagarousse.
Silent Click.

33. *By Sliding Contact,*
Cams.
Screw returning into itself.
Swash Plate.
Solid Cam.
Cam with equidistant parallel Tangents.
Escapements.

34. *By Wrapping Connectors,*
Curvilinear Pully.

35. EXAMPLES OF COMPLETE MACHINES.
Pedal Harp Motion.
Arithmetical Machine.
Winding Machine.
Throstle.
Mortising and Grooving Engine.
Planing Engine.
Boiler Punch.
Pumping Engine.
Buhl Saw.

SECTION II.

ON AGGREGATE MOTION.

36. THE motion of a point, with respect either to its path or velocity, may be considered as the resultant of two or more component motions. If it happen that the latter taken separately are more simple and practicable than the resultant motion, this may be produced by communicating simultaneously to the given point the component motions.

37. To carry this principle into effect, requires that we should be able to communicate motion from a driver to a follower, when the relative position of their respective paths is variable.

EXAMPLES.

Long Pinion.
Long Endless Screw.
Epicyclic Wheels.
Bands.
Link-work.

38. EAMPLES OF MOTION IN A SIMPLE PATH WITH AGGREGATE VELOCITY:

By Link-work,
Compound Curve Engine.
Hank Machine.
Copping Machine.
Lazy Tongs.

By Wrapping Connectors,
Chinese Windlass.
Differential Pully.

By Sliding Contact,
White's Screw.
White's Screw and Nut.
Wollaston's Odometer.

By Epicyclic Trains in general,
Sun and Planet Wheels.
Ferguson's Paradox.
Planetary Mechanism.
Rope Making, by Huddart's Machinery.
Differential Index.
Equation Clock.

39. EXAMPLES OF MOTION IN AN AGGREGATE PATH.

Writing Machine.
Trammel.
Oval Chuck.
Screw Cutting and Boring.
Cylinder Boring.
Block-scoring Engine.
Geometric Pen.
Epicycloidal Chuck.
Rose Engine.
Curves of the Rose Engine.
Shaping Engine.
Anaglyptograph.
Pentagraph.
Centrolinead.
Green's Specular Engine.
Dressing Brushes.
Parallel Motions.

ADJUSTMENTS.

40. The alterations and adjustments of the communication of motion that may be required in a train are three:—

(*a*) To break off or resume at pleasure the communication of motion. (*b*) To reverse the direction of motion of the follower with respect to that of the driver, that is, to change the directional relation. (*c*) To alter the ratio of velocity between driver and follower, either by determinate or by gradual steps.

41. These changes may either be made by hand at any moment, or they may be effected by the

machine itself by means of a class of organs especially destined for that purpose.

42. (*a*) The communication of motion may be broken off.....

(1) By detaching pieces that remain united during the action of the machine; as, pullies or wheels from shafts, or shafts from each other by means of catches, claws, couplings, or frictional adhesion.

(2) By disengaging the driver from the follower.

EXAMPLES.

In Wheels, by withdrawing the Teeth from contact directly or laterally, or in the case of contact without Teeth, by removing the Pressure.

In Screws, by a Split Nut or Half Nut.

In endless Screws, by withdrawing the Wheel in the direction of its Shaft.

In Pullies, by slipping the Belt laterally to a loose Pully; or by slackening the Belt.

In Link-work, by raising a Pin from a notch: by dropping the fulcrum of a Lever, &c.

43. (*b*) The directional relation may be changed by a pair of Reversing Bevels, by Spur Wheels, by a pair of direct and crossed Belts, by shifting a double hook in Link-work, &c.

44. (*c*) The adjustments of the velocity ratio may consist either of (1) Determinate changes, and for the most part requiring the machine to be stopped,

or of (2) Gradual changes, and not requiring the machine to be stopped.

EXAMPLES OF DETERMINATE CHANGES.

Change-wheel Systems.
Shifting different pairs of wheels into Geer.
Screw-cutting Lathe.
Common Crab.
Speed Pullies.
Metal Turning Lathe.
Adjustable Levers.

EXAMPLES OF GRADUAL CHANGES.

Disk and Roller.
Equitangential Conoid.
Speed Pullies.
Pair of Cones.
Cone and Cylinder.
Expanding Riggers.
Surface Lathe.
Adjustable Levers.

45. Examples of machines containing adjustments for position, for limiting motions and self-adjustments, &c.

Engraver's Ruling Machine.
Cutting Engine, with Dividing Plate, or Trains of Change Wheels.
Ramsden's Dividing Engine.
Weaving in general.
Jacquard Loom and Punching Apparatus.
The Organ.
Locks.

PART II.

MACHINES CONSIDERED WITH RESPECT TO FORCE.

---

46. MOVING powers and parts adapted to receive their actions.

EXAMPLES.

Windmills.
Waterwheels.

47. The Steam Engine.
Newcomen's Engine.
Watt's double acting Engine.
Watt's single acting Engine.
Principle of working by Expansion.
The Marine Engine.
The High-pressure Engine.
Locomotive Engine.
Rotative Engines.

48. Examples of the application of Statics to Machines.

Lagrange's Demonstration of the Principle of Virtual Velocities.
Balances.
Printing Presses with variable Pressure.
Flatting Rollers.
Crushing Stones.
Pullies and Tackle in general.

49. Friction. Experimental Laws.
Friction increases by rest—is proportional

to Pressure, and independent of the Velocity, and of the Extent of Surfaces in Contact.

50. Employment of Friction.
Brakes.
Friction of Cord wrapped round a Cylinder.
Capstan.
Whitworth's Drilling Machine.

51. Diminution of Friction.
Perrault's Pully.
Friction Wheels.

52. To measure the force exerted by Machines, or required to move them.
Dynamometers of White, Prony, Morin, and others.

53. Dynamical Experiments of Atwood, Smeaton, &c.

54. To govern the velocity of Machines.
Pendulums.
Balances.
Escapements.
Revolving Pendulum, or Governor.
Fly.
Flywheel.
Bottlejack.
Striking parts of Clocks.
General Construction of Clocks and Watches.

THE END.