1. A governor is said to be isochronous if it is :

(1) highly stable (2) stable and sensitive

(3) least stable (4) least sensitive

Ans: 1

A governor that maintains the same speed in the mechanism controlled regardless of the load. A governor is said to be isochronous **when the equilibrium speed is constant (i.e. range of speed is zero) for all radii of rotation of the balls within the working range**, neglecting friction. The isochronism is the stage of infinite sensitivity. A spring-loaded governor can only possibly be an Isochronous governor

2. A screw jack acts like

(1) an inclined plane (2) a pulley block

(3)a hoist (4) a crow bar

Ans: 1

3. What is the standard addendum of involute gears ?

(1) 0.8 module (2) 1.0 module (3) 1.25 module (4) 1.50 module

Ans: 2

4. Which of the following statement is true ?

(1) For smooth gearing action base circle should be below dedendum circle

(2) Cycloid gears are commonly used in all applications

(3) Interference can occur only in involute gears

(4) Number of teeth on a gear wheel is directly proportional to the module

Ans: 3

5. In the case if inverted gear train the axes of driving and driven wheels will be

(1) Parallel (2) Perpendicular (3) Inclined (4) Co-axial

Ans: 4

In inverted gear trains, **the driver and the last gear are Co-axial**.

6. The device attached to the crankshaft of an engine which controls crankshaft torsional vibration is

(1) Fly wheel (2) Governor

(3) Vibration damper (4) Timing gears

Ans: 3

7. What is a kinematic pair ?

(1) Two links connected and having fully constrained relative motion

(2) Two or more links in a mechanism with their motion fully constrained

(3) Paired links in a mechanism having relative motion between them

(4) A pair of links which do not have relative motion between them

Ans: 1

https://en.wikipedia.org/wiki/Kinematic_pair

In classical mechanics, a **kinematic pair** is a connection between two physical objects that imposes constraints on their relative movement (kinematics).

Kinematics is the branch of classical mechanics which describes the motion of points, bodies (objects) and systems of bodies (groups of objects) without consideration of the causes of motion.[3] Kinematics as a field of study is often referred to as the "geometry of motion".[4] For further detail, see Kinematics.

In kinematics, the two connected physical objects, forming a kinematic pair, are called `rigid bodies'. In studies of mechanisms, manipulators or robots, the two objects are typically called 'links'.

A lower pair is an ideal joint that constrains contact between a surface in the moving body to a corresponding in the fixed body. A lower pair is one in which there occurs a surface or area contact between two members, e.g. nut and screw, universal joint used to connect two propeller shafts.

A higher pair is a constraint that requires a curve or surface in the moving body to maintain contact with a curve or surface in the fixed body. For example, the contact between a cam and its follower is a higher pair called a *cam joint*. Similarly, the contact between the involute curves that form the meshing teeth of two gears are cam joints, as is a wheel rolling on a surface. It has a point or line contact

8. Which of the following is an inversion of double slider crank chain ?

(1) Quick return mechanism (2) Skotch yoke

(3) Ackermann steering gear (4) Reciprocating engine mechanism

Ans: 2

There are three important inversions of double slider crank chain. These three are :-
1) Elliptical Trammels
2) Scotch Yoke Mechanism
3) Oldham's Coupling

9. Relative velocity of two points on a rigid link is
   (1) always zero
   (2) parallel to the line joining the points
   (3) perpendicular to the line joining the points
   (4) parallel to the line of action of force

   Ans: 1

10. In a velocity compounded impulse steam turbine, as steam flows over the guide blades
   (1) pressure remains constant
   (2) pressure increases
   (3) pressure decreases
   (4) velocity increases

   Ans: 1

The Velocity - Compounding of the Impulse Turbine

The velocity-compounded impulse turbine was first proposed by C.G. Curtis to solve the problems of a single-stage impulse turbine for use with high pressure and temperature steam. The *Curtis stage* turbine is composed of one stage of nozzles as the single-stage turbine, followed by two rows of moving blades instead of one. These two rows are separated by one row of fixed blades attached to the turbine stator, which has the function of redirecting the steam leaving the first row of moving blades to the second row of moving blades. A Curtis stage impulse turbine is shown below with schematic pressure and absolute steam-velocity changes through the stage. In the Curtis stage, the total enthalpy drop and hence pressure drop occur in the nozzles so that the pressure remains constant in all three rows of blades.

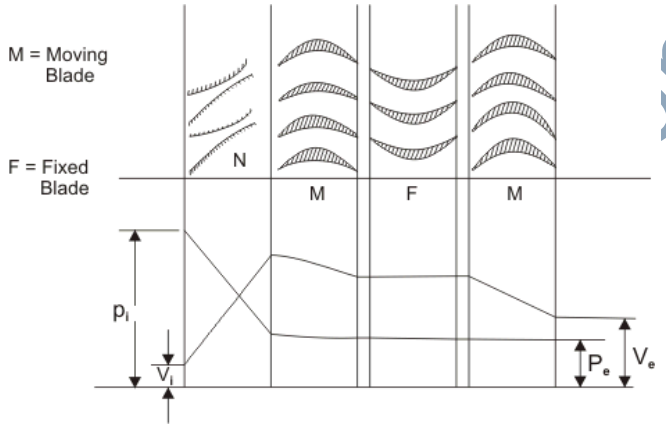


Figure: Velocity Compounding arrangement

Velocity is absorbed in two stages. In fixed (static) blade passage both pressure and velocity remain constant. Fixed blades are also called guide vanes. Velocity compounded stage is also called **Curtis stage.**
https://nptel.ac.in/content/storage2/courses/112104117/chapter_6/6_8.html

11. Thermostat in the coolant circuit of an internal combustion engine
(1) Quickens warm-up
(2) Maintains coolant temperature
(3) Permits evaporative cooling
(4) Increases boiling point

Ans: 2

12. The device for some vehicles which causes the propeller shaft to drive faster than the engine crankshaft is called
(1) Fluid drive
(2) Centrifugal clutch drive
(3) Hotchkiss drive
(4) Over drive

Ans: 1

13. The volume of a gas will vary directly as the absolute temperature, if the pressure remains constant. This is

(1) Boyles' law
(2) Gay Lussac's law
(3) Charles's law
(4) Kirchoff's law

Ans: 3

14. A type of wear of moving parts characterized by transfer of material from one to another part and results in pits and grooves is called

(1) Scuffing
(2) Seizing
(3) Abrasive wear
(4) Cavitation

Ans: 1

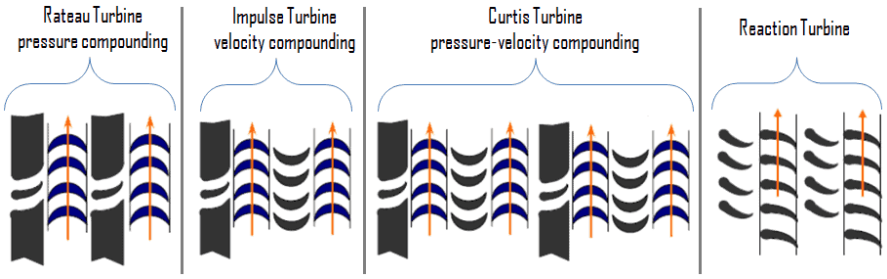
15. Compounding in on steam turbine, results in

(1) Increased turbine output
(2) Increased speed of operation
(3) Reduced speed of operation
(4) Increased leakage losses

Ans: 3

Compounding of steam turbines is the method in which energy from the steam is extracted in a number of stages rather than a single stage in a turbine. In all turbines the rotating blade velocity is proportional to the steam velocity passing over the blade. If the steam is expanded only in a single stage from the boiler pressure to the exhaust pressure, its velocity must be extremely high. An impulse steam turbine compounding can be achieved in the following three ways:

- **pressure compounding**
- **velocity compounding**
- **pressure-velocity compounding**



WHAT IS COMPOUNDING OF STEAM TURBINES –

DEFINITION

2019-05-22 by Nick Connor

https://www.thermal-engineering.org/what-is-compounding-of-steam-turbines-definition/

Compounding of steam turbine is **used to reduce the rotor speed**. It is the process by which rotor speed come to its desired value. A multiple system of rotors are connected in series keyed to a common shaft and the steam pressure or velocity is absorbed in stages as it flows over the blades.

16. An actual air compressor compresses air as per

(1) Isothermal law (2) Adiabatic law
(3) Polytropic law (4) Isentropic law

Ans: 3

17. The heat that produces a change of state is called

(1) Specific heat (2) Latent heat
(3) Sensible heat (4) Heat of combustion

Ans: 2

18. The heat that produces a change in temperature (increase or decrease) is called

1.Specific heat (2) Latent heat
3. Sensible heat (4) Heat of combustion

Ans: 3

19. Opening out of the ends of a hole with a suitable drill bit to form a conical hollow is called

(1) cupping (2) dinking
(3) countersinking (4) piercing

Ans: 3

20. Arrangement incorporated for easy starting of an engine and which prevents the intake of exhaust valve from closing completely is called

(1) Choke valve (2) Breather pipe
(3) Decompressor (4) Valve over lap

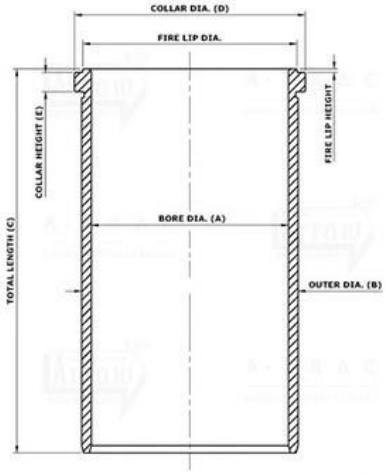
Ans: 1

21. The cylinder liner which is supported in the cylinder block over its entire length is known as

(1) wet liner (2) dry liner
(3) composite liner (4) Honed liner

Ans: 2

Dry Liners. The dry liner does not come in contact with the coolant. Instead, it fits closely against the wall of the cooling jacket in the cylinder block. With the wet liner, the coolant comes in direct contact with the liner. Wet liners may have a cooling water space between the engine block and liner, or they may have integral cooling passages. Liners with integral cooling passages are sometimes referred to as water-jacket liners.



Dry liners have relatively thin walls compared with wet liners. The cross-section of a dry liner can be seen in the above image.

Wet Liners

In wet liners that do not have integral cooling passages, the

water jacket is formed by the liner and a separate jacket which is a part of the block. A static seal must be provided at both the combustion and crankshaft ends of the cylinders to prevent the leakage of coolant into the oil pan sump, or combustion space. Generally, the seal at the combustion end of a liner consists of either a gasket under a flange or a machined fit. Rubber or neoprene rings generally form the seal at the crankshaft end of the liner. Liners of this type are constructed to permit lengthwise expansion and contraction. The walls of a wet liner must be strong enough to withstand the full working pressure of the combustion gases.
https://medium.com/@a.trac.engineeringco/what-is-the-difference-between-a-wet-type-and-a-dry-type-cylinder-liner-f4036985fd38

22. Two wheelers in our country are widely using
(1) power brake (2) drum brake
(3) disc brake (4) parking brake

Ans: 2

23. An engine with two rows of cylinders which are opposed and are on the same plane is known as
(1) Opposed piston engine (2) Pancake engine
(3) V engine (4) In line engine

Ans: 1

24. A smith's tool, made either in CI or steel and weighing roughly 70 kg, used for shaping and finishing or forgings of a variety of cross sections is called
(1) sledge hammer (2) about sledge
(3) swage block (4) caulking tool

Ans: 3

A **swage block** (or swager block) is a large, heavy block of cast iron or steel used in smithing, with variously-sized holes in its face and usually with forms on the sides.

The through-holes are of various shapes and sizes and are used to hold, support or back up a hot bar of metal for further shaping. Operations performed on a swage block include but are not limited to bending, cutting, punching and forming. The sides are scalloped to present formed shapes for forging operations. Shapes are for example the curve of a wheel, which could be used to finish a wheel rim, using a suitable hammer. Other shapes, such as the half hexagon, can be used with a matching top swage to form a hexagonal cross-section on a bar. The various shapes around the edge of the swage block all have corresponding shapes in the form of top swages to shape iron bar into various sections.

https://en.wikipedia.org/wiki/Swage_block
https://commons.wikimedia.org/wiki/File:SmithsSwageBlock.jpg

25. Rust prevention method i.e. treatment which consists of coating the metal (iron or steel) with a fairly thick film of zinc is called

(1) Metallizing (2) calorizing
(3) Austenitizing (4) Galvanizing

Ans: 4

26. The operation of cutting or shearing a shape with a die from sheet metal stock and using the hole material i.e., material with hole for further operations is called

(1) punching (2) blanking
(3) coining (4) piercing

Ans: 4

27. Class of fit which will allow two parts to be assembled under hand pressure is called

(1) interference fit (2) push fit
(3) running fit (4) press fit

Ans: 2

28. In supercharged diesel engine

(1) Air mass is increased
(2) Fuel injected in increased
(3) Mechanical efficiency decreases
(4) Air mass and fuel injected are increased

Ans: 4

Supercharging is the process of supplying air for combustion at a pressure greater than that achieved by naturally aspirated engine so that more fuel can be burnt . The

compressor of the turbocharger brings in ambient air and compresses it at enhanced pressure before it enters the intake manifold. This results in a higher mass of air on each intake stroke entering the cylinders.
Superchargers are pressure increasing devices that supply air at high pressure to the engine. A supercharger is driven by the engine power itself & the power is delivered through a pulley and a belt.

A turbocharger is a form of the supercharger. It's a gas compressor (exhaust gas specifically) which is used for forced induction on an internal combustion engine (car engines for instance). The use for a turbocharger is to produce more power by raising the density of the air entering the engine.

The turbocharger has the compressor that is driven by the engine's exhaust.

https://gomechanic.in/blog/turbocharger-vs-supercharger/

29. The joint which permits the transmission of motion in any direction as in the steering system is called

(1) knuckle joint (2) Flange joint
(3) Slip joint (4) Ball joint

Ans: 1

30. If m and k refer to mass and stiffness of a vibrating body, the critical damping coefficient is

(1) $2\sqrt{mk}$ (2) $\sqrt{m/k}$ (3) $\sqrt{mk}$ (4) $\sqrt{2mk}$

Ans: 1

31. Which of the following processes is used for making internal splines ?

(1) shaping (2) milling (3) knurling (4) broaching

Ans: 4

32. Which one of the following casting methods is the most precise ?

(1) Wet sand process
(2) Dry sand process
(3) Die-casting
(4) Investment casting

Ans: 4

33. Which one of the following statements is true ?

(1) Cavitation is likely to occur in both steam and water turbines
(2) Pressure inside the casing of Pelton turbine is less than atmosphere
(3) Draft tube is essential for all types of turbines
(4) Kaplan turbine is a reaction turbine of axial flow type

Ans: 2 and 4. (Draft tube is essential for all reaction turbines like Francis and Kaplan turbine)

34. A pitot tube measures

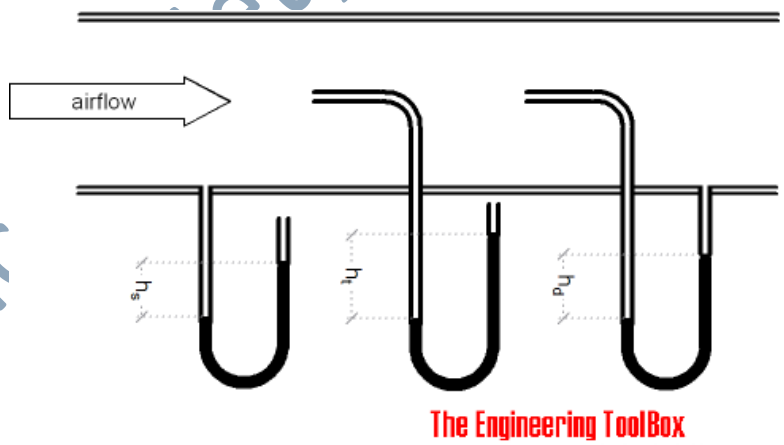
(1) velocity at a point
(2) average velocity across a duct
(2) static pressure
(4) average static pressure

Ans: 1

A pitot tube, also known as pitot probe, is a flow measurement device used to measure fluid flow velocity. The pitot tube was invented by the French engineer Henri Pitot in the early 18th century and was modified to its modern form in the mid-19th century by French scientist Henry Darcy.

THE PITOT TUBE

The pitot tube is a simple and convenient instrument to measure the difference between **static, total** and **dynamic pressure (or head)**.



The head - Δh - (or pressure difference - Δp) can be measured and calculated with the help of u-tube manometers, electronic pressure transmitters or similar instrumentatio

Pitot tube, instrument for measuring the velocity (speed) of a flowing fluid. Invented by Henri Pitot (1695–1771), it consists of a tube with a short right-angled bend, which is placed vertically in a moving fluid with the mouth of the bent part directed upstream; the pressure, measured with an attached device, depends on the fluid flow

and can be used to calculate the velocity. Pitot tubes are used in anemometers to measure airspeed in wind tunnels and aboard aircraft in flight; they are also used to measure the flow of liquids

Britannica, The Editors of Encyclopaedia. "pitot tube". ***Encyclopedia Britannica***, 1 Mar. 2021, https://www.britannica.com/technology/pitot-tube. Accessed 26 April 2022.

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Venturi tube, short pipe with a constricted inner surface, used to measure fluid flows and as a pump. The 18th–19th-century Italian physicist Giovanni Battista Venturi, observing the effects of constricted channels on fluid flow, designed an instrument with a narrow throat in the middle; fluid passing through the tube speeds up as it enters the throat, and the pressure drops. There are countless applications for the principle—***e.g.,*** an automobile carburetor, in which air flows through a venturi channel at whose throat gasoline vapour enters through an opening, drawn in by the low pressure. The pressure differential can also be used to measure fluid flow.

Britannica, The Editors of Encyclopaedia. "venturi tube". ***Encyclopedia Britannica***, 31 Jul. 2018, https://www.britannica.com/technology/venturi-tube. Accessed 26 April 2022.

35. Head loss in pipe flow due to friction is
(1) directly proportional to the diameter
(2) directly proportional to the square of the diameter
(3) inversely proportional to the pipe diameter
(4) inversely proportional to the square of the pipe diameter

Ans: 3 (Head losses are due to the frictional resistance of the piping system (pipe, valves, fittings, entrance, and exit losses). In fluid dynamics, the **Darcy–Weisbach equation** is an empirical equation that relates the head loss, or pressure loss, due to friction along a given length of pipe to the average velocity of the fluid flow for an incompressible fluid.)

Head loss is a measure of the reduction in the total head of the fluid as it moves through a pipe system. Head loss that occurs along the pipe wall is called friction loss. The head loss due to the friction H_f in a given pipeline for a given discharge is determined by the Darcy-Weisbach equation:

$$H_f = f \frac{L}{D} \frac{v^2}{2g}$$

where

f = friction factor (unitless)

L = length of pipe

D = diameter of pipe

v = fluid velocity

g = acceleration due to gravity

https://www.corrosionpedia.com/definition/625/head-loss

36. Which of the following statements is true ?

(1) Air vessel is used in almost all types of pumps

(2) Vapour pressure of a liquid is dependent only on the ambient pressure

(3) Cavitation in pumps can occur only at the suction end

(4) Reciprocating pumps are run at higher speed than centrifugal pumps

Ans: 2 and 4

Cavitation is a phenomenon in which the static pressure of a liquid reduces to below the liquid's vapour pressure, leading to the formation of small vapor-filled cavities in the liquid. When subjected to higher pressure, these cavities, called "bubbles" or "voids", collapse and can generate shock waves that may damage machinery. These shock waves are strong when they are very close to the imploded bubble, but rapidly weaken as they propagate away from the implosion.

Cavitation is a significant cause of wear in some engineering contexts. Collapsing voids that implode near to a metal surface cause cyclic stress through repeated implosion. This results in surface fatigue of the metal causing a type of wear also called "cavitation". The most common examples of this kind of wear are to pump impellers, and bends where a sudden change in the direction of liquid occurs.

https://en.wikipedia.org/wiki/Cavitation

37. Curtis turbine is a

(1) single stage impulse turbine

(2) pressure compounded impulse turbine

(3) velocity compounded impulse turbine
(4) reaction turbine

Ans: 3

The Velocity - Compounding of the Impulse Turbine

The velocity-compounded impulse turbine was first proposed by C.G. Curtis to solve the problems of a single-stage impulse turbine for use with high pressure and high temperature steam. The ***Curtis stage*** turbine is composed of one stage of nozzles as the single-stage turbine, followed by two rows of moving blades instead of one. These two rows are separated by one row of fixed blades attached to the turbine stator, which has the function of redirecting the steam leaving the first row of moving blades to the second row of moving blades

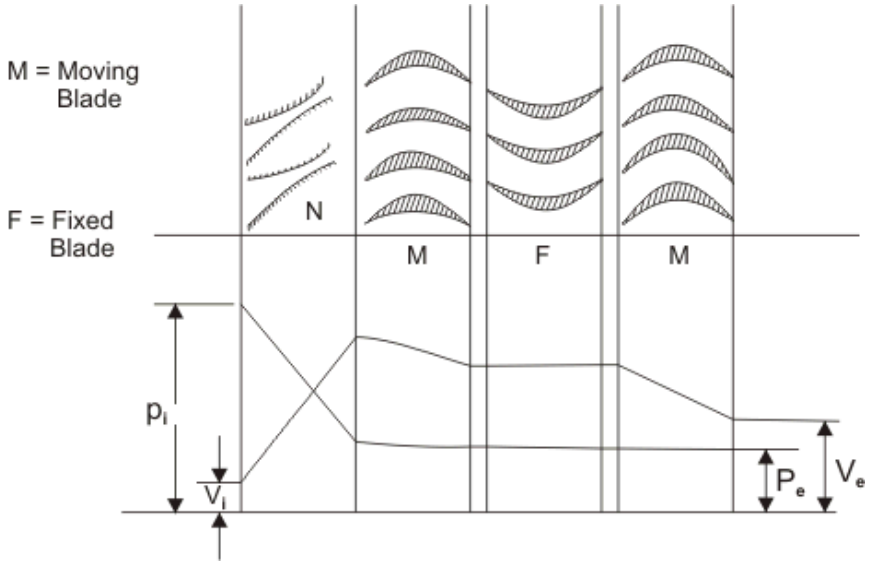


Figure 23.1 Velocity Compounding arrangement

Velocity is absorbed in two stages. In fixed (static) blade passage both pressure and velocity remain constant. Fixed blades are also called guide vanes. Velocity compounded stage is also called **Curtis stage.** The velocity diagram of the velocity-compound Impulse turbine is show

https://nptel.ac.in/content/storage2/courses/112104117/chapter_6/6_8.html

38. Regenerative feed water heating is done in steam power plants
(1) to increase power output
(2) to reduce condensation
(3) to improve cycle efficiency
(4) to improve turbine efficiency

Ans: 3

39. The time taken to drill a hole through a 25 mm thick plate with the drill rotating at 300 r.p.m. and moving at a feed rate of 0.25 mm/revolution is

(1) 10 sec (2) 20 sec
(3) 60 sec (4) 100 sec
Ans: 2

Given : t = 25 mm, N = 300 rpm, f = 0.25 /mm rev
We know, time taken to drill a hole,
T = t/fN
= 25/(0.25 x 300/60)
= 20 Sec

40. A built-up-edge is formed while machining

(1) ductile materials at high speed (2) ductile materials at low speed
(3) brittle materials at high speed (4) brittle materials at low speed
Ans:2

41. If x is the distance measured from the leading edge of a flat plate, the laminar boundary layer thickness varies as

(1) 1/x (2) $x^{4/5}$ (3) x^{2} (4) $x^{1/2}$
Ans:4

42. Flow separation in flow past a solid object is caused by

(1) a reduction of pressure to vapour pressure
(2) a negative pressure gradient
(3) a positive pressure gradient
(4) the boundary layer thickness reducing to zero
Ans:3

43. A correctly designed convergent-divergent nozzle working at a designed load is

(1) always isentropic (2) always choked
(3) never choked (4) never isentropic
Ans:2

Nozzle design –Converging-Diverging nozzle

Choked flow is a **fluid dynamic condition associated with the venturi effect**. When a flowing fluid at a given pressure and temperature passes through a constriction (such as the throat of a convergent-divergent nozzle or a valve in a pipe) into a lower pressure environment the fluid velocity increases. **Choked flow** is a limiting condition where the mass flow will not increase with a further decrease in the downstream pressure environment for a fixed upstream pressure and temperature.

The choked flow of gases is useful in many engineering applications because the mass flow rate is independent of the downstream pressure, and depends only on the temperature and pressure and hence the density of the gas on the upstream side of the restriction. Under choked conditions, valves and calibrated orifice plates can be used to produce a desired mass flow rate.

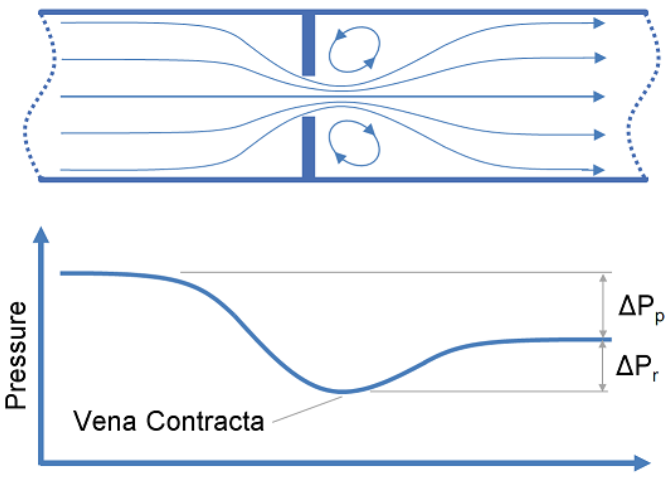
https://en.wikipedia.org/wiki/Choked_flow

……..

Choked flow is a phenomenon that limits the mass flow rate of a compressible fluid flowing through nozzles, orifices and sudden expansions. Generally speaking it is the mass flux after which a further reduction in downstream pressure will not result in an increase in mass flow rate.

NON-CHOKED FLOW

As a compressible fluid passes through a restriction there are changes in both velocity and pressure. The fluid starts upstream at a higher pressure, which falls as it increases velocity flowing through the restriction, and may continue to fall as the velocity increases through the vena contracta. After passing the vena contracta the fluid will begin expand to fill the cross sectional area of the pipe and as it does will slow down and regain pressure.



For normal non-choked flow with a given inlet pressure, reducing the outlet pressure will cause a greater differential pressure across the restriction and therefore increase the fluid flow rate and velocity. This holds true until the flow rate is increased to the point that the fluid reaches the local sonic velocity at the throat of the restriction and

becomes choked.

SUPERSONIC FLOW

Reducing the downstream pressure of a choked system will not result in increased mass flow rate but it will however, result in an increased velocity of the fluid after the restriction. After reaching the point of choked flow, further reductions in downstream pressure will result in the fluid accelerating away from the throat and in some cases achieving supersonic speeds (Mach number > 1).

Depending on the outlet nozzle design shock waves may form as the fluid returns to subsonic speeds.

https://neutrium.net/fluid-flow/choked-flow/

44. The value of Biot number is very small (less than 0.01) when

(1) the convective resistance of the fluid is negligible
(2) the conductive resistance of the fluid is negligible
(3) the conductive resistance of the solid is negligible
(4) none of these

Ans:3

Biot number is the ratio of the heat transfer resistance inside a body to the heat transfer resistance at the surface of the body. It gives a simple index of the ratio of the thermal resistances *inside of* a body and *at the surface* of a body. This ratio determines whether or not the temperatures inside a body will vary significantly in space, while the body heats or cools over time, from a thermal gradient applied to its surface.

Values of the Biot number smaller than 0.1 imply that the heat conduction inside the body is much faster than the heat convection away from its surface, and temperature gradients are negligible inside of it.

Generally, in bodies of simple geometry, e.g., plates, cylinders, spheres, the error introduced by the assumption of uniform body temperature will be less than 5% when the internal resistance is less than 10% of the external resistance, i.e., when the Bi < 0.1.

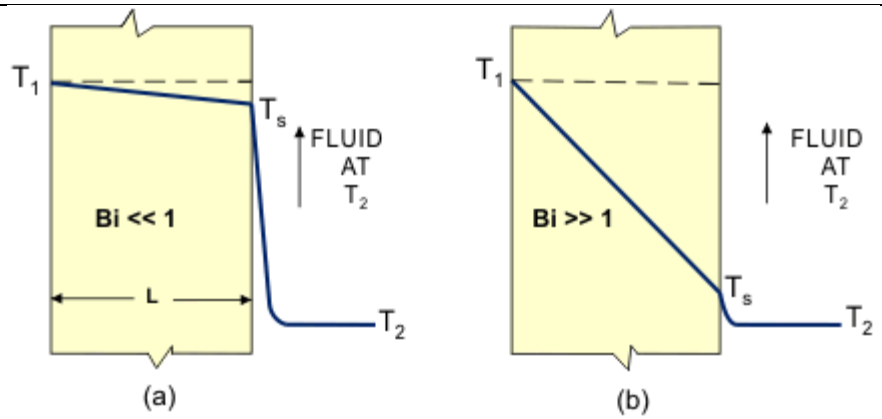


Figure 1. Comparison of fully developed temperature profiles in two plates cooled by the same fluid.

https://www.thermopedia.com/content/585/

45. For the same inlet and oulet temperatures of hot and cold fluids, the Log Mean Temperature Difference (LMTD) is

(1) greater for parallel flow heat exchanger than for counter flow heat exchanger
(2) greater for counterflow heat exchanger than for parallel flow heat exchanger
(3) same for both parallel and counter flow heat exchangers
(4) dependent on the properties of the fluids

Ans:2

Eq. fig…

46. The coupling used to connect two shafts with large angular misalignment is

(1) a Flange coupling
(2) an Oldham's coupling
(3) a Flexible bush coupling
(4) a Hooke's joint

Ans: 4

A shaft coupling is a mechanical component that connects the drive shaft and driven shaft of a motor, for example in order to transmit power. Shaft couplings introduce mechanical flexibility, providing tolerance for shaft misalignment. As a result, this coupling flexibility can reduce uneven wear on the bearing, equipment vibration, and other mechanical troubles due to misalignment. Different types of Coupling are

Rigid Coupling: They are used to connect two perfectly aligned shafts.

Flexible Coupling: They are used to connect two shafts having lateral and angular misalignment.

Fluid Coupling or Hydraulic Coupling: They transmit power from one shaft to another shaft, acceleration, and deceleration of hydraulic fluid.

47. A static load is mounted at the centre of a shaft rotating at uniform angular velocity. This shaft will be designed for

(1) the maximum compressive stress (static)
(2) the maximum tensile stress (static)
(3) the maximum bonding moment (static)
(4) fatigue loading
Ans:4

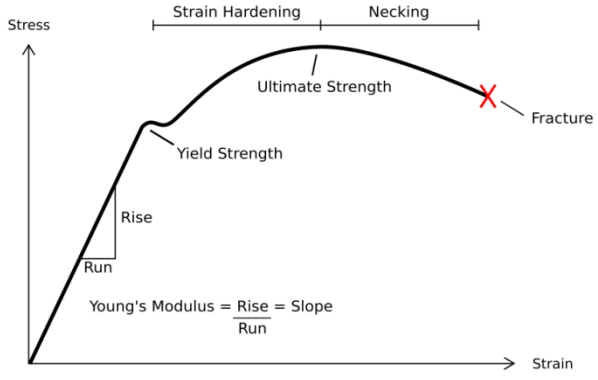
48. Large speed reductions (greater than 20) in one stage of a gear train are possible through

(1) Spur gearing
(2) Worm gearing
(3) Bevel gearing
(4) Helical gearing
Ans: 2

49. A material property capable of absorbing large amount of energy before fracture is known as :

(1) ductility (2) toughness (3) resilience (4) shock proof
Ans:3

In material science, resilience is **the ability of a material to absorb energy when it is deformed elastically, and release that energy upon unloading**. Proof resilience is defined as the maximum energy that can be absorbed up to the elastic limit, without creating a permanent distortion.

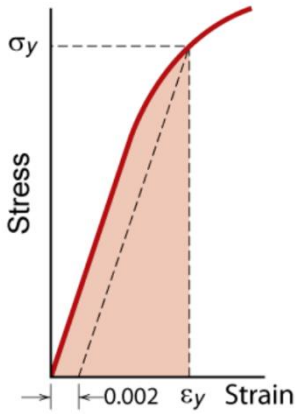


By Breakdown - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=3702892
https://en.wikipedia.org/wiki/Resilience_(materials_science)

RESILIENCY AND TOUGHNESS

Resilience of the material to be the amount of energy the material can absorb and still return to its original state. If we are talking about stressing the material and having it return to its original state, we are talking about the material remaining in the elastic region of the stress-strain curve. It turns out that we can get the energy

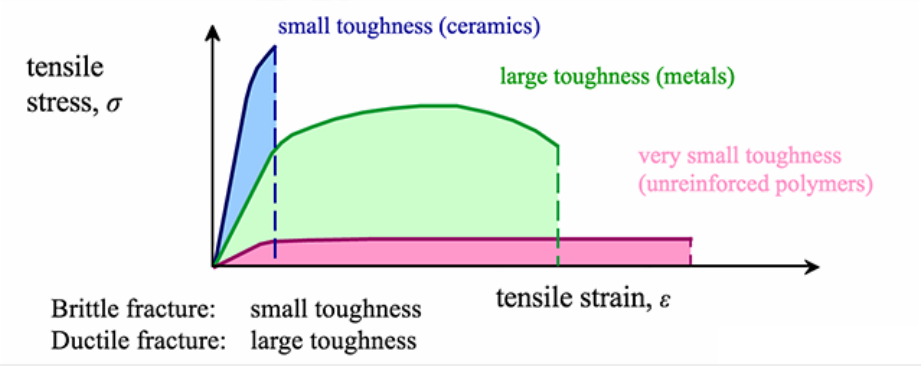
of elasticity by taking the area under the curve of the stress-strain curve. That area has been highlighted in the figure below, which is the area under the curve from the origin to the yield strength.



Energy of elasticity shown under the curve of the stress-strain curve.
Credit: Callister

Toughness, in contrast to resilience, is how much energy can be absorbed and still keep going. One analogy that can be used when describing toughness is that of a car in a demolition derby. The car is allowed to continue the competition as long as it is capable of moving. It does not matter how many hits and how much destruction has been done to the car, but rather as long as the car can move it can stay in the competition. The toughness of the car is based on how many hits and how much damage the car can sustain and continue in the competition. In the case of materials, the amount of energy that the material can absorb plastically before fracturing is the toughness.

In the figure below, we can see that a material can have a high tensile strength (ceramics) and yet have a small toughness. In addition, materials can be extremely ductile (unreinforced polymers) and also have a small toughness. So, a large toughness (metals) is obtained by having a high tensile strength and a high ductility.



Stress-strain curve for a material with a high tensile strength (ceramics) and a small toughness.

Author: Dr. Ronald Redwing, Senior Lecturer, Department of Material Sciences and Engineering, College of Earth and Mineral Sciences, The Pennsylvania State Univers

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Toughness. In materials science and metallurgy, toughness is **the ability of a material to absorb energy and plastically deform without fracturing**. One

definition of material toughness is the amount of energy per unit volume that a material can absorb before rupturing.