ENGINEERING STATICS AND DYNAMICS

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INTRODUCTION TO STATIC AND DYNAMIC SYSTEMS

- The terms dynamic and static can be used in a variety of different ways, therefore, their processes and differences are dependent on the system they are describing. However, in general, there are a few common characteristics.
- In general, *dynamic* means *energetic, capable of action and/or change*, or *forceful*, while *static* means *stationary* or *fixed*. In computer terminology, *dynamic* usually means *capable of action and/or change*, while *static* means *fixed*.
- The concepts of statics and dynamics are basically a categorization of rigid body mechanics. Dynamics is the branch of mechanics that deals with the analysis of physical bodies in motion, and statics deals with objects at rest or moving with constant velocity. This means that dynamics implies change and statics implies changelessness, where change in both cases is associated with acceleration.

FUNDAMENTALS OF STATICS AND DYNAMICS

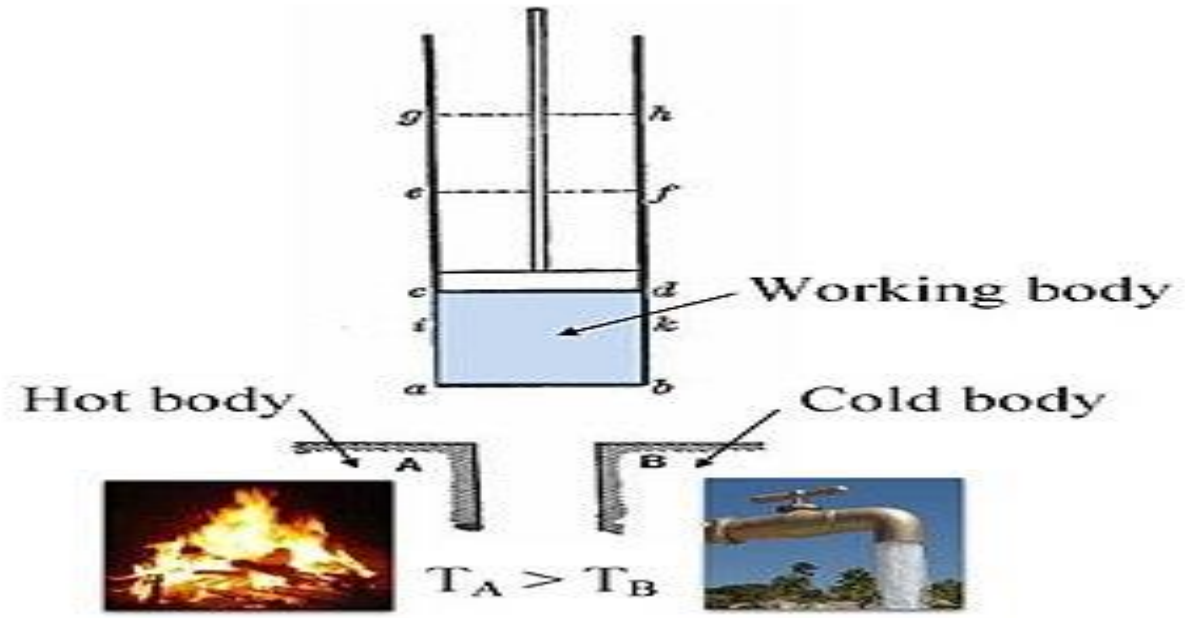
- Statics is concerned with the forces that acts on bodies at under equilibrium conditions. This is expressed in the first part of newton's first law of motion, where equilibrium conditions are met: A body will remain at rest(zero displacement) and A body will remain in uniform motion.
- Acceleration is always zero in statics, so the right hand side (RHS) of the equation of newton’s second law of motion will always amount to zero as well. This means that most statics problems are going to be associated with the analysis of the force on the left hand side(LHS) of newton’s second law of motion. F = ma
- Dynamics: In mechanics studies the forces that cause or modify the movement of an object. It deals with the analysis of physical bodies in motion. Therefore acceleration is factor in these problems.
- Dynamics can be divided into kinematics and kinetics.
- Kinematics is an area of study that focuses on the movement of objects disregarding the forces that cause the movements. It studies motion that are relate to displacement, velocity, acceleration and time. It deals with forces and the geometric aspects of the motion, which is related to velocity and acceleration.
- In kinematics , we can have problems associated with either acceleration being constant or

- Or acceleration changing over time(variable acceleration).kinematic equations associated with either constant acceleration are only valid when acceleration is constant and motion is constrained to a straight line. Variable acceleration problems deals with kinematics where acceleration changes over time.
- Kinetics on the other hands studies motion that relates to the forces that affects the motion.
- It takes force for objects to stay at rest(static) and to be in motion(dynamic)
- Differentiation (calculus) is used to convert displacement to velocity and velocity to acceleration.
- Integration(calculus) is used to convert acceleration to velocity and velocity back to displacement.
- These makes velocity the first derivatives and acceleration the second derivatives with respect to time(t). $S=f(t)$, $V=u + at$, $V^2 = U^2 + 2as$

THERMODYNAMICS

- Thermodynamic deals with after effects of statics and dynamics forces which keeps a body or an object in constant motion or at uniform rest such as heat, temperature and work done by the object or a body.
- Thermodynamics is a branch of physics that deals with heat, work, and temperature, and their relation to energy, entropy, and the physical properties of matter and radiation.
- The behavior of these quantities is governed by the four laws of thermodynamics which convey a quantitative description using measurable macroscopic physical quantities, but may be explained in terms of microscopic constituents by statistical mechanics.
- Thermodynamics applies to a wide variety of topics in science and engineering, especially physical chemistry, biochemistry, chemical engineering and mechanical engineering, but also in other complex fields such as meteorology.
- Classical thermodynamics is the description of the states of thermodynamic systems at near-equilibrium, that uses macroscopic, measurable properties. It is used to model exchanges of energy, work and heat based on the laws of thermodynamics.
- The qualifier *classical* reflects the fact that it represents the first level of understanding of the subject as it developed in the 19th century and describes the changes of a system in terms of macroscopic empirical (large scale, and measurable) parameters. A microscopic interpretation of these concepts was later provided by the development of *statistical mechanics*.

- Equilibrium thermodynamics is the study of transfers of matter and energy in systems or bodies that, by agencies in their surroundings, can be driven from one state of thermodynamic equilibrium to another. The term 'thermodynamic equilibrium' indicates a state of balance, in which all macroscopic flows are zero; in the case of the simplest systems or bodies, their intensive properties are homogeneous, and their pressures are perpendicular to their boundaries. In an equilibrium state there are no unbalanced potentials, or driving forces, between macroscopically distinct parts of the system.



FLUID STATICS AND DYNAMICS

- Fluid Dynamics and Statics: Fluid mechanics is a sub-discipline of physics that focuses on all fluidic matter, which includes liquids and gases, and the forces involved. A fluid can be defined as a substance that does not have a fixed shape, and it is deformed continuously by applied, tangential forces. There are two principal categories of fluid mechanics: fluid statics and fluid dynamics. These two categories explore both fluids at rest and moving fluids, respectively.
- Fluid statics, also known as hydrostatics, is one of the chief categories of fluid mechanics. Contrary to fluid dynamics, it is the study of fluids at rest, and at equilibrium.
- According to current laws in fluid mechanics, a fluid will not be at rest if there is shear stress present – shear stress being the force per unit area, where the stress is parallel to the surface of the fluid.
- Buoyancy is an example of the forces studied in hydrostatics, being defined as the vertical force that is equal in magnitude but opposite in direction of the weight of the fluid. This concept is taught in physics and it is particularly used for the designing of floatation devices and boats. The study of fluid statics is also useful for a variety of other fields, such as medicine and geophysics.

- Fluid dynamics, also called hydrodynamics, is the second main category of fluid mechanics. It is defines as the study of fluids in motion, such as the motion of water around an object.
- Hydrodynamics has numerous applications, and is such a large discipline that it contains several branches (e.g. aerodynamics). Additionally, it is used to calculate pressure, viscosity, and mass flow.
- Equations, known as the Naiver-Stokes equations, are used to perform similar calculations, relating to the motion of fluids.
- Currently, hydrodynamics is a discipline of intense, active research – such that cash rewards are offered to those who can solve existing problems.
- The two major forces in fluid dynamics are pressure and force. The terms force and pressure are used extensively in the study of fluid power.

TYPES OF FLUIDS

- Ideal fluid.
- Real fluid.
- Newtonian fluid.
- Non-Newtonian fluid.
- Ideal plastic fluid.
- Incompressible fluid.
- Compressible fluid.

- However fluids are categorized into liquid or gas.

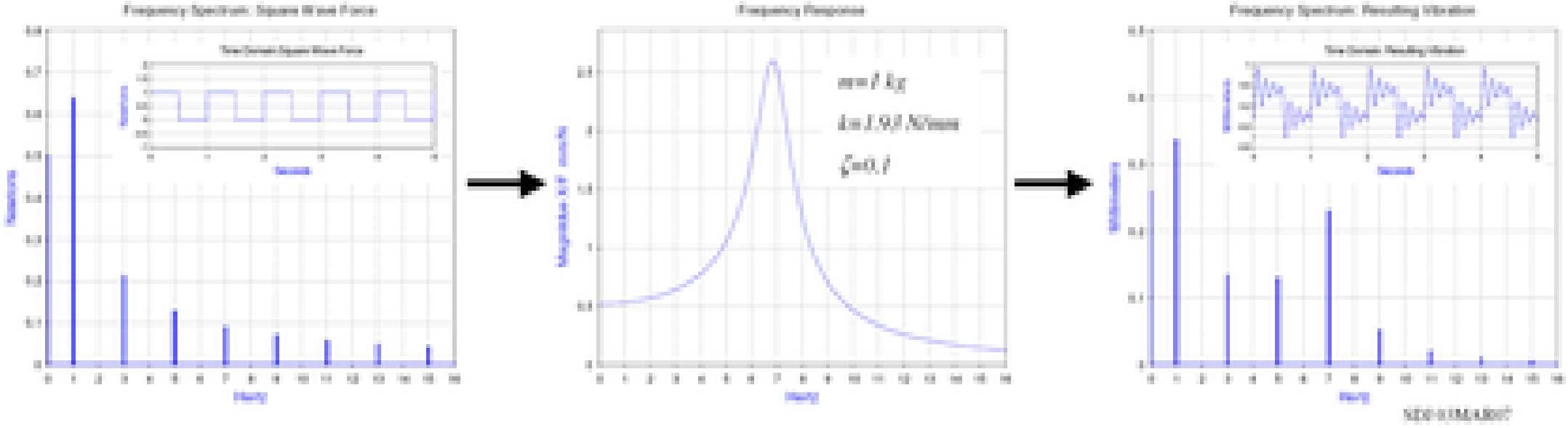
MECHANICAL VIBRATIONS

- *Mechanical vibration is defined as the measurement of a periodic process of oscillations with respect to an equilibrium point.*
- when referring to mechanical systems we are implying systems such as compressors, pumps and other machines. When referring to structures we are implying buildings, space craft and other large scale objects. A most intuitive differential is simply that mechanical systems are ones that we use, whereas a structural system is one that we can physically enter. Although there are clearly many cases where a studied system can be categorized as both
- There are mainly three basic types of vibration according to the axis of body move :1 Longitudinal vibration, 2 Transverse vibration, 3 Torsional vibration.

Input Force
(*Amplitude*, *Frequency*, *Phase*)

Vibration
(*Amplitude*, *Frequency*, *Phase*)

$$F(\omega) \quad x \quad H(\omega) \quad = \quad X(\omega)$$



STATICS AND DYNAMICS ANALYSIS

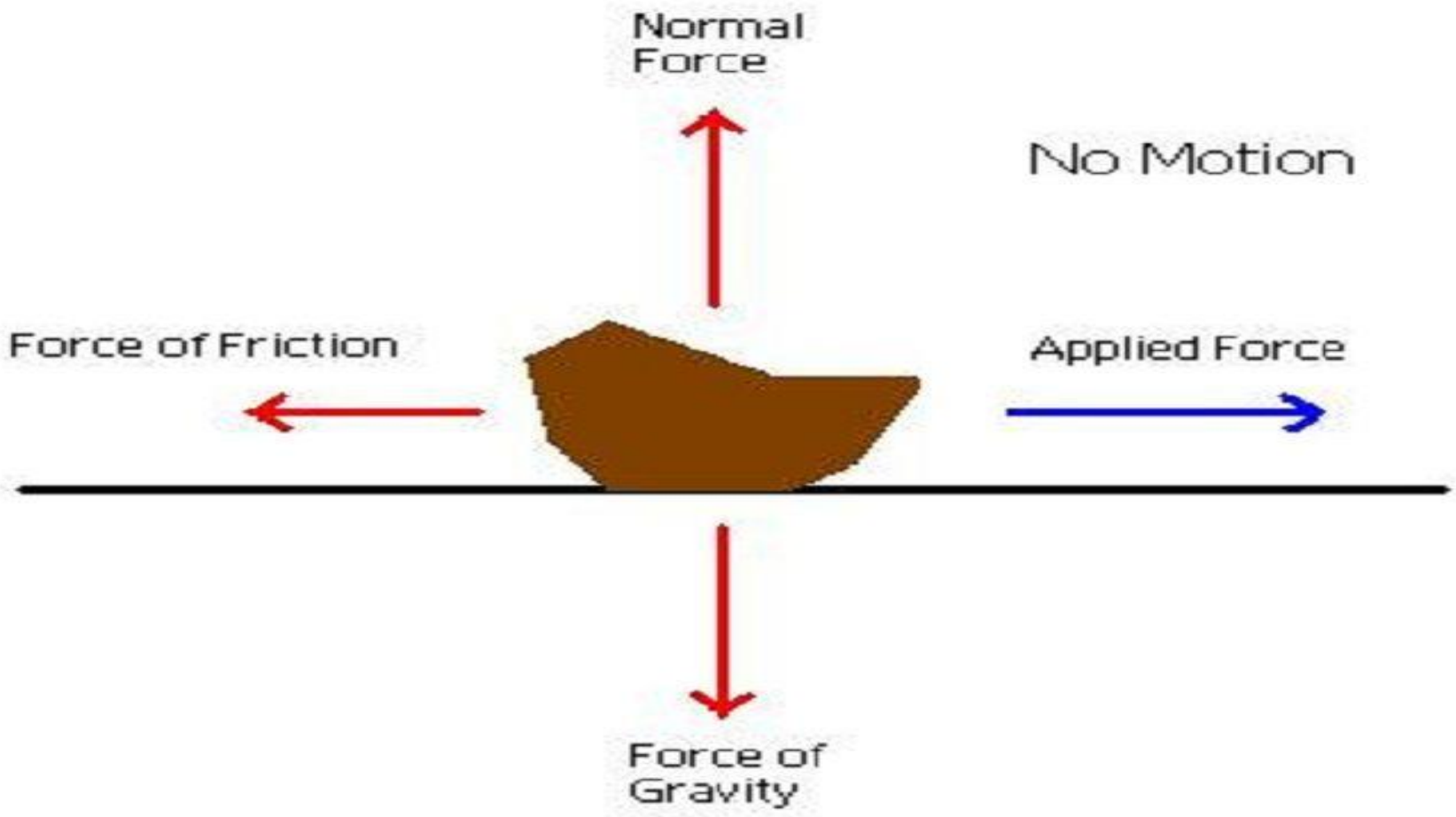
- There is dynamics and static every where and in most everything.
- Dynamics is studied and applied in almost everything such as in person, computer, physics, chemistry, music and so on.
- Static is the study of internal and external forces in a structure. Is a branch of mechanics that deals with bodies at rest.
- Statics is the study of systems in which momentum does not change, whereas dynamic involves the study of change of momentum.
- Forces are responsible for maintaining balance and causing motion of bodies or changes in their shape.
- A static system is memoryless system, a dynamic system is a system in which it’s output at any instant of time depends on the input at the same time and as well at the other time.

STATICS AND DYNAMICS APPLICATIONS

- Websites- A dynamic website generates content automatically based on the user. An example of a dynamic website is Instagram, which tailors each feed based on the user and updates dynamically over time. A set of HTML capabilities are provided that help developers create dynamic websites, generally known as dynamic HTML. A static website does not utilize an external database, is written in HTML and displays the same information to every user.
- IP addresses- Most IP addresses are considered a dynamic IP, or one that can change at any time, while a static IP reserves the same address every time. A static IP address can be purchased or requested by organizations that use dedicated services or host computer servers.
- Programming languages- In a dynamic language, such as Perl or LISP a developer can create variables without specifying their type. This creates more flexible programs and can simplify prototyping and some object-oriented coding. In a static programming language, such as C or Pascal, a developer must declare the type of each variable before the code is compiled, making the coding less flexible, but also less error-prone.
- Marketing content- Dynamic content is copy that does not remain constant and can change depending on customer or channel. This type is usually generated from a backend system. Static content remains the same across all applications, such as a slogan, logo or terms and conditions.

- Cloud computing subscriptions- When a subscriber chooses a cloud service, they can choose between a dynamic or static pricing model. A dynamic subscription is one that adjusts to how much or how little of a service the customer used while a static subscription is a fixed price that is independent of use.
- Data hashing- Hashing is a method of indexing or retrieving items from a database that can be done dynamically or statically. Dynamic hashing occurs when the set of characters grows, shrinks or reorganizes based on how the data is being accessed. Static hashing occurs when the hash function length always remains the same.

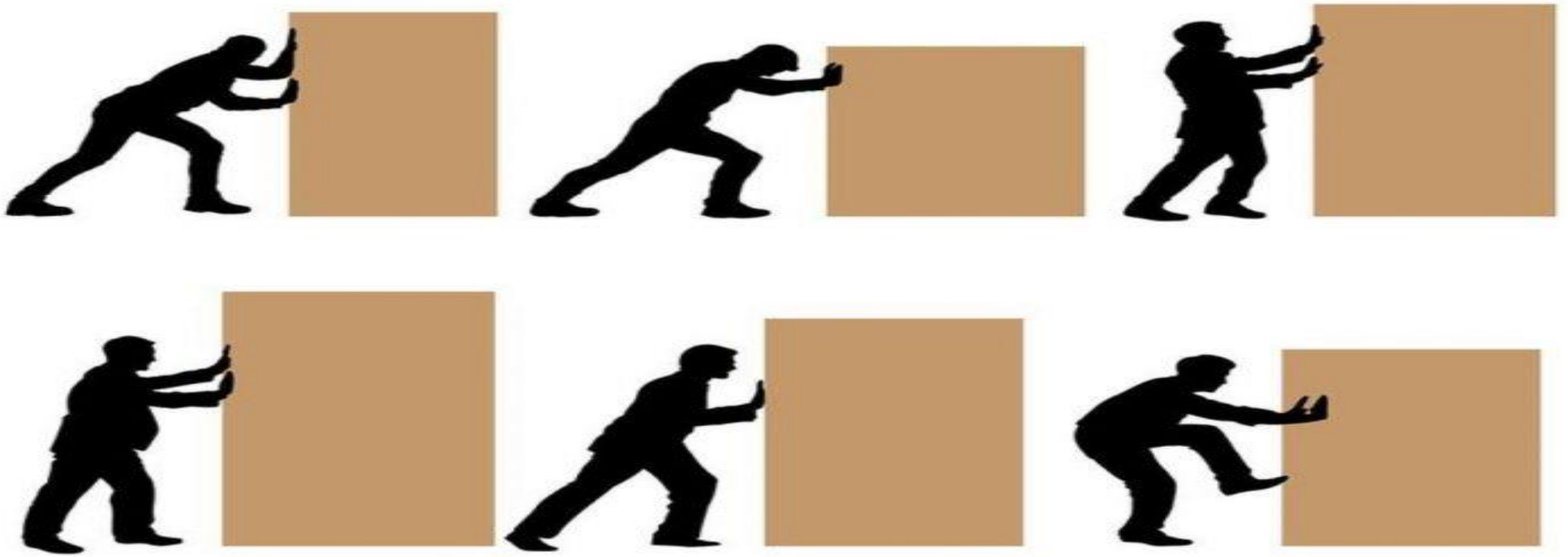
5 Static Force Examples in Everyday Life



- A force acting on an object is said to be a static force if it does not change the size, position, or direction of that particular object.
- The force applied to a structure acts as a load to that particular structure, which is why static force is also known as a static load.
- The static force is independent of time because it does not involve any change in magnitude and direction with respect to time.
- Static force does not allow any sort of change and helps to maintain the state of equilibrium of the object.
- In a nutshell, the static force enables the forces acting on the body or the load to remain constant and allows the state of the body to remain unaffected.

- **1. Weight of a Body**:The weight of a body is nothing but the amount of gravitational force acting on it. The gravitational constant is the same for all the objects present on the surface of the earth; therefore, the weight of a body does not vary or change with change in location. Hence, the weight of a body is a prominent example of a static force.
- **2. Car Resting on a Bridge**: A car resting on a bridge exerts a considerable amount of force and pressure on the contact surface between the bridge and the car. This force does not cause any change in the state, position, or shape of the car or the bridge. Hence, the type of force existing between the bridge and the car is known as static force.

- **3. Pushing a Heavy Block**
- While pushing a heavy block that does not move upon applying a significant amount of force, the presence of a force of friction can be felt. It has a magnitude greater than the applied force and acts on the block from the direction opposite to that of the applied force. This force does not allow any change in the position of the block. Therefore, it is called a static force.



- **4. Ship Floating on Water Surface**
- A ship floating on the surface of water experiences the effect of gravitational force and gets pulled towards the core of the earth, but the buoyant force presented by the water surface to the structure of the boat tends to push it in an upward direction. Both the forces acting from the opposite direction establish a balanced force. The balanced force acts as a static force that helps to maintain the stationary state of the boat and helps it to float on the surface.

- **5. A Coolie Carrying Bags over Head**
- While a person is holding a bag on his head, his/her work done is said to be zero. However, he tends to lose energy and feel tired after a little time. This is because a force is required by the person to hold the bags or the suitcases in a stationary position. This force is static in nature.

5 Dynamic Force Examples in Everyday Life

- Dynamic force is a force acting on an object that causes it to vary or change its size, position, or direction. Force and load are two distinct terms however, they are very much related to each other. A force acting on an object becomes the load to that particular object. This is the reason why a dynamic force is also known as a dynamic load. A dynamic force is time-dependent in nature.

- **1. Hitting a Cricket Ball**
- When a ball thrown in the direction of a cricket player gets hit with force, the direction of motion of the ball gets altered or reversed. The force exerted on the ball with the help of a bat tends to change its position, speed, and direction. Hence, the force exerted by the player on the ball is definitely a dynamic force.

- **2.Moving a Car**
- The driving force supplied by the engine of the vehicle helps the car to accelerate and move. The movement of the vehicle refers to its change in position with respect to time. A dynamic force, when exerted on an object, helps to change the position from one place to another. Also, the change in location caused due to dynamic force is time-dependent. Hence, the force acting on the vehicle responsible for its motion and acceleration is the dynamic force.
- **3. Earthquake**
- An earthquake is caused when the tectonic plates of the earth get displaced from their normal positions. This results in the development of seismic waves. The disturbance or displacement of the earth’s tectonic plates leads to a significant amount of variation and change in the position and direction of the objects present on the earth’s surface. This corresponds to the existence of a dynamic force. The dynamic force here is also known as the seismic force.

- **4. Hammering a Metal**
- Metals possess the ability to get molded into sheets and rods. These properties of a metal are called malleability and ductility, respectively. The process of transforming a raw piece of metal into a perfect sheet or rod involves repeated action of force onto the surface of the material with the help of a heavy object. This force helps the raw metal to transform and change shape therefore, the force in action is known as a dynamic force.

- **5. Churning Milk**
- When a blender or a mixer is used to stir the milk or some other fluid, a certain change in its state is observed. For example, the cream gets separated from the milk on churning it. The process of constant stirring certainly leads to a change in the state of the matter. Hence, the force that is responsible to separate cream from milk comes under the category of dynamic force.

CONCLUSIONS, DISCOVERIES AND RECOMMENDATIONS

- Forces are responsible for maintaining balance and causing motion of bodies or changes in their shape.
- It takes force for objects to stay at rest(static) and to be in motion(dynamic)
- Differentiation (calculus) is used to convert displacement to velocity and velocity to acceleration.
- Integration(calculus) is used to convert acceleration to velocity and velocity back to displacement.
- In a nutshell, the static force enables the forces acting on the body or the load to remain constant and allows the state of the body to remain unaffected
- Dynamic force is also known as a dynamic load. A dynamic force is time-dependent in nature.
- The two major forces in fluid dynamics are pressure and force. The terms force and pressure are used extensively in the study of fluid power.
- Thermodynamic deals with after effects of statics and dynamics forces which keeps a body or an object in constant motion or at uniform rest such as heat, temperature and work done by the object or a body.
- thermodynamics can be used to describe how systems respond to changes in their environment.
- Heating and cooling systems in our homes and other buildings, engines that power our motor vehicles, even the design of buildings and vehicles, all incorporate information from thermodynamics to make them perform well.

REFERENCES AND CITATIONS

- According to Engr Ogunlade Kehinde Samuel, the author of Engineering handbook says “Thermodynamic deals with after effects of statics and dynamics forces which keeps a body or an object in constant motion or at uniform rest such as heat, temperature and work done by the object or a body”.
- More than 2000 years ago, Greece, Egypt and Mesopotamia began constructing water canals and channels – hence engineers had to study the motion of water to develop plans to construct the canals. This led to the invention of methods of storage for water, and the invention of ships as a means of transportation. However, it was not until the period of Leonardo da Vinci that hydraulics, as a science, was properly studied. In Leonardo’s work, many passages describing the flow of water, the destructive forces of water, buoyancy, and hydraulic machinery are mentioned. He also created a sketch showing the movement of water around an object, and the subsequent formation of vortices. After the times of Leonardo, many scientists found interest in the mechanics of fluids – inventing modern hydraulic machinery and improving the maritime industry.

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