

Forces, moments and couples

Force :- is the influence tending to change the motion of the body or produce stress in a stationary body.

① The magnitude of such influence of the body calculated by $M \times A$

② there are different type of stress are discussed

③ When force is applied some distance from the point, so the force measurement a distance component such as pound - inches.

④ In aerodynamics, the point is the center of lift. In weight and balance the point is center of gravity.

⑤ the effect of force actions on stationary body or structure is stress.

⑥ the force acting on stationary body measure in pounds or newtons (N)

⑦ the force has both magnitude and direction, because of this are frequently represented by vectors.

⑧ In both, it is possible to consider force that impinge on the aircraft around central point.

Torque :- the resultant movement caused by the couple force.

moment :

The distance between an applied force and reference point

moment torque of couple force

① is independent. The longer the or any particular arrow, the greater force.

② can be consolidated into a single vector pointing in a direction that is the resultant of the direction force applies.

③ when two force are = in magnitude and in opposite direct, but are applied parallel to each other, it is called couples.

④ The coupled force are not applied at the same point.

⑤ They produce a rotational force upon the body to which they are applied

vector : is represented by an arrow that point in the direction the force is applied.

① using geometry, vector representing force in different directions.

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Center of gravity (CG)

is the balance point for the aircraft.

① An aircraft suspended from this point has no tendency to rotate either a nose up or nose down attitude.

② The CG is the point about which the weight of the airplane (or any object) is concentrated.

Arm (inches)

is the horizontal distance that a part of the aircraft or a piece of equipment is located from a manufacture specified reference point called datum.

① moment is the product of weight (force) multiplied by its arm.

② We use weight and arm to find moment and make sure that CG of the aircraft is unchanged or within acceptable range.

③ Flight personnel must also insure the CG remain within safe limit when loads passengers, baggage and fuel

④ The moment for a piece of equipment installed on an aircraft is in fact a torque value, measured in inch-pound (in-lb)

⑤ Maintenance personnel are required to incorporate CG consideration during routine inspection as well as when aircraft modified with new equipment

→ The tensile strength of a material is measured in pounds per square inch (psi) and calculated by

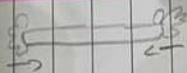
The load (in unit weight) ^{to pull a material apart}
 its cross-sectional area (in distance squared)

Compression:-

is the stress that resists a crushing force.

↳ Compressive strength of a material is measured in (psi)

↳ Compression is the stress that tends to shorten or squeeze aircraft parts



Torsion:-

is the stress that resists twisting,

↳ While an aircraft moving forward, the engine also tends to twist it to one side, but other aircraft component hold it on course forward.

Thus, torsion is created.

↳ Torsion strength of material is its resistance to twisting or torque

Elements of Stress, Strain, and Stress

Element of theory of stress

Whenever an aircraft is in operation, it experiences something called stress.

Reactionary force inside the materials of the components counter the external forces.

There are five major stresses to which all aircraft are subjected

tension compression torsion shear bending

tension is the stress that resists a force that tends to pull something apart

↳ The engine pull the aircraft forward, but the air resists tries to hold it back.

↳ the result is tension, which is stretches the aircraft

External forces are applied to the

1. airframe
2. engine component

This internal resistance to deformation is known as stress.

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Shear :- is the stress that resists the force tending to cause one layer of a material to slide over an adjacent layer.

↳ Two riveted plates in tension subject the rivets to a shearing force.



↳ Usually, the shearing strength of a material, is either equal to or less than its tensile or compressive strength.

↳ Aircraft parts, especially screws, bolt and rivet joints, are often subject to a shearing force.

Bending :- is a combination of compression and tension.

↳ The rod has been shortened (compression) on the inside of the bend.

↳ and stretched on the outside of the bend.

↳ An airplane in flight experiences a bending force on the wing as aerodynamic lift tries to raise the wing.

↳ This force of lift actually causes,

Strain :- if the stress acting on an object's great enough, it can cause the object to change its shape or to become distorted.

① One characteristic of matter is that it tends to be elastic, meaning it can be forced out of the shape when a force is applied.

The object is said to be strained.

② When the force (thrust) of the engine is pulling on gauges, the strain gauges, the amount of distortion is measured and then transferred into the appropriate thrust reading.



deflection beam torque wrench used measures strain by distortion

③ and then, return to its original shape when force is removed.

④ When an object becomes distorted by an force applied force.

⑤ On turbine engine test cells, the thrust of the engine's typically measured by what called strain gauges.

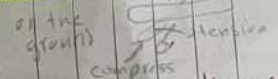
A deflection beam style of torque wrench

1. uses strain on the drive end of the wrench
2. and the resulting distortion of the beam indicate the amount of torque on a bolt or nut.

→ The skin on the top of wing to compress and the skin on the bottom wing to be under tension.



↳ When the airplane is on the ground sitting on its landing gear, the force of gravity tries to bend the wing downward, subjected the bottom of the wing to compress and the top of the wing to tension.



↳ there are other called to controlling the five major Cowling, Fairings, and similar parts may not be subject to sign/fret loss or required a high degree of strength.

these parts must have streamline shapes to meet aerodynamic requirement, such as reducing drag or directing airflow.

Elasticity :- is the ability of a material to return to its original shape after being affected by a force such as stretching or bending.

Example :-

① rubber band and some other material, elasticity is caused by the stretching of the atomic structure when forces are applied.

② metal spring

1. atomic structure changes when force is applied.
2. When the force are removed, the structure returns to the original state.

③ A flexible aircraft wing is a good example of elasticity.

⑤ Opposite of elasticity is rigidity.

without ability of a wing flex and return to its normal shape when stressed it would be much more likely to fail during turbulence, hard landing or affect by other stress.

Pressure and Buoyancy in Liquids

Fluid pressure :-

if the pressure was measured half way down, 8.34, or 21.7 psi.

The pressure is adjustable by varying the height of the column.

with liquid, such as gasoline, it is sometimes referred to as head of pressure.

When rain pressure and static pressure add together, the result is known as total pressure.

pressure based on the column height of a fluid is known as static pressure.

When a fluid is in motion, and its volume is converted to pressure, that pressure known as ram.

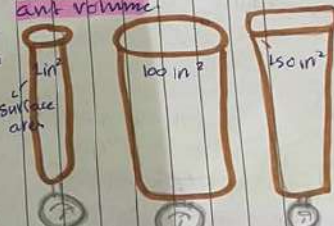
For example :- In the inlet of a gas turbine engine, the total pressure is often measured to provide a signal to fuel metering device or to provide a signal to gauges on the flight deck.

The pressure exerted on the bottom of the container by a liquid is determined by

the height of the liquid.

not by the shape of the container.

Three different shapes and size of containers are full of colored water. They have different shapes and volume.



Container	Height	Pressure	Volume
1 in²	height = 23.1 in	Exert pressure on bottom = 8.34 psi	Volume = 23.1 in³ (one gallon)
100 in²	height = 23.1 in	pressure = 8.34 psi	
150 in²	height = 23.1 in	pressure = 8.34 psi	

one gallon of water weighs 8.34 lb, that's why the pressure is 8.34 psi. Fluid pressure based on column height.

Atmospheric pressure:

is often measured by a mercury barometer.

A second means of measuring atmospheric pressure is with an aneroid barometer.

① This mechanical instrument is a much better choice than mercury barometer for use on airplanes.

② The pressure of the atmosphere is exerted against an thin metal aneroid connected to the pointer.

For example: ③ the standard pressure at sea level is 29.92 "Hg, or 14.7 psi.

④ Aneroid barometers (altimeters) are used to indicate altitude in flight.

⑤ Calibrations are made in thousands of feet rather than psi or inches of mercury.

⑥ At 10,000 feet above sea level, standard pressure is 20.88 "Hg, or 10.1 psi.

⑦ Altimeters are calibrated so that pressure exerted by atmosphere is 10.1 psi, the altimeter will point to 10,000 ft.

Example:

Heavy metal cube is weighed in still air and weighs 10 lb.

The difference it will be Buoyancy force of water

$$10 \text{ lb} - 3 \text{ lb} = 7 \text{ lb}$$

Then weight while completely submerged in water and it weighs 3 lb.

The volume of water which overflows = The volume of the cube.

Buoyancy:

A solid body submerged in a liquid or gas ~~will weigh~~ less than when weighed in free space.

① This is because of upward force called buoyant force.

which any fluid exerts on bodies submerged in it.

An object will float if this upward force of fluid is greater than the weight of the object.

Objects denser than the fluid, even then sink readily.

Appear to lose a part of their weight when submerged.

A person can lift a large weight under water than he or she can lift in the air.

Archimedes (287-212 B.C.)

He discovered that the buoyant force which a fluid exerts upon a submerged body is = to weight of the fluid the body displaces. This statement is referred to as Archimedes principle.

This principle applies to all fluids, gases as well as liquids.

Just as water exerts buoyancy force on submerged body, air exerts buoyancy force on submerged in it.

1. find Density weight by density water $12500 \div 62.4 = 200.3$
2. $200.3 \times 80\% = 160.2 \text{ ft}^3$
3. total volume of floats $200.3 + 160.2 = 360.5 \text{ ft}^3$

Amount of buoyancy force available to an object

Buoyant force = Volume of fluid displaced $\times$ Density of fluid displaced

If the buoyancy force is greater than the object weight, the object will float $B > W \Rightarrow \text{float}$

If the buoyancy force is less than the object weight, the object will sink. $B < W = \text{sink}$

For the object that sink, its measurable weight will be less by the weight of the displaced fluid

If an fluid is fully submerged, volume of fluid displaced = the volume of the object

Example: A 10 ft^3 object weighing 700 lbs is placed in pure water. Will the object float? If the object sinks what is its measurable weight in the submerged condition? If the object will float, how many cubic feet of its volume is below the water line

Because $B < W$, the object will sink. The difference between B and W is 76 lb

two good example of buoyancy:

1. helium filled airship
2. seaplane on floats

Newton 1 law tell us:

$\rightarrow$ When airship float stay's with same height,

the $B = W$

$\rightarrow$ When airseaplane float, the same is

valid, the $B = W$

Then Buoyancy calculated:

The volume of "fluid displaced" = the volume of float that is beneath the water level (submerged part of float)

thus, when airship and seaplane float it means both have $B > W$ more

Example:

takeoff weight = 12500 lb
80%, Density = 62.4

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