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2.2.3 Dynamic

Mass and Weight

1. is a measure of the quantity of matter in an object.
2. in other word,
   1. how many molecules
   2. how many atoms
   or how many protons, neutrons and electrons.
3. The mass does not change regardless of where you take it in the univers
   -> does not change with a change of state
4. the only way to change mass is to add or take away atoms.

Formula:

$$Mass = \frac{W \rightarrow \text{weight}}{A \rightarrow \text{acceleration due gravity}}$$

gravity = 32.2 or g

Example:

$A = 32.2$ fps/s
$W = 32.2$ lb
$m = ??$

$$m = \frac{W}{A} = \frac{32.2}{32.2} = 1 \text{ slug}$$

For example, if we apply force for an object, the tendency will be for the object to move or look at it is that For work, Power, torque to exist there has to be a force that initiates the process.

GE90-115 turbofan engine, powerplant for Boeing 777-300 Pounds of thrust = 115000

-> unit of the force, pound (lb) and Newton (N)

-> When we calculate thrust the turbine engine we use $F = m \times a$ and thrust expressed in pound (lb)

1 lb = 4.448 N

Inertia:

1. is a resistance of an object to change in its state of motion, including changes to its speed or direction
2. Intertia tend to keep an object moving in straight line and constant ~~speed~~ velocity
3. Intertia is a property, needs to be overcome before a stationary body may begin to move from it its present position

object more mass ↑ has more interia ↑ than lesser object for example sand in bucket

4. The object will continue moving at its current velocity, until force causes its speed or direction to change.

5. Slug is a quantity of mass.
gravity = 32.2
mass of 1 slug = 32.2 lb

Weight

1. is a measure of the pull of the gravity acting on the mass of an object
2. The more mass an object has, the more it will weigh under the earth's ~~force~~ of gravity. m↑ W↑
3. The only way for an object to be weighed is for gravity to go away.
4. it is not possible for the mass to go away of object

Formula:

$$W = m \times \text{Gravity}$$

Force:

1. is intensity of impetus
2. or intensity of an input

work:

-> The study of machine both simple and complex, is in one sense a study of energy of mechanical work

-> this is true because

-> All machine transfer input energy

-> work done on the machine to output energy

-> work done by machine

WOR: is done when a resistance is overcome by a force acting through a measurable distance.

Example:

a small aircraft stuck in snow, the two men push against it for a period of time but the aircraft not move. So no work is done in pushing against aircraft

$w = 0$

work: is accomplished only when an object is displaced some distance against a resistive force

Formula:

work = Force x distance

$W = F \times d$ -> linear distance

imperial system $F \Rightarrow lb$

$d \Rightarrow$ Feet or in

so $W \Rightarrow$ Feet-pound or inch-pound

meteric system: $F \Rightarrow N$

$d \Rightarrow m$

$w \Rightarrow$ Joules

1 lb Force = 4.448 N

1 m = 3.28 ft

1 J = 1.36 ft-lb

Example:

$w = ??$ $\quad W = F d$

$F = 150000$ lb $\quad = 150000 \times 3$

$d = 3$ ft $\quad 150000 \times 3 = 450000 \quad = 450000$ ft-lb

refer to the book p=(2.20), last Example of the work:

$F \neq W$ of airplane. Because the airplane being moved horizontally and not lifted / vertically

In all cases, it take less work to move something horizontally than it does to lift it vertically.

power:

-> Force being applied over a measured distance add one more thing over time

-> How long does it take to accomplish the work

-> if weight is to be lifted in a shorter period of time, it will take more power

Formula:

power = Force x Distance / time

$P = \frac{F \times d}{t}$

P => ft-lb/min, ft-lb/s, in-lb/min, in-lb/s

depend how distance and time are mean

horsepower (hp) = 550 ft-lb/s

to convert power to horsepower, follow

1 hp = 550 ft-lb/s

1 hp = 33000 ft-lb/min

1 hp = 375 mi-lb/hr

1 hp = 746 watts ← electricity convention

divide the power by appropriate conversion based on the unit given

38000 $\quad 2 \overline{)76000}$ $\quad \frac{38000}{76000}$

Example:

$p = ??$ $\quad P = \frac{F \times d}{t}$ lbs

$d = 4$ ft $\quad = \frac{19000 \times 4 \text{ ft}}{2 \text{ min}} = \frac{76000}{2}$

$t = 2$ min $\quad$ power $= \boxed{38000 \text{ ft-lb/min}}$

$F = 19000$

$Hp = \frac{38000}{33000} = 1.15$

torque:

as we know, work is force acting through a distance.

Torque:

-> Force acting along a distance

-> is something that creates twisting and tries to make something rotate.

example of work = push object

but torque like wrench, bolt.

Formula:

Torque = Force x Distance

$T = F \times d$ -> rotate

Torque:

L> nothing had to move, because force being along distance not through distance

L> the work unit is inch-pound

L> the torque unit is pound-inches

so both are different not same.

Example of torque:

-> piston engine

-> gas turbine engine

-> piston engine:

Force in pound pushes down on the top of piston and tries to make it move

piston is attached to connecting rod, which attached to the crankshaft at offset.

Offset: length of the wrench.

Force: acting on that length won't create torque

Example:
Force = 500 lbs pushing down
offset distance = 4 in
τ = ??
$\tau = F \times d$
$= 500 \times 4$
$= 2000$ pound-inches
2000 lbs-in

There is a relationship between horsepower of engine and torque of engine

Formula:
Torque = Horsepower x 5252 ÷ rpm

$T = \frac{HP \times 5252}{rpm}$

Example:
engine creates = 180 HP at 2700 rpm, How many pound feet of torque is
Horsepower = 180 Hp
rpm = 2700 rpm
τ = ??

$\tau = \frac{HP \times 5252}{rpm}$

$= \frac{180 \times 5252}{2700}$

$= \frac{945360}{2700}$

= 350 lb-ft

Both type create torque in advance of being able ~~to create work or power~~.

similar to work
ft-lb or ~~ft~~
in-lb

Energy:
↳ Something that givens capacity to perform work.
↳ when we said that we feel full of energy, means we can perform a lot of work.
↳ Energy can be classified as one of two types:
either potential or kinetic

Potential energy PE
↳ being energy at rest
↳ or energy that is stored
PE classified into three groups:
-> that due to position
-> that due to distortion of elastic body
-> which produce work through chemical action

Example due to position:
-> water in an elevated reservoir
-> airplane raised off the ground sitting on jacks

Example due to distortion of elastic body:
-> stretched bungee chord on a piper-tri-pacer
-> compressed spring.

Example of produce work through chemical action:
energy in
-> aviation gasoline
-> food
-> storage batteries

To calculate PE due to position (hight):

Formula: mg

PE = Weight x hight

Example:
weight = 450 000 lb
raised = 4 feet (hight)
PE = ??
$PE = W \times h$
$= 450\,000 \times 4$
= 1800000 ft-lb

Gasoline has a potential to realese heat energy based of BTU -> unit (British thermal)

1 lb = 18900 BTU heat energy.

each BTU capable of 778 ft-lbs of work

1 lb = BTU x ft-lb
= 18900 x 778
= 14704200 ft-lb of work

Kinetic Energy
defined as:
Being energy in motion
Examples:
-> airplane rolling down the runway
-> rotating flywheel on an engine
KE = unit
same as PE
foot-pound / inches-pound

Formula:

$KE = \frac{1}{2}\, mass \times velocity^2$ $\quad m = \frac{W}{g}$

$KE = \frac{1}{2}\, m \times V^2$

-> show mass as weight ÷ gravity
velocity => feet/s

Example:
Weight = 600 000 lbs
V = 200 f/s.
KE = ?? F-lb

$KE = \frac{1}{2} \times m \times v^2$

$= \frac{1}{2} \times \frac{600\,000}{32.2} \times 200^2$

40000

18633.54 $\frac{1}{2} \times 18633.54 \times 40000$

$= 372670$ 800 ft lb

Total energy:

mechanical energy of an object : can be result of

-> its moshion (KE)

-> its stored energy of position (PE)

Total amount of mechanical energy :

sum of PE and KE

Total ME = PE + KE

Total ME = $\underbrace{mgh}_{weight} + \frac{1}{2}mv^2$

Heat and Efficiency

Mechanical Efficiency :

require :

the actual performance of a machine to be as closet as possible to ideal performance of that machine

In addition of friction losses :

Many machine fail to convert some of the input energy to output due to heat loss.

an engine for example :

losses significant heat energy through conduction to the various parts of the engine.

not only the combustion of the fuel need to be maximized,

Transfer of the energy Released must occure with the least amount of heat loss

this is a significant loss for heat engine

Because

engine, which is turning due heat energy from combustion

is always cooler than heat of combustion and will constantly act as a heat sink.

The most efficient heat engines operate at around 50% efficiency with average engine operating at 25-35% efficiency.

Momentum

Newton third law " : "for every action there is an equal and opposite reaction "

is most associated with

-> the force involved jet engine thrust.

-> it also applied to the momentum and the actions of the object that are interacting.

there is allwayse :

equal force of opposite direction when an one object act upon another

check example about 2 object

the momentum will be affected by applied force

Because

force affects acceleration

F = M x A and acceleration will affect momentum.

Momentum = M x V

thus, the force of the object will be equal but their acceleration will be affected differently in relation to their masses

Conservation of momentum :

1. even, object 2 is stationary when object 1 applies force to the object 2, so object 2 will accelerate and giving momentum.

2. object 1 it is allready had moment by its interacting with object 2.

In this case or other case momentum is conserved.

The moment of each object changes but total momentum of both object remain the same.

object 2 will accelerate but object 1 will decelerate. but total momentum of both remain same

this is called conservation of momentum

Impulse :

Force x time called impulse

→ impulse = change in momentum

$F = m \times a$

a = Change in velocity / time

$F = m \times \frac{\text{Change in velo}}{\text{time}}$

$F = m \times \frac{\Delta V}{t} \cdot t$

$\underbrace{Ft}_{\text{impulse}} = \underbrace{m\Delta V}_{\text{change in momentum}}$

impulse $= \Delta M \Delta V$

momen = $m \times V$

Δ Momentum = $m \times \Delta V$

Impulse = chang in mom

$Ft = M \Delta V$

Gyroscopic principle

→ ply a large role of aviation

→ from propeller effect on the behavior of aircraft.

↳ Mechanical gyroscope is comprised of a wheel or rotor with its mass concentrated around its perimeter.

↳ The rotor has bearing to enable it to spin at high speed

↳ 2-31A, different mounting configuration are available for the rotor and axle.

→ which allow the rotor assembly to rotate one or two axes ⊥ to its axis of spin.

→ to suspend the rotor for rotation, the axle is first mounted in a supporting ring.

2-31B,

If brackets are attached 90° around supporting ring from where the spin axle attached,

→ the supporting ring and rotor can both move freely 360°.

→ when in this configuration the gyro said to be "a captive gyro".

→ it can rotate about only one axis that is ⊥ to the ~~axis~~ axis of spin.

2-31C

1. supporting ring can also be mounted inside an outer ring.
2. The bearing point are the same as ((bracket 90°)) as discussed.
3. Attachment of a bracket to this outer ring allows the rotor to rotate in two planes while spinning.
4. Both of these are ⊥ to the spin axis of rotor.
5. A gyroscope with this configuration, two rings + mounting bracket is said to be "free gyro"

why:

Because it's free to rotate about two axes that are both ⊥ to the rotor's spin axis.

2-31D, as a result

supporting ring with spinning gyro mounted inside is free to ~~rotat~~ turn 360° inside the outer ring.

when rotor is rotated at high speed, and due to its inertia

The gyro exhibits a couple unique characteristics this is called gyroscopic rigidity of, rigidity in space.

this means the rotor of a free gyro always point in the same direction no matter which way the base of the gyro is positioned

Gyroscopic rigidity depend upon several design factor

Weight : for given size, heavy mass is more resistant to disturbing forces than a light mass.

Angular velocity : the higher the rotational speed, the greater the rigidity or resistance is to deflection.

Radius at which weight is concentrated :-

Max effect is obtained from a mass when its principle weight is concentrated near the rim, rotating at high speed.

Bearing friction :

Any friction applies deflecting force to a gyro minimizing bearing friction keeps deflecting force at a minimum.

this characteristic of gyro to remain rigid in space is exploited

→ attitude-indicating instrument

→ directional indicator that use gyro.

Precession:

→ is second important characteristic of gyroscope.

→ By applying force to a horizontal axis of the gyro, unique phenomenon occurs.

→ The applied force is resisted.

→ instead of responding to the force by moving about the hori' axis,

the gyro moves in response about its vertical axis.

This predictable controlled precession of a gyroscope is utilized in a turn and back instrument.

The rigidity in space and precession characteristic of gyroscopic action must always be considered when objects of any appreciable mass are rotating.

Figure 2-33,

when a force is applied to a spinning gyroscope,

it reacts as though the force coming from 90° further around the rotor in the direction it is spinning.

→ plane of the applied force, plane of rotation, and plane when the gyroscope response (known as precession) are all ⊥ to each other.

Friction:

N = (mg)

A 400 lb is being pulled a distance 200 ft.

→ this is does not mean the work done (F×d) is 80000 ft-lbs.

why:

Because the person pulling the load is not working against the total weight of the load, but against the rolling friction of the cart.

Friction:

1. is an important aspect of work.
2. without friction it would impossible to walk
3. is a liability as well as asset and require consideration when dealing with any moving mechanism

Measurement of applied force reveals that there are three kinds of friction:

1. one force: is required to start a body moving
2. another: keep body moving at constant speed
3. After a body is in motion, large force: to keep it sliding than to keep it rolling

Three kinds of friction:

→ Starting (static) friction

→ Sliding friction

→ Rolling friction.

Static Friction: (at rest) starting

1. When we tried to slide a heavy object on surface, first will broken looses or start, once in motion, it will slide easily.
2. The breaking loose force is proportional to the weight of body.
3. force necessary to start body moving slowly is F.
4. this is normal force presses body against the surface

Usually weight

Coefficient:-

1. nature of the surface
2. designated by letter "k".
3. can be established for various material
4. is often published in tabular form.

if load (weigh of object) is known,

starting can be used by this formula:

$F = kF'$ ← coefficient

Example:

$F = 10\,lb$ $k = 0.3$

$F = kF'$

$= 0.3 \times 10$

$\boxed{= 3\ lbs}$

$0.3 \times 10 = 00 + 030 = 3.0$

Sliding Friction:

1. is the resistance to motion offered by an object sliding over a surface.
2. it pertains to friction produced after the object has been set in motion.
3. is always less than starting friction
4. The amount of sliding resistance is dependent to the nature of the surface of the object

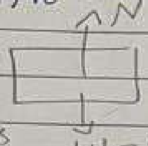
→ surface over which it is slide

→ Normal force between the object and surface

$F = mN$ → force exerted or object exert ⊥ to the surface over which it slide (Normal)

F: ~~Resistive~~ Force due to Friction (pound) lb

m: coefficient of sliding friction



area has ~~no effect~~ on the ~~result~~

$W = mg$

lb

$N = mg$

~~block = textured wood with not slide on any side easier than other, area not include in the formula~~

Rolling friction :-

~~Resistance to motion :-~~

is greatly reduced if an object mounted on wheels or rollers.

rolling friction :

The force ~~of~~ friction for object ~~mounted on wheels or roller.~~

This force :

may be computing by the same equation of sliding friction, but "m" will be ~~much smaller.~~

Example :-

m for rubber tires or concrete or macadam = 0.02

The value of m" for roller bearing

~~is very smally usually ranging~~ from 0.001 to 0.003 and often disregarded

Example: an aircraft with gross weight 79600 lb is towed over concrete ramp what force must be exerted there airplane rolling after once set in motion

Weight = ~~79~~600 lb => N

m => 0.02

$F = mN$

$F = ??$

$= 0.02 \times 79600$

$\boxed{1592.0}$

coefficient of friction :

1. is a value that shows the relationship between → force of friction

2. between → two ~~object~~.

3. and the normal reaction between → the object that involved

↳ it is a value that is used to

→ find an object normal force

→ frictional force when other method are unavailable

Coefficient it can be different things :

→ coefficient of static friction

→ coefficient of kinetic friction.

→ Coefficient of static friction : is the friction force of two object when neither of object is moving or not move

→ coefficient of ~~static~~ kinetic friction : is the friction force of two object when one object is moving, or both object are moving against one another

Coefficient of friction depend on object that are causing friction.

the value usually between 0 and 1, but can be greater than one.

0 => means there is no friction at ~~all~~ ~~of or~~ between object.

it can be friction only when two object touch each other.

1 => means friction force is = normal force

more than 1 means friction is stronger than normal force.

A material such as rubber, have coefficient greater than one

coefficient of friction ~~can also be changed by the mass~~

→ and speed of the moving object