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2.2.2 Kinetics

motion :-

The study of the relationship between the mosition of bodies or objects and the force acting on them. Called Force and motion. the relationship between velocity, acceleration and distance is known as Kinematics

Linear movement :

x → a = constant speed

$a = 0$

motions :-

may be difined as

1. continuity change of position or place.
2. or as process which undergo displacement.

When the object said to be in motion?

1. when the object at different point in space at different time.

when the motion described as uniform?

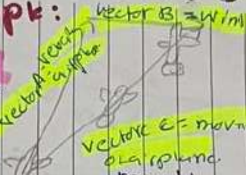
~~the~~ if the distance the object moves remains the same for a given period of time

The object in uniform motion always has a constant speed.

Example :

① adding velocity A and B is called vector ~~an~~ analysis

② when accounting for wind direction and speed, the airplane ends up flying at speed and direction shown by C.



When an airplane move in circular pattern at constant speed,

$\boxed{a = 0}$ The change direction means velocity change.

Measurments:

$$\text{Speed} = \frac{\text{distance}}{\text{Time}} = \frac{x}{t}$$

- if the distance measure in miles and time in hours (mph) → unit of speed m/h
- if the distance measure in feet and time in second (Fps) → unit of speed f/s
- To convert mph to Fps X 1.467.
- Velocity calculated in the same way, but it must recalculated every time direction chang

Speed and velocity :-

speed refers to how fast an object is moving or how far the object will travel in a specific time.

speed doesn't has a direction only magnitude

Example: when airplane leaves New york travels 8 h at speed is omph, there is no direct mension.

velocity :-

is that quantity in which denotes Both the speed of an object and the direction in which the object moves.

can be defined as the rate of motion in a particular direction.

described as being a vector quantity

Vector being a line of specific length

The length of the line indicates the number value

having an arrow on one end or the other.

The arrow indicates the direction in which the numer is acting.

Acceleration :

is defined as a rate of change of velocity.

Example :-

-20 mph → 30 mph

if velocity increased ~~from~~ so the object has been accelerated.

if $V = 10$ mph $a = \frac{10}{5} = 2$ mph/s

$t = 5$ s

$\boxed{\text{to convert mph to fps} \times 1.467}$

$1.467 \times 2 = 2.934$

$\boxed{= 2.934 \text{ fps/s}}$

Acceleration gravity :

32.2 fps/s (9.8 mph/s).

Acceleration = $\frac{V_f - V_i}{t}$

Example :- An air force F-15 fighter is cruising at 400 mph. The pilot advances the throttles to full after burner and accelerate to 1200 mph in 20 s. What is the average acceleration in mph/s and fps/s ?

Formulas

Force = $\frac{\text{Weight (Velocity final - Velocity initial)}}{\text{Gravity (time)}}$

Force = $\frac{w(V_f - V_i)}{gt}$

② unless ~~it~~ acted on by an external force.

Example :

a ball rolling down a hill will continue unless force stops it.

④ **momentum :**

Bodies in motion have the property.

⑥ Example :

A train moving at even low velocity is difficult to stop because of it large mass.

③ **Second law :-**

when a force act upon the body, the momentum of that body is change,

The rate of change of momentum is $\propto$ to the applied force

⑤ proportional

A body that has great momentum has a strong tendency to remain in motion and hard to stop.

Newton second law

$F = ma$

mass $= \frac{W}{g}$

$\frac{W}{g} = m\frac{a}{g}$ $\frac{V_f - V_i}{t}$

$A = \frac{V_f - V_i}{t}$

$V_i = 400$ mph $V_f = 1200$ mph

$t = 20$ s

$= \frac{1200 - 400}{20} = \frac{800}{20}$

$1200 + 400 = 800$

$2 \overline{)80} = 40$

$\boxed{= 40 \text{ mph/s}}$

in fps/s

$40 \times 1.467 = \boxed{58.680 \text{ fps/s}}$

$1.467 \times 40 = 58.680$

or

$\boxed{58.7 \text{ fps/s}}$

If to calculate A due to gravity

$A = 58.7$

$g = 32.2$

$\frac{58.7}{32.2} = 1.82$ G's

Newton's laws of motion

① **First law :** object at rest tends to remain at rest and object in motion tend to remain in motion at same speed and direction.

Example :

A turbojet engine is moving 150 lb of air per second through the engine. The air enters going 100 fps and leaves going 1200 fps. How much thrust in pounds, is the engine creating

$w = 150$ lb

$v_i = 100$ fps

$v_f = 1200$ fps

$g = 32.2$ fps²

$t = 1$??

$F = ??$

$$F = \frac{w(v_f - v_i)}{g\,t}$$

$$= \frac{150(1200 - 100)}{32.2(1)}$$

$$= \frac{150(1100)}{32.2} = \frac{165000}{32.2} = \boxed{512.4 \text{ lb}}$$

① $1200 - 100 = 1100$

② $1100 \times 150 = 165000$

③ $165000 \div 322 = 512.4$

$322 \times 5 = 1610$

$322 \times 2 = 644$

$322 \times 4 = 1288$

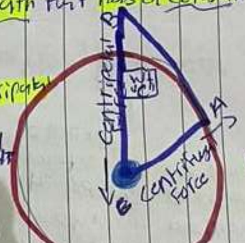
This forward force cause the aircraft to move forward

turbofan engine exerts force on the air entering the inlet duct, causing it to accelerate out the fan duct and tailpipe.

air accelerate to the rear is the action, and the force inside the engine that make it happen is the reaction also called thrust

Rotational movement

Circular motion :- is the motion of an object along a curved path that has a constant radius.



1. String exerts a centripetal force on an object
2. object exert an equal but opposite force on the string. Newton 3ed law
3. The force that is = to centripetal force, but acting opposit called centrifugal force.
4. Centripetal force always $\propto$ mass of object in circular motion ($F_c \propto m$) "proportional"

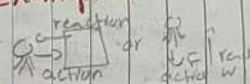
Third law :-

For every action there is an equal and opposite reaction.

Newton 3rd law is often called the law of action and reaction.

This means that force applied to an object, the object will supply resistive force exactly = and opposite direction of force applied.

Example :-



Force always occur in pairs.

acting force: means the force one body exerts on a second body

reacting force: means the force second body exerts on the first body.

Example:

when an aircraft propeller pushes a stream of air backward with F = 500 lb, the air pushes the blades forward with F = 500 lb.

5. ~~ma~~ if the mass double, the pull of string must be doubled to keep the object it is circular path. (m ↑2 F ↑2) speed remain constant

6. F_c is inversely proportional to the radius of circle.

$$\left\{ F_c \propto \frac{1}{r} \right\}$$

Formula:

centripetal force $= \dfrac{mv^2}{r}$

$$\frac{w}{g} \leftarrow F_c = \frac{mv^2}{r} \rightarrow fps$$

$r \rightarrow ft$

Example: what would the centripetal force be if a 10 pound weight was moving in 3 ft radius circular path at velocity of 500 fps?

$$F_c = \frac{mv^2}{r}$$

$F_c = ??$
$m = 10\ lb$
$r = 3\ ft$
$v = 500\ fps$
$m = \frac{10}{32.2} =$

$$F_c = \frac{10(500)^2}{3}$$

$$\frac{10(250000)}{32.2 \cdot 3}$$

$$\frac{2500000}{966} = 2588 \text{ lb}$$

Pendulums: are unique in that the period of a pendulum will remain the same as it swing back and forth.

even though it gradually displaces less and less with each ensuing swing.

This regularity has resulted in pendulum motion to be the regulation motion in mechanical clocks.

Theory of vibration, Harmonic and Resonance.

Vibration اهتزاز is periodic motion caused by oscillation of the parts of a fluid or an elastic solid who equilibrium has been disturbed

An electromagnetic wave also experiences vibration.

while this can be harmless in an aircraft, vibration can also be destructive.

something that vibration has back and forth across a central point.

Periodic movement

Pendular motion:-

Periodic motion:- is evident during pendular motion and vibration.

A pendulum is a weight suspended from a fixed point so it can swing freely back and forth.

The motion is characterized by a few important variable

The period is the time it takes for the weight to complete one cycle of motion

it is dependent on the Length of suspending rod or string.

period varies directly with $\sqrt{L}$ and inversely with $\sqrt{g}$

$$T \propto \sqrt{L} \text{ and } T \propto \frac{1}{\sqrt{g}}$$

Formula:

$$T = 2\pi\sqrt{\frac{L}{g}}$$

period in second (s)

Length of the pendulum in feet or meter

acceleration of gravity (32.2 ft/s² or 9.8 m/s²)

Vibration motion also known as harmonic motion.

It is regular in nature.

Vibration is characterized by having a period, which is time it takes to complete cycle of movement.

It's frequency is the number of time per second or complete cycle occurs.

The unit of measure for f is hertz (1Hz).

one cycle per second = one hertz

$1/s = 1\,Hz$ $\quad f = \frac{1}{T}$

Vibration also has amplitude.

Amplitude is measured from midpoint of the motion to the point max displacement

Example: on a musical instrument it's f sets the pitch of tone created when the string plucked, but A ~~dep~~ related to the loudness.

$T = \frac{1}{f}$

$$T = 2\pi\sqrt{\frac{m}{k}}$$

T → period in seconds

m → mass in pound (lb) or kilograms (kg)

k → (lb/ft) (N/m) Force in pound/feet or newton/meter

~~Velocity ratio~~ :- Resonance :

types of All matter, regardless of whether it is solid, liquid or gas have a natural frequency at which the atom within that matter vibrate.

This transfer of energy is known as resonance.

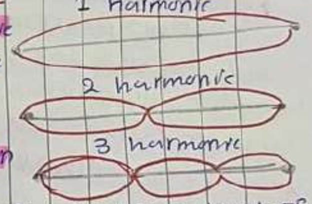
If two piece of matter have the same natural frequency, and one of them start to vibrate, it can transfer its wave energy to other one and cause it to vibrate.

Some piston engine powered airplane have rpm range that they are placarded to avoid because spinning the prop at that rpm can cause vibration problems.

Harmonics:-

When an object is forced to vibrate at its natural frequencies, if vibration in a manner such that standing wave pattern is formed within object

For object that vibrate in regular and periodic fashion, the harmonic frequencies are related to each other by simple whole number ratios.



The first three levels of harmonic vibration.

Velocity ratio, mechanical Advantage and Efficiency ~~Velocity Ratio, mechanical Advantage and Efficiency~~

Simple machine :-

A machine is any device with which work may be accomplished.

↳ In application, machines can be used for any of the following purposes, or combination of these purposes.

1. Machines are used to transform energy as in the case of a generator transforming mechanical energy into electrical energy.
2. Machines are used to transfer energy from one place to another, in example connecting rods, crankshaft, and reduction gears transferring energy from aircraft engine to its propeller.
3. machines are used to multiply force, for example a system of ~~pulleys~~ pulleys may be used to lift a heavy load. The pulley system enables the load to be raised by exerting a force that is ~~similar to~~ smaller than the weight of the load.
4. machines can be used to multiply speed. a good example is the bicycle, by which speed can be gained by exerting a greater force.
5. machines can be used to change the direction of a force. Example flag hoist.

raising the flag toward the top of the pole

There are only six simple machines.

They are the lever, pulley, wheel and axle, inclined plane, screw and the gear.

The pulley (block and tackle), wheel and axle and gear operate on the machine principle of lever.

physicists recognize only two basic principle in machines

1. the lever
2. inclined plane

Velocity Ratio :-

is the ratio of the distance traveled by the effort compared to the distance traveled by the load in a simple machine.

Friction is not included in the computation.

Figure 2-14, Because of lever distance between handle and wheels,

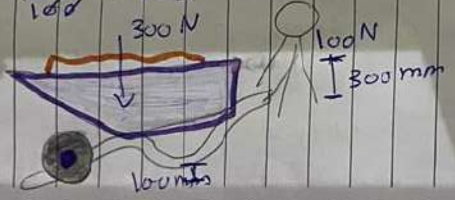
1. the worker has pulled the handle up distance 300 mm,
2. causing wheelbarrows supporting legs to raise by 100 mm.

velocity ratio: $\frac{300}{100} = 3:1$

effort exerted of 100 N for d = 300 mm = result of 300 N moved a d = 100 mm

velocity ratio = $\frac{\text{distance moved by effort}}{\text{distance moved by load}}$

$\frac{300}{100} = 3:1$



The wedge and screw use the principle of inclined plane.

Mechanical Advantage

1. it cannot mutiply force and speed at the same time. in order to gain one, it must lose the other.

2. machine has more power going out than going in and that is not possible

3. mechanical advantage is a comparsion of the Fout to the Fin, or din to dout.

4. If there is a mechanical advantage in term of force, there will be a fractional disadvantage in term of distance.

Formula

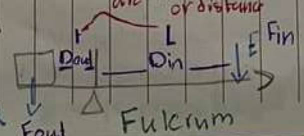
Mechanical advantage = Force out ÷ Force in

or

Mechanical advantage = Distances in ÷ distance out

$$MA = F_{out} \cdot D_{out} = F_{in} \cdot D_{in}$$

$$MA = \frac{F_{out}}{F_{in}} = \frac{D_{in}}{D_{out}}$$



$F_{in} \cdot 60 = 500 \cdot 12$

$\frac{F_{in} \cdot \cancel{60}}{\cancel{60}} = \frac{600\cancel{0}}{6\cancel{0}}$

$\boxed{F_{in} = 100 \text{ lb}}$

$500 \times 12 = 6000$

$6000 \div 60 = 100$

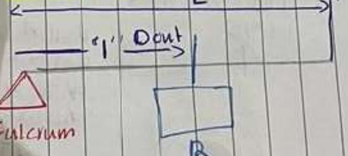
The mechanical advantage

$\therefore MA = \frac{F_{out}}{F_{in}} = \frac{50\cancel{0}}{10\cancel{0}} = \frac{5}{1} = \boxed{5 \text{ lb}}$

point of N

Second lever:

has fulcrum at one end and the effort is applied at the other end. the Resistance is between these points



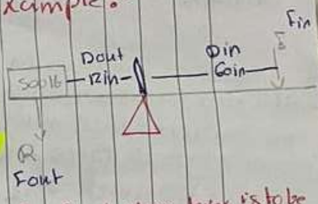
The lever:

is the simplest machine and perhaps the most familiar one, is the lever

First lever :-

The furlcrum is located between the effort and the resistance.

Example:-



The first class lever is to be used to lift 500 lb w. the distance from the weight to the furclum is 12 in and from the fulcrum to the applied force effort is 60 in. How much force is required to lift the weight?

$F_{out} = 500$ lb

$D_{out} = 12$ in

$F_{in} = ???$

$D_{in} = 60$ in

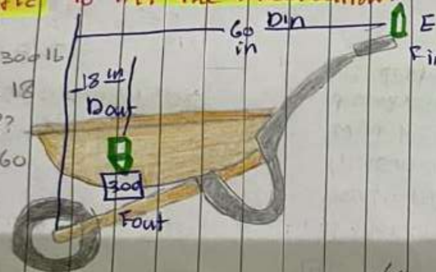
$\frac{F_{out}}{F_{in}} = \frac{D_{in}}{D_{out}}$

$\frac{500}{F_{in}} = \frac{60}{12}$

$F_{in} \cdot 60 = 500 \cdot 12$

Example :- the distance from the center of the wheel to the handle 60 in. The weight in the bucket is 18 in from center of wheel. if 300 lbs is plased in the bucket. how much force must be applied at the handle to lift the wheel barrow?

$F_{out} = 300\ lb$
$D_{out} = 18$
$F_{in} = ??$
$D_{in} = 60$



$$MA = \frac{F_{out}}{F_{in}} = \frac{D_{in}}{D_{out}} = \frac{300}{F_{in}} = \frac{60}{18}$$

$$= F_{in} \cdot 60 = 300 \cdot 18$$

$$\frac{F_{in} \cdot \cancel{60}}{\cancel{60}} = \frac{540\cancel{0}}{6\cancel{0}}$$

$$\boxed{F_{in} = 90\ lb}$$

300
× 18
2400
3000
5400

$540 \div 6 = 90$

Mechanical Advantage :

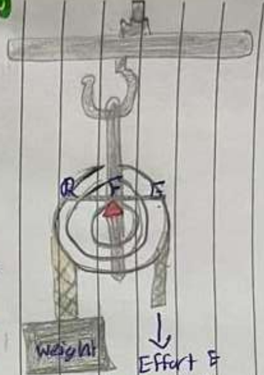
$$MA = \frac{F_{out}}{F_{in}} = \frac{30\cancel{0}}{9\cancel{0}}$$

$$\boxed{= 3.33}$$

$30 \div 9 = 3.333$

Single fixed pulley

1. is a first class lever with equal arm "l" = "L"
2. "R" to "F" = "F" to the "E".
3. when it is equals so MA is 1.
4. The only advantages of single fixes is to change the direction of force, or pull on the rope.



Single fixed pulley

Single movable pulley

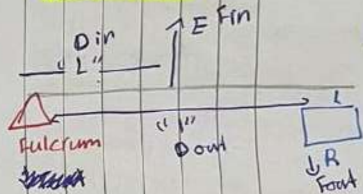
1. used to magnify the force exerted
2. pulley is the movable
3. act like second lever.
4. E arm (EF) being the diameter of pulley and R arm (FR) the radius of pulley.
5. mechanical advantage is two, because diameter double the radius.

Block and tackle

1. is made up of mutiple pulleys
2. some fixed and some moveable
3. block and tackle is made up of four ~~each~~ pulleys. two being fixed and two being moveble.

Third level

are easily recognized because the effort is applied between the fulcrum and the distance.



The pulley :-

are simple machine in the form of a wheel mounted on a fixed axis and supported by a frame

1. The wheel or disk is normally grooved to accommodate a rope.
2. Wheel sometimes referred to as "sheave" or "sheaf".
3. The frame that support the wheel is called block
4. Block and tackle consists of pair of blocks

Each block contain one or more pulleys and rope connecting the pulley

The Gear

The two gear with teeth on their outer edge act like first lever.

2. The gear with F_{in} is called drive gear

3. The ~~gear~~ other is called driven gear.

4. the resistance arm is the diameter of the drive gear.

5. two gears turn in opposite directions (The bottom one clockwise and the top counterclockwise)

$$\frac{\text{effort arm}}{\text{resistance arm}} = \frac{F_{out}}{F_{in}} = \frac{9 \div 3}{12 \div 3} = \boxed{\frac{3}{4} = 0.75}$$

This called fractional disadvantage

less F_{out} than F_{in}

mechanical advantage

$$\boxed{\frac{12 \div 3}{9 \div 3} = \frac{4}{3} \text{ or } 1.33}$$

$4.0 \div 3 = 1.333$

The Bevel gear:

1. are used to change the plane of rotation

2. so shaft turning horizontally can make a vertical shaft rotate

1. Is typically of what would be found in a propeller reduction gearbox

2. power shaft output of the engine would drive the sun gear in the middle which rotate the planetary gear and ultimately ring gear

Gear Ratio :-

1. The velocity ration and gear ratio of a geared drive are essentially the same thing.

2. gear is calculated by comparing The number of teeth on a drive gear to the number of teeth on the driven gear

-> result is a ratio that ~~that bring~~ brings into focus the amount of mechanical advantage produced by the assembly.

3. speed ratio and velocity ratio can also be calculated.

-> instead of comparing number of teeth on the gears, the rotational speed of each gear is considered.

3. The size and their number of teeth of gear determine mechanical Advantage

4. Whether F being increased or rpm is increased. If each gear has the same number of teeth, there would be no change in force or rpm

The warm gear

1. has extremely high mechanical advantage.

2. F_{in} goes into spiral worm gear which drives the super gear.

3. 1 complete revolution of warm gear only makes the super gear turn an amount = to one teeth

4. mechanical Advantage = to the numer of teeth on super gear.

The planetary sun gear system

4. When two gears are used in aircraft component, the rotational speed of each gear is represented "speed ratio"

5. The number of ~~gear~~ teeth in gear ↓

The rotational speed of that gear ↑

Speed ratio of two gear inverse of gear ratio, $\boxed{\text{Example:}}$

gears ratio $2:9 = \frac{2}{9}$, so

speed ratio $= \frac{9}{2}$ → $9:2$

Example: A pinion gear with 10 teeth is driving a super gear with 40 teeth. the super gear is rotating 160 rpm. Determine the speed of the pinion gear.

(1) $\frac{\text{Teeth in pinion Gear}}{\text{Teeth in super Gear}} = \frac{\text{speed of super Gear}}{\text{speed of pinion Gear}}$ (2)

$\frac{10}{40} = \frac{160\ \text{rpm}}{??}$

$10 \cdot S_p = 160 \cdot 40$

$\frac{\cancel{10} \cdot S_p}{\cancel{10}} = \frac{640\cancel{0}}{1\cancel{0}}$

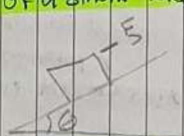
$\boxed{S_p = 640\ \text{rpm}}$

$160 \times 40 = 000 + 6400 = 6400$

$24 \times 2 = 48$, $24 \times 3 = 72$, $24 \times 4 = 96$

inclined plane:

is a simple machine that facilitates the raising or lowering heavy object by application of a small force over a long distance.



2. two example of inclined plane are

→ mountain highways

→ and loading ramp on the back of truck

Example to calculate force needed to push airplane up the ramp,

Effort (E) × Effort Arm (L) = Resistance (R) × Resistance Arm (l)

(F_{in}, D_{in}, F_{out}, D_{out})

1600 lb weighing → force

$F_{in} = ??$

$F_{out} = 1600\ \text{lb}$

Effort Arm (L) = 24 in (D_{in})

Resistance Arm (l) = 6 in

$F_{in} \cdot D_{in} = F_{out} \cdot D_{out}$

$F_{in} \cdot 24 = 1600 \cdot 6$

$\frac{F_{in} \cdot \cancel{24}}{\cancel{24}} = \frac{9600}{24}$

$\boxed{F_{in} = 400\ \text{lb}}$

$1600 \times 6 = 9600$

$9600 \div 24 = 400$

Example: if the cruising speed of airplane is 200 knots and max speed 250 knots, what is the ratio of cruising speed to max speed

cruising speed = 200

max speed = 250

Ratio $= \frac{\text{cruising speed}}{\text{max speed}}$

$= \frac{20\cancel{0}}{25\cancel{0}}$

$= \frac{20 \div 5}{25 \div 5} = \frac{4}{5}$

$\boxed{\text{The ratio is } 4:5}$

Another example, Express the ratio 9:5 as a ratio with denominator of 1.

$\frac{9}{5} = \frac{?}{1}$

$9(1) = 5(?)$

$\frac{9}{5} = \frac{5(?)}{5}$ → $\frac{9}{5} = \frac{1.8}{1}$

$9 \div 5 = 1.8$

$\boxed{9:5 \text{ same as } 1.8:1}$

NO:

DATE:

The Wedge

1. The chisel is a good example of wedge.
2. The chisel might be 8 in long and only $\frac{1}{2}$ in wide, with a sharp tip and tapered sides.
3. The 8 in length is the effort arm and $\frac{1}{2}$ in width is the resistance arm.
4. this chisel would provide a force advantage (mechanical advantage) of 16.

$$MA = \frac{\text{effort arm}}{\text{resistan arm}} = \frac{8}{\frac{1}{2}} = 16$$

$$8 \div \frac{1}{2} \Rightarrow 8 \times \frac{2}{1} \boxed{= 16}$$

Efficiency :-

Mechanical Efficiency is always a goal of the aircraft designer.

losses due to heat, friction, deflection, and wear cause a machine to be inefficient.

Efficiency refers to how well a machine uses input energy (Ein)

A machine that minimize these losses in said to be efficient.

Efficiency is measured in percentage.

No machine can be 100% efficient.

Equation:

Efficiency = Mechanical Advantage ÷ speed ratio x 100

$$\text{Efficiency} = \frac{MA}{\text{speed ratio}} \times 100$$

Another way

$$\text{Efficiency} = \frac{\text{Measured performance}}{\text{ideal performance}}$$