1582185 A.C.2 WAKEFIELD, H.E.
123 ENTRY.

Form 714.

ROYAL AIR FORCE.

Rough Notebook for use in Laboratories and Workshops.

T. 9686. Wt. 8030. 350,000 Bks. 2/41. E. J. & S. Ltd.

Questions & Answers

1. It is a compound of iron & carbon called ferro carbide.

2. ... is a laminated structure of cementite + ferrite (iron) it is the constituent of steel

Solid solution is an intimate mixture of one substance dissolved in another in the solid state.

Austenite is a solid solution of cementite in ... It is formed when steel is heated above the upper critical point.

Critical or change points are those temperatures at which structural changes take place in the solid metal. Lower critical point is the temp at which the change from pearlite steel to austenite begins (also called A.C.1)

Upper critical point is the temperature at which the change is complete (also called A.C.3)

Recalescent points are the change points recorded on heating the metal which appear to glow less brightly at that temperature.

Recalescent points are change points observed on cooling the metal which appear to glow more brightly at that temp.

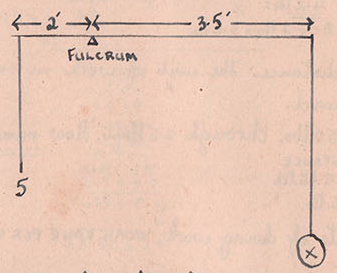
6. ... is that alloy which changes completely from solid solution to normal particle solution (or vice versa) at a temp lower than any other constituent. It has only one critical point for example 8% carbon steel or pearlite.

FORCE:- is that which will cause a body to move faster or to move slower.

The units of force in British engineering practise is the pound weight.

The pound weight is the force exerted by gravity on a mass of 1 lb.

Moments of a force



It is required to find the value of X

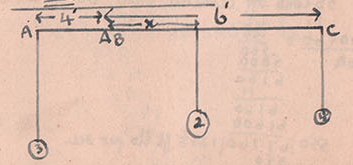
Sum of clockwise moments = Sum of anti-clockwise moments.

$$3.5x = 2 \times 5$$

$$3.5x = 10$$

$$x = \frac{10}{3.5}$$

$$x = 2.86 \text{ lb.}$$

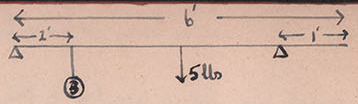


where must a 2lb weight be placed between B + C so that the lever is just kept horizontal.

$$1\tfrac{1}{2} \times 6 + 2x = 3 \times 4$$

$$9 + 2x = 12$$

$$2x = 3 \qquad x = 1\tfrac{1}{2} \text{ feet.}$$



The weight of the lever is 5lbs. Find the reaction on each support.

$5x3+3x2 = 5x$

$21 = 5x$

B $4{\cdot}2$lb $= x$

A $8-4{\cdot}2$lb $= 3{\cdot}8$lb.

Work = force x distance. The unit of work in engineering practice is the foot pound.

A crane raises 650 lbs. through 25 ft. How much work has been done?

WORK = FORCE x DISTANCE

= 650 x 25 ft.lb.

= 16250 ft.lb.

Power:- is the rate of doing work, WORK DONE PER SECOND or $\frac{\text{WORK DONE}}{\text{TIME}}$.

An aeroplane weighing 5 tons rises through a vertical distance of 1000 ft. in 5 mins. What power is the aircraft developing during ascent?

$\frac{5 \times 2240 \times 1000}{5 \times 60} = 37{,}333{\cdot}3$ Ft.lb. per sec.

Horse power:- is the rate of doing 550 ft. lbs. of work per second.

$\text{H.P.} = \frac{\text{WORK DONE}}{\text{TIME} \times 550}$

1/ A crane raises 55 tons of cement thro' 66 in 2 mins. What H.P. is developed?

$\frac{55 \times 2240 \times 66}{2 \times 60} = 55 \times 560 \times 66 = 55 \times 6160 = 6160 \times 11 = 61600$

550)67760(123⅕ ft lb per sec.
550
1276
1100
1760
1650
110
550

2/ A small engine of cyl. bore 2·8 and stroke 4" has an average pressure 50 lb and makes 1000 revs per min. What H.P. is developed? (N.B. is 2 stroke).

$\frac{2 \times 1{\cdot}96 \times 6}{7 \times 25} = \frac{23{\cdot}52}{175}$

$\frac{22}{7} \times 1{\cdot}4^2 \times 4 \times 50 \times 60 \times \frac{1000}{25} \times \frac{550}{14}$

$\sqrt{50} \times 12 \times \frac{22}{7} \times 1{\cdot}96 \times 4 \times \frac{60}{1000} \times \frac{1}{550}$

$1{\cdot}01 \times 12 \times \frac{2}{7} \times 1{\cdot}96 \times \frac{6}{25} \times \frac{25}{5}$

$\frac{285{\cdot}0624}{125} =$

125)285·0624(2·2804
250
350
250
1006
1000
624

1·01
24
404
2020
24·24
1·96
14544
218160
242400
475104
6
2850624

1·96
12
2352

1000 every 60
1 every $\frac{60}{1000}$

7·07

)50(7)50·00(
49
14)10000
9849
151

3/ A loco. has a mass of 120 tons & maintains a speed of 30 mph. up a slope of 1 in 100. If one slope is 2 miles long what extra h.p. is required to make the ascent?

$\frac{1}{100} \times 1760 \times 3 = \frac{528}{10} = 52\frac{3}{5}$

$\frac{120 \times 2240 \times \frac{1}{100} \times 1760 \times 3}{550 \times 4} =$

$\frac{120 \times 2240 \times 52{\cdot}8}{550 \times 4} =$

2240
3
6720
52·8
53760
134400
3360000

55)3548160(6451·2 hp.
330
248
220
281
275
66
55
1100
110

N.B. Mechanical advantage = $\frac{\text{load}}{\text{effort}}$

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

Effeciency = $\frac{\text{work done by load}}{\text{effort}}$

N.B. The effeciency is always less than 1

Effeciency = $\frac{\text{Work got out}}{\text{Work put in}}$

MECH. AD = $\frac{R}{E} = \frac{4}{3} = 1\frac{1}{3}$

VEL. RATIO = $\frac{D}{d} = \frac{1}{\frac{1}{2}} = 2$

EFFECIENCY = $\frac{R \times d}{E \times D} = \frac{4 \times 1}{3 \times 2}$

$= \frac{4}{6} = \frac{2}{3}$

Density = wt. of 1 cu. ft of substance

Specific gravity = $\frac{\text{wt. of substance}}{\text{wt. of equal substance of water}}$

Pressure = Force per unit are (lbs. per sq. inch)

Pressure = $\frac{\text{Force (lb.)}}{\text{Area (sq. in.)}}$ Density = $\frac{\text{Weight (lb.)}}{\text{Volume (cu. ft.)}}$

Pressure = Ht. x Density (lbs./sq. ft.)

Degree of hotness = Temperature.

1. Heat to raise 1 lb. water through 1 Deg C.
   = 1 Centigrade Heat Unit (CHU)

2. Heat to raise 1 lb water through 1 deg F
   = 1 British thermal Unit (B. Th. U.)

Fuels

Hydrocarbons

Mixture Strength - ratio of air / fuel by weight.

A. Chemically correct - ideal, worked out from chemical equation (15 : 1 for petrol).

B. Rich mixture - contains less air than A 12 : 1 = 20% rich.

C. Weak mixture contains more air .. .. 18 : 1 : 20% weak.

Density of a gas varies with pressure + varies inversely with temperature.

Cylinder temperature:-

Flame rate -1 rapid for rich or correct mixture.
2 slow for weak mixture.

causes high cyl. temp in (2).

Detonation - spontaneous ignition of part of the charge - due to high cyl. temp. + pressure.

Over Rich - 1 take-off. Extra fuel for cooling, to prevent detonation.
2 Rich (12-1) full power, normal running.
3 Weak (16-1) cruising under small load. Gives fuel economy.

Energy equation: Total energy in a gas is constant.

Pressure energy + kinetic energy = constant.

1 Volatility:- property of vapourising easily.
2 Calorific ~~heat~~ value:- heat produced in combustion of 1 lb. of fuel.
3 Latent heat of vapourisation:-
4 Freezing point:- should be as low as possible (about -50°C to -60°C)
5 High anti-knock value:- can be raised by
(1) Blending (e.g. benzole)
(2) Doping (with tetra-ethyl-lead)

Requirements of A/c carburettor.

1 the liquid fuel must be broken up as far as possible and thoroughly mixed with the air.
2 in normal working conditions a constant mixture strenght must be maintained.
3 a rich mixture must be supplied for idling.
4 extra fuel must be supplied during acceleration.
5 provision must be made for weakening the mixture when cruising at reduced power.
6 provision must be made for enriching the mixture for max. power + take off.
7 means must be provided for preventing the mixture from becoming richer with increase in altitude.
8 ice must be prevented from forming within the carburettor.
9 as far as possible the carb. should be automatic, simple to adjust, + robust enough to remain in adjustment under service conditions.

Idling System:-

Volumetric Efficiency :- $= \frac{\text{Wt. of charge drawn in}}{\text{Wt. of charge filling cyl. at S.T.P.}}$

To increase power, we raise V.E. by increasing density of charge by supercharging.

Reasons for supercharging –

1. To increase the power of an engine of given size + weight.
2. To maintain the sea-level power up to a high altitude.

Acceleration :- Sudden throttle opening causes fuel deposition + the mixture tends to become weak. Prevented by small pump discharge of fuel.

Rated Altitude – that at which full power is obtained at full throttle, with climbing boost + standard RPM.

Supercharger –

1. Fixed gearing
2. Two-speed gearing
3. Exhaust-driven turbine.

STRESS When a body is acted upon by a force these forces are called stress.

Stress is measured as internal force per unit ~~measure~~ area, & so measure the tendency to break.

Measurement of stress :- Stress equals $\frac{\text{applied load}}{\text{area transmitting load}}$.

Strain when a body is acted upon by a force it is deformed. This deformation is called strain.

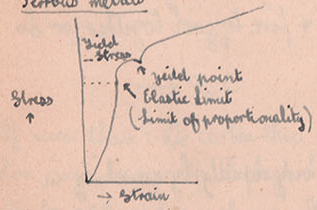
Measurement of strain, tensile strain = $\frac{\text{extension}}{\text{original lenght}}$

compressive strain = $\frac{\text{contraction}}{\text{original length}}$.

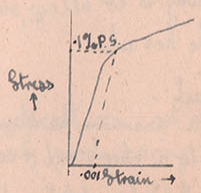
Elasticity. If strain dissappears when the force is removed the body is elastic.

Relation between stress & strain. ~~to~~ within the elastic limit, stress is proportional to strain. (Hookes law). $\frac{\text{Stress}}{\text{Strain}}$ = Constant (E)

Ferrous metals



Non-Ferrous



Proof Stress :- the test piece is subjected to a specified stress for 15 secs. The stress is removed & if there is no permanent deformation the yeild point must be higher than the applied stress.

Heat treatment normally applies to high carbon steels.
Steel when heated undergoes several changes of internal structure which affect it properties. These changes in the reverse order take place on cooling only if a cooling is slow. The various changes take place at fairly well defined temp.'s. Steel should be heated slowly. Do not insert directly into the furnace.

Normalising:- object,
1. To relieve the stresses set up by previous work, such as forging + bending +
2. To produce a good internal structure.

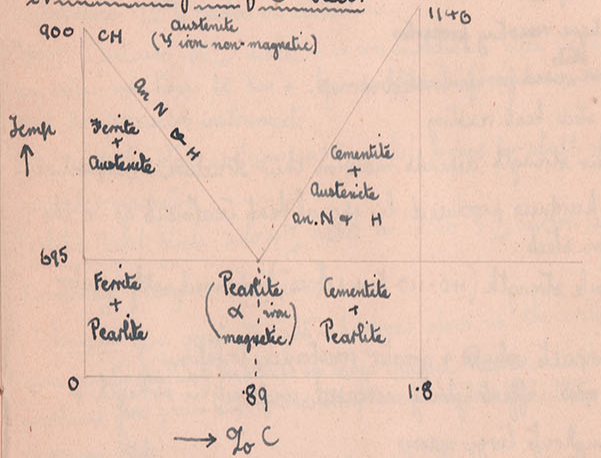
Method:- Heat to a cherry red heat + allow to cool freely in air.

Annealing:- object,
1. To produce softest possible state when cold.
Method:- heat to a cherry red heat + cool as slowly as possible
N.B. The best way is to allow steel + fire to cool together, or to bury steel in the hot ashes.

Hardening:- object:-
1. To produce a maximum hardness.
Method:- heat to a cherry red + cool very rapidly by quenching in water, or oil, which is less drastic.
The rapid quenching prevents the usual change of structure + traps the steel in a hard intermediate form. This form is only stable providing that the steel is not heated above 200°C in use.

Tempering:- Object.
1. To relieve excessive brittleness consequent on hardening while retaining sufficient hardness.
Method:- Reheat to the temp. appropriate to the purpose of the two + quench.

Equilibrium Diagram of C-Steel.



If more than 1·8% carbon then you get cast iron. Cast iron used for piston rings, because of its high elasticity, good wearing, self-lubricating.
1. Up to ·25% carbon is always called low carbon or mild steel
2. ·25 to ·7 .. .. medium .. ..
3. ·7 - 1·5 .. .. high .. ..
all known as straight steels as there is no alloy present in them.

as the percentage of carbon increases the hardness & tensile strenght increases but the material becomes more & more brittle.

Impurities of carbon steel:- all classes of carbon steel contain small quantities of silicon sulphur & phosphorus. Sulphur causes brittleness & tensile strength. The ill-effects of sulphur eliminated by adding ·5 to ·7% manganese, which combines with the sulphur to form anon injurious product.

Phosphorus causes softness

Silicon gives fatigue resisting properties

Silicon manganese steels used for laminated springs.

Silicon chrome steels heat resisting.

Alloy Steels Their strength depends more on their structure & composition than on the hardness produced by special heat treatment as in the case of carbon steels.

1. Increased tensile strength (40-110 tons per □") combined with greater ductility.
2. Increased impact volume & greater resistance to fatigue
3. Minimised mass effect giving increased uniformity in strength & toughness throughout large masses
4. Anti-corrosive properties
5. Large reduction in weight.
6. Greater strenght at high temps
7. Less rapid quenching necessary, owing to slower critical changes consequently less risk of cracking.
8. More difficult to produce needs special care & treatment during manufacture, thus more expensive

alloying elements used:-

Nickel Ni Molybdenum Mo Vanadium V Cobalt Co Tungsten W
Chromium Cr Manganese Mn Silicon Si

Ni Increases tensile strenght. lowers critical points & percentage carbon in the eutectoid. Anti-corrosive, reduces the crystal size increases the depth of hardening, gives a fine grain, no scaling. (3·15% nickel gives ·75% carbon in eutectoid.

Invar Contains 36% nickel & is an austenetic steel i.e. critical points are below room temp. It has a low coefficent of expansion & is thus used for precision instruments

Non-magnetic steel contains 25% nickel. Is used for shafts of polar inductor magnetos.

Perlitic Nickel Steels 3 to 4% nickel & ·2 to ·5% carbon used for case hardening (tough core, hard case)

Chromium gives great strenght & hardness slows up the critical changes gives greater depth of hardness in large masses. Raises critical point & produces fine grain i.e. added strenght without loss of ductility

Chromium Steels

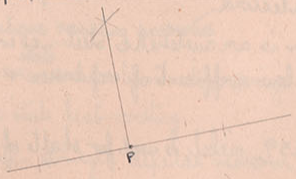
1. Less than 2% chromium if strenght & hardness & toughness required
2. 2 to 4% chromium - for permanent magnets.
3. 10 to 20% " - stainless steel.

Nickel Chrome Steels When alloyed together they give increased strength & hardness combined with greater toughness & ductility. These steels must be quenched to avoid brittleness.

MARKING OUT EXS.

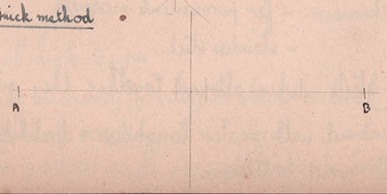
1. To bisect an angle.

2. To draw a perpendicular to a line.

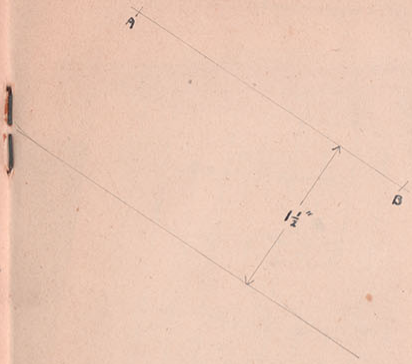


3. To bisect a line.

b. Quick method



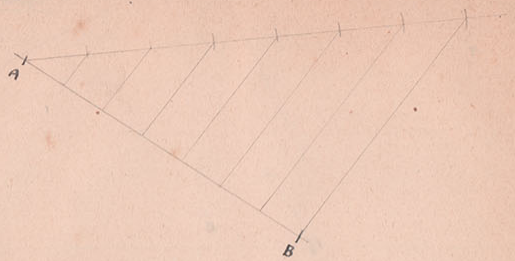
4. To draw a parallel to a given line ($1\frac{1}{2}$" from it)



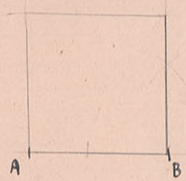
5. Bisection of angle - lines not meeting

6. Perp. ~~at~~ near end of line.

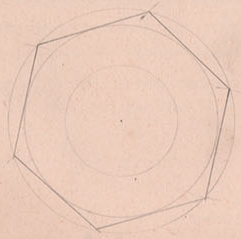
7. To divide a line into 7 equal parts



8 To draw square on given base line.



9 To contruct a regular hexagon. (2" across corners)



10 Chamfer.

Radius of chamfer $\frac{1}{2}$"

11 Draw circle of radius $\frac{3}{4}$"
In centre of circle, draw 1"□

1. $\frac{29}{32}$ 32)290(·906
288
200
192
8

2. $\frac{49}{64}$ 64)490(·765
~~448~~
490
448
420
384
360

·796 to 64"

·796 × 64 = Ans.

Magnetism:- Natural magnet - lodestone

Artificial .. - Cobalt Steel, Nico & Alnico.

Rule:- Like poles repel

Unlike poles attract each other.

A magnet is surrounded by

a magnetic ~~flux~~ field

A magnetic field is made up of a number of lines of magnetic force

The closer together these lines of force lie the stronger is the magnetic field or flux.

Soft iron is easily magnetised & demagnetised & is more permeable to magnetic lines of force than air.

This means that when a piece of soft iron is placed in a magnetic field, the lines of force crowd into the iron increases the magnetic flux & the iron becomes a temporary magnet. The iron loses its magnetic properties on being removed from the field.

Electricity An electric current is a flow of electrons.

All material is made up of small particles called atoms

Atoms have equal amounts of positive electricity (protons) & negative electricity (electrons)

Conductors of electricity e.g. metals.

Will lose electrons when a force is applied. This is called an Electro motive Force (EMF) & is measured in volts.

There must be a potential difference or pressure difference between the terminals of a battery or a storage cell, before a current flows through a circuit.

This P.D. is also measured in volts.

Electric current is measured in amperes (amps)

Ohm's Law

$$\frac{\text{EMF}}{\text{current}} = \text{constant.}$$

$$\frac{E}{I} = R \text{ (Resistance)}$$

Resistance is measured in Ohms.

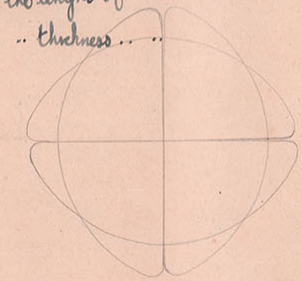
If a current of 1 amp. flows through a conductor under a force of 1 volt the resistance of the resistance of the conductor is one Ohm.

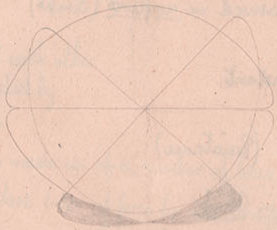
Resistance depends on

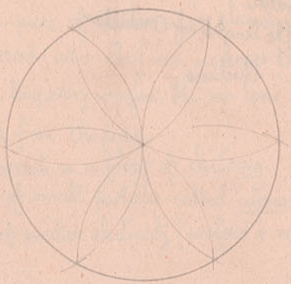
(1) The kind of metal

(2) Secondly on the lenght of conductor.

(3) .. .. thickness .. ..







1582185 A.C.2 Wakefield, H.E.
Hut No 1, A Line,
A Squadron, I.T.T. Wing,
R.A.F. Cosford.
Nr. Wolverhampton.
Staffs.
Tuesday.

Dear Sheila,

Many thanks for your last letter. You're nearly as bad as Den, it took him two weeks to reply to my letter it took you ten days. I thought you weren't going to write back. Not that it's worried me!

At the moment a Flt. Lieut. is giving us a lecture on something or other, I don't know what because I'm not listening.

Two Score Steel High Cr non-corrodable steel.
Staybright (High chromium, high nickel steel) 18 8 Steel 18% chrom 8% nickel
This is more resistant to corrosion, is austenetic & so can't be hardened by quenching. Hardened by cold working. Non-magnetic. Very tough & difficult to machine. Resistant to scaling at high temperature & no tendency to harden on cooling. Is used for aero-engine valves.

Chromium is key element in valve steels

Molybdenum - small quantities ·15 to ·65% produce fine grain; it also induces a uniformly fine grain or structure in steel. Thus it increases impact value greatly, gives a tougher steel which is more resistant to vibration

Tungsten is the base of all high speed tool steels (i.e. steels which retain their cutting edge to a dull red heat & also permit of heavy rapid machining operations in which a straight carbon steel would be completely softened. Tungsten raises the critical point (almost double)

2% tungsten to straight carbon tool steel gives a finer grain, a tougher material & a much more durable cutting edge. 6% tungsten used for permanent magnet steels. 14% tungsten gives normal qualities of tungsten 22% tungsten gives better qualities

Silicon is not a metal but behaves as one in steel alloys. It is present in all steels up to ·33% as an impurity, gives fatigue resisting properties this good quality is increased if alloyed with manganese Silic-manganese steels are used for laminated springs.

Silico Chrome gives great heat resisting properties

Nickel Molybdenum Chrome Steel - High expansion steel used for steel inserts for valve seats the valve seats are hardened by facing with

1 Stellite

	Co	Cr	W	Si	C
	66%	27%	4%	2·75%	1·25%

2 Brightray 80% Ni 20% Chrome.

3 Duro-chrome Si Cr Mb

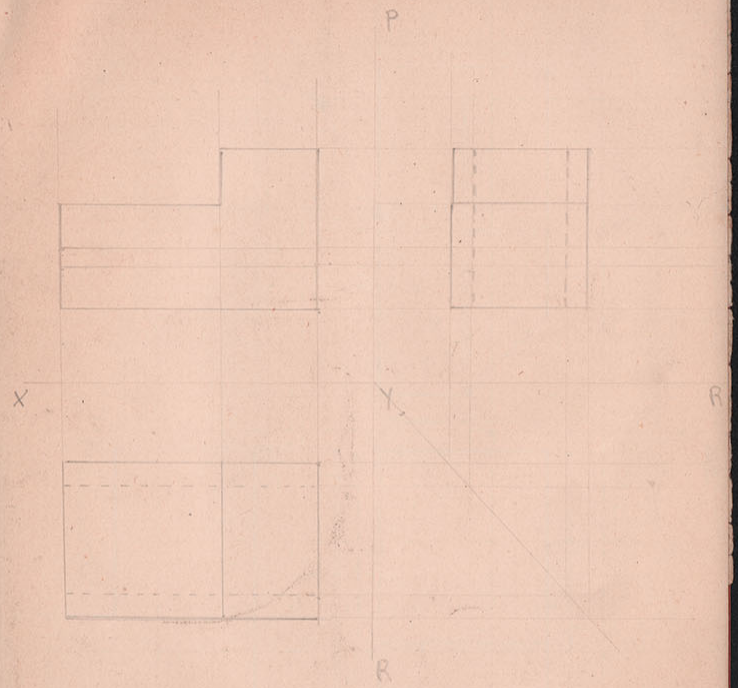
These are also used for facing rockers, valves, stems, tappets, cams, etc.

Vanadium in small quantities up ·25% increases fatigue resistance usually alloyed with tungsten, cobalt & mb. are sometimes added. used in valve springs.

Cobalt gives powerful magnetic properties

Alnico, 15 25 & 10%

Mn gives greater depth of hardness in large masses a tough non magnetic steel used for steel helmet.



The in that alloy which completely solidifies at a melting point lower than any of the metals of which the alloy is made, is denser than any other alloy of the metals

α
β
γ
δ
ε
ζ
θ
χ
ω