

welcome to this lecture module on optics in the last class we discussed about refraction by spherical surfaces and then by lenses we also derived the lens formula and we have seen expression for the magnification we have also seen formation of image by a lens

so let me quickly recap what we have studied before we take up today's topic and that and today's topic is power of a lens and combination of thin lenses in contact

so before we take up this topic we will just quickly recall what we had studied in the last lecture and i will take a couple of examples

so refraction and image formation by lenses

so this is the summary of what we have studied

so we have derived the thin lens formula there is a lens here a biconvex lens an object of height h forming an image of height h' f_1 and f_2 are the principal force i of this lens u is the object distance v is the image distance and f is the focal length r_1 is the radius of curvature of the first surface r_2 is the radius of curvature of the second surface n_1 is the refractive index outside the lens and n_2 is the refractive index of the material of the lens and we have derived the lengths formula thin lens formula $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$ where all the parameters are shown in the figure and the magnification lateral magnification is equal to $\frac{h'}{h}$ size of the image by size of the object is equal to $\frac{v}{u}$ we have seen that for a converging lens f the focal length is greater than zero focal length is positive and for a diverging lens focal length is less than zero that is focal length is negative

so we come back to the some examples we will try to work out a couple of examples here

so exercise a 2 centimeter long needle is placed erect at a distance of 10 centimeter in front of a thin biconcave lens

so what is given is a thin biconcave lens distance is 10 centimeter height is 2 centimeter it is a 2 centimeter long needle placed erect which means it is sitting straight and the focal length of the lens is given as 10 centimeter determine the position and size of the image to draw a ray diagram with appropriate numbers for the object distance image distance etcetera showing formation of the image

so let us first look at the first part we have to be careful it is a bi-concave lens what we quickly observe is that the object distance u is the same as focal length 10 centimeter both are same

so we may jump to a conclusion that in the case of a biconvex lens if the object is placed at the focus then the image is formed at infinity but this is a biconcave lens here we are dealing with a biconcave lens and therefore let us see ah what we get

so let us use the thin film ah thin lens formula

so the thin lens form formula

so $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$ or let me take $\frac{1}{u}$ to the other side

so plus $\frac{1}{u}$

so given its u is equal to it is 10 centimeter in front 10 centimeter in front

so u is equal to minus 10 centimeter it is a by concave lens of focal length n therefore f is also equal to minus 10 centimeter f is equal to is a biconcave therefore f is equal to minus 10 centimeter therefore $\frac{1}{v}$ is equal to minus $\frac{1}{10}$ minus $\frac{1}{10}$ which is equal to $\frac{1}{10}$ centimeter each

so minus is common

so we have $\frac{2}{10}$ which is equal to minus $\frac{1}{5}$ or v is equal to minus 5 centimeter v is equal to minus 5 therefore immediately

so we need to find out the position

so position is where the image position is minus 5 which means in front of the lens and what we also have is the size

so size is given by m is equal to v by u which is equal to minus 5 centimeter by minus 10 centimeter which is equal to 0.5

and therefore this is equal to size of the image divided by size of the object therefore size of the image is equal to 0.5

into size of the object object size is given 2 centimeter long needle therefore is equal to 2 centimeter which is equal to 1 centimeter note that the size is 1 centimeter which means it is an erect image it is a virtual image because there is no negative sign it is not an inverted image it is an erect image and the image is formed at minus 5 centimeter in front of the concave lens by concave lens

so let us try to with these two data there let us try to draw the diagram here

so here we have let me show here itself here we have a biconcave lens the axis is shown here this axis and here is the object

so this is the focal length and also the object distance

so this is minus 10 centimeter this distance

so we consider image formation we have to draw a diagram showing image formation

so we consider a parallel ray and a ray passing through the axis like this the parallel ray will get deflected because by concave lens the focal length is here

so this is also the focal length f and therefore it would go in such a way that it will appear to come from the focus that means the ray would travel like this it would appear to come like this the ray which is going through the geometric center of the lens will go undeviated therefore the intersection point here is where the image is formed

so the image is formed here

so this is the object of length 2 centimeter and image is formed here

so what we have got is this position the image position is 5 centimeter this is minus 5 centimeter minus sign because we are on the left side of this rays are coming from the left side and the distances to the left of the lens are negative and distances to the right of the lens are positive this is what we see now is this is one centimeter height this is minus 5 centimeter this is almost obvious if you see the geometry carefully that this is a triangle where this is 2 centimeter a parallel ray comes here therefore this is also height 2 centimeter this is 10 centimeter and therefore the rates the diagonal these are the two diagonals which will intersect at half the point that half the distance which is minus 5 centimeter and the height will also be equal to half the object height that is what we have got from the mathematics which is consistent with the geometry its a very simple example but also tells you how to record formation of the image

so this is consistent and a simple example

so let us take a second example

so let me look at a second example

so exercise 2 a particular lens made of glass of refractive index 1.5

has a focal length f in air that is n equal to 1 when the lens is immersed in a liquid the focal length increases to $4f$

so for this is $4f$ here it is f refractive index is given 1.5

and outside it is air and when it is immersed in a liquid focal length increases to $4f$ determine the refractive index of the liquid

so the given data is we have a lens of material n is equal to 1.5

when the outside medium it is air then we have a certain focal length

so if i show quickly the focal length like this

so this distance is f what is given is if this lens is immersed in a liquid the focal length will increase to four f

so when it is immersed in a liquid

so let me use a different color the focal length increases to $4f$

so it is intersecting somewhere here and this separation is 4 times the original separation determine the refractive index of the liquid

so how do we go about this

so let us use the lens formula and we know that the focal length $\frac{1}{f}$ is given by $\frac{n_2}{n_1} - \frac{1}{r_1} - \frac{1}{r_2}$ this is the formula for the focal length n_2 is the refractive index of the lens and n_1 is the outside medium

so when this is

so for the particular case the problem it is f when it is n_{glass}

so let me write this as $n_{\text{glass}} / n_{\text{air}}$ standing for n_{glass} divided by n_{air}

so n_{air} is refractive index of air minus 1 divided by r_1 multiplied by $\frac{1}{r_2} - \frac{1}{r_1}$ and this is first data and it is $\frac{1}{4f}$ the focal length has increased to four f when we have instead of air we have the liquid

so we have n_{glass} refractive index of the lens material of the lens remains the same but now we have an n_{liquid} is that of the liquid

so we are asked to find out what is this $\frac{n_{\text{liquid}}}{n_{\text{air}}} - \frac{1}{r_1} - \frac{1}{r_2}$ yeah

so very simple we simply divide if i call this as equation 1 and equation 2 if we divide 1 by 2 then we have here f f cancelling and we have 4 going upward

so we have 4 is equal to these terms cancel this bracket completely cancels with this this i can write as $n_{\text{glass}} - n_{\text{air}}$ by n_{air}

so i have $n_{\text{glass}} - n_{\text{air}}$ by n_{air} divided by $n_{\text{glass}} - n_{\text{liquid}}$ by n_{air} but it is in the denominator

so i have to flip it

so n_{liquid} divided by $n_{\text{glass}} - n_{\text{liquid}}$ that's it now we can substitute the values of the refractive index n_{glass} is given as 1.5

this is 1

so 1.

5 which is equal to let me substitute 1.

5 minus 1 divided by 1

so it is simply 0.

5 by 1 which is 0.

5 into n_{liquid} divided by $n_{\text{glass}} - n_{\text{liquid}}$

so this is 0.

5

so 0.

5 goes to the denominator this will become 8 8 is equal to n_{liquid} that is 1.

5 ah sorry n_{liquid} sorry 8 is equal to n_{liquid} divided by n_{glass} is 1.

5

so 1.

5 minus n_{liquid}

so we can transpose and let me continue here in this line

so if i take this here we have 8 into 1.

5 minus n_{liquid} is equal to n_{liquid}

so eight n_{liquid} goes to the other side can become nine n_{liquid} eight into one point five is twelve

so we have nine n_{liquid} is equal to twelve one point 1.

5 into 8 or n_{liquid} is equal to 12 by 9 which is equal to 4 by 3 which is equal to 1.

33 one point three three the refractive index of the liquid is one point three three this is the refractive index of water we are familiar that refractive

index of water is one point three three and we see that if you have a lens which is in air of certain focal length f and if you immerse the lens in a liquid of refractive index n_l then if you immerse it in water then the focal length becomes four times f all right

so these two simple examples i had taken to illustrate the applicability of the formulae which we have derived and now let us proceed to the topic of power of a lens what is power of a lens

so power of a lens the converging or diverging capability

so the converging or diverging capability of a lens is quantified by the parameter power of a lens what does a lens do a lens can either converge or diverge a parallel beam a parallel beam incident on a convex lens will converge to the principal focus and if it is incident on a concave lens for example if it is incident on a concave lens then it will diverge

so converging or diverging capability of a lens is quantified by power of a lens intuitively what i have shown in this diagram here is the green colored rays here focus to a point f here it's a thinner lens with a larger focal length then it is converging slowly slowly or weakly converging the focusing ability the focusing is slowly happening here to this point slow in the sense with distance not in time with the distance whereas in this case it is focusing rapidly to a point f which is close to the lens and therefore smaller the focal length stronger converging ability and larger the focal length weaker converging ability in other words intuitively we can say that the converging capability is inversely proportional to the focal length

so the power of a lens is inversely proportional to the focal length the same thing what i have shown is with respect to a convex lens but the same thing will be true if i use a concave lens

so if you have a concave lens like this a concave lens which has a larger focal length here which means parallel rays which are incident here will appear to diverge from this point

so if i show this as the focal point or focus then it appears to diverge in this direction and similarly it appears to diverge along this line whereas if the focus were here then the ray would have diverged like this

so the diverging capability whether it is converging

so the ray would have gone like this

so the diverging capability or the converging capability as we saw in the earlier case depends on the focal length small focal length stronger divergence and in the by convex case small focal length that means it is a stronger convergence and here it is a stronger divergence in either case the converging power or diverging power are inversely proportional to the focal length and therefore the power of a lens is defined as the

so the power of a lens p is defined as p is equal to $1/f$ where f is in meters it is very important to recognize that the focal length has to be substituted in meters

so the unit is meter inverse meter inverse which is in this case is also called diopter and denoted by the symbol capital D thus for example a convex lens of focal length 50 centimeter has power p is equal to 1 divided by 0.5 meters 50 centimeter which is 2 .

5 meters and which is equal to two diopters two D D standing for diopter

similarly if we use a concave lens or focal length let us say forty centimeter then the power p is equal to one divided by minus 0.4 because it is given that it is a concave lens

4 meters which is equal to minus 2.5

so the focal length is minus 40 centimeters which is minus 0.4 meters which is equal to minus 2.5 .

4 meters which is equal to minus 2.5 .

5 D normally conventionally when we talk we drop this D and we say that the

power is plus 2 or power is minus 2 this is what people refer to particularly with regard to spectacles the power of spectacles someone says that i am wearing a spectacle of power plus two

so a power plus two what does that mean

so my spectacle lens as a power p is equal to plus 2 what he implies is this means it is plus $2d$ and this implies that the focal length is equal to 50 centimeter 50 centimeter and focal length it is plus therefore focal length is positive which implies it is a convex lens convex lens the lens used in his or her spectacle is a convex lens of focal length 50 centimeter similarly if one says power is equal to minus one this is commonly when we talk we say power is plus one minus one and

so on we normally do not use d but it implies the power is minus one d which implies the focal length f is minus 100 centimeter or 1 meter which implies it is a concave lens concave lens why some people use convex lens and why some people use concave lens is convex lens and concave lens depends on the defect in the vision that they have this we will discuss at a later time all right

so its and it is very important to remember that f has to be substituted in meters when we calculate the power right

so let us now move on to the next topic which is combination of thin lenses in contact combination of thin lenses consider two thin lenses 1 one and 1 two here 1 one and 1 two of focal lens f one and f two placed in contact

so first the focal length the lens a thin lens 1 one i have shown in this case both s convex by convex lenses but it could be ah one biconvex one biconcave or one plano convex and etcetera but consider two lenses 1 one and 1 two of focal length f_1 and f_2 placed in contact they are in contact here they are just touching each other without any air gap at the center here there will be some air gap at the ends but they are just touching each other

so what would be the focal length of this combination if this has a focal length f what would be f that is how f is related to f_1 and f_2 .

so this is what we have to determine now there are other combinations possible in this case i have shown that it is converging because intuitively i know that the first lens is converging the second lens is also converging therefore the combination must be converging but in a general case when you have one convex lens one concave lens for example then it is not possible to straight away say whether the combination will act as a converging lens or a diverging lens is not clear

so we have to have a method of seeing that as i said there are other combinations which are possible for example we may have a convex lens like this and a concave lens which is also just in contact

so here is the concave lens

so 1 one is

so f_1 is greater than zero but f_2 of this lens f_2 is less than zero what about the combination it will depend obviously on the values of f_1 and f_2 as we will see in some cases we have plano convex lens

so in one side it is plane other side it is convex and we may have a concave lens plano concave lens

so like this in this case f_1 is greater than 0 again and f_2 is less than 0 now why do we use such lenses there may be more lenses

so why go for combination of lenses combination of lenses why use combination of lenses there are several reasons one of the reasons we will see that you have a lens of focal length f_1 and a lens of focal length f_2 it could be both convex or both concave or one convex one concave then it is possible

so one of the reasons is it is possible to obtain an f which is required for a

particular application required for a particular application this is one of the reasons particular application that is we have lenses of focal length f_1 and f_2 but we do not have a focal length of lens a lens or focal length f then it may be possible sometimes to have a combination

so that we can have a combination which has a focal length f that is required for a particular application but this is not the main reason there are other reasons usually one of the lengths will be of a particular material of refractive index n_1 then the other material the of the second lens is usually different and this is for

so if we have one

so let me show in the same diagram here this could be of refractive index n_1 and this could be of refractive index n_2 one of the important applications is what is called to compensate to compensate compensate for chromatic dispersion chromatic dispersion we will discuss about dispersion in one of the subsequent classes

so chromatic dispersion compensate for chromatic dispersion every material has a certain dispersion n_1 this material has a certain dispersion this material has a certain dispersion dispersion refers to refractive index seen by different wavelengths of light different wavelengths of light will see different refractive indices this is called dispersion or chromatic dispersion the effects of chromatic dispersion we will discuss a little later but compensation means the dispersion due to one lens can be compensated by dispersion due to another lens if the materials are different

so that for all wavelengths the behavior of the lens is the same we will discuss this at a later stage but this is the major major application of using a combination of ah multiple lenses ok

so let us come back to the problem

so how to determine

so how to determine the focal length of this combination now we should recall that in determining the lens formula what we did was this was a lens with the two refracting surfaces r_1 and r_2

so this is refracting surface r_1 and this is refracting surface 2 of radius of curvature r_2

so we treated first this as one surface r_1 followed by refraction at the second surface refraction at the first surface this is just to recall because we want to apply the same technique here recall that refraction by a lens here

so there was an object and rays traveled and formed an image i

so this is the point object and image i this was treated as first refraction by the first surface here followed by

so this would form an image somewhere here let's say i_1 and this image will form will be treated as a virtual object for the second image formation

so this the ray which is coming from here will

so let me draw this we have already discussed this in detail

so forms an image here

so this is i

so we first applied the formula for this refraction and then treated this refraction where we have

so this is i_1 and this was the virtual object for the second refraction

so this is the image distance this is the actual object distance actually made distance which is treated as first the actual object distance object here which forms an image in the absence of the second refracting surface and then the second refracting refraction at the second surface considers i_1 as the virtual object and forms an image at i and then we derived the lens formula

so we got the lens formula by

so lens formula we derived the lens formula by successive application
so successive application there is one after the and one after another
successive application of the formula for refraction at a single interface
so successive application of the formula for single interface we did this to
obtain the lens formula we follow the same procedure now

so here

so let the picture will become clear when i place this now let's look at this
so here it is

so let me cover the rest first successive application of the thin lens formula
there are two lenses

so first we treat this first lens refraction at the first lens and second lens
earlier we treated refraction at the first interface and the second interface
now first lens and second lens now because we are treating thin lenses since the
lenses are thin we assume the optical centers to coincide midway between the two
lenses

so here it is the optical center here of the first lens and the second length
is assumed to coincide at the midway because its thin lens

so the difference is very small

so we assume that to be the center

so that this is the object distance and this is the image distance the
combination forming object distance image distance object is here and images now
first for the image formed by l one

so let us look at this we first consider image formed by the first lens the
object is here minus u and the image is formed here in the absence of the second
lens when the second lens is not present the first lens would have formed an
image at the point i_1 and at a image distance which is v_1 and we know the thin
lens formula $\frac{1}{v_1} - \frac{1}{u} = \frac{1}{f_1}$ this is the object distance is equal to $\frac{1}{f_1}$
where f_1 is the focal length of the first lens now we successive now we apply
refraction by the second lens

so here it is the second lens for the second lens i_1 acts as the virtual object
because the object tree is coming from here this is the object ray which is
coming

so the object tray is coming from here which would refract to form the actual
image here the object ray would have come if the virtual image the image which
is here is treated as a virtual object that is if a wave have to start from here
it would have gone along this way along this way which is the object ray and
that is why it is called a virtual object

so the object ray undergoes refraction and forms the image here

so for this the thin lens formula tells us that $\frac{1}{v_2} - \frac{1}{v_1} = \frac{1}{f_2}$ this is the image
distance minus $\frac{1}{v_1}$ v_1 is the object distance now virtual object is equal
to $\frac{1}{f_2}$ equation 1 and 2 successive application of the thin lens formula
successively for the first lens and the second lens if we set up once we set up
these two equations i_1 is the virtual object for l_2 once we set up these two
equations the rest is very simple the combination of thin lenses adding
equations 1 and 2

so the same equations 1 and 2 we can add we can see that this cancels $\frac{1}{f_1}$
plus $\frac{1}{f_2}$ on the right hand side this cancels and we are left with $\frac{1}{v_2} - \frac{1}{u}$

so thats what is written $\frac{1}{v_2} - \frac{1}{u} = \frac{1}{f_1} + \frac{1}{f_2}$
which is equal to $\frac{1}{f}$ that is with $\frac{1}{f}$ is equal to $\frac{1}{f_1} + \frac{1}{f_2}$
we can write $\frac{1}{v_2} - \frac{1}{u} = \frac{1}{f}$ this is of the same form as
the thin lens formula for a lens of focal length f this implies the combination
behaves like an equivalent length of focal length f of focal length

so what does this mean

so $1/f$ is equal to $1/f_1 + 1/f_2$

so the same form as that of a thin lens since $1/f$ is the power p power of the lens this implies p is equal to p is the power of the combination is equal to $p_1 + p_2$ power of the first lens plus power of the second lens

so p_1 is $1/f_1$ p_2 is $1/f_2$ now

so the power is added here this is the sum of the powers of the two lenses there are there can be several lenses we can have combination of several lenses we have seen two lenses i had taken both as convex lenses but as i indicated earlier some lenses could be convex and some lenses could be concave and that's what i have shown here combination of several lenses i have here again considered only four lenses there could be more but four lenses i have considered as you can see the first one is a plano convex second one is a biconvex the dotted line indicates the material lens material dotted dots indicate the lens material

so this is a plano convex lens plane and convex double convex that is biconvex lens next one that is 1 three is a biconcave lens and 1 four is a plano convex lens one surface is plane one is this

so again the combination

so what is shown here as the shaded region is basically fixtures which hold the lenses together

so the equivalent the combination has an equivalent focal length is equal to $1/(1/f_1 + 1/f_2 + 1/f_3)$

so $1/f$ equivalent is given by this in other words in terms of power the equivalent power of this combination is the sum $p_1 + p_2 + p_3 + p_4$ but note that some of them are concave and some of them are convex which means some of the powers are negative and therefore it is an algebraic sum of the powers of individual lenses

so the power of a combination of lenses is equal to the algebraic sum of the power of individual lenses now the examples let us work out some examples and understand this better

so here it is

so let me take a first example here

so here it is what is the focal length of the combination of two thin lenses a convex lens of focal length 30 centimeter and a concave lens of focal length 20 centimeter is the combination converging converging type or diverging time the combination

so this is an exercise from the textbook is a very simple exercise but let us start with this

so here it is there is a lens convex lens a focal length 30 centimeter and a concave lens of focal length 20 centimeter but f_2 is therefore minus 20 centimeter we will see later on does it matter if we interchange the position of 1 1 and 1

so let us work out the focal length of the combination

so what we know is $1/f$

so let me keep this here and start working out like this

so $1/f$ is equal to $1/f_1 + 1/f_2$ which is equal to $1/30$ divided by 30 centimeter the first one plus $1/(-20)$ which is equal to $1/30 - 1/20$

so minus 20 centimeter

so that is $1/30 - 1/20$

so $1/30 - 1/20$ which is equal to

so 60 could be the common denominator

so we have 60 and therefore this is $2/60 - 3/60$ which is equal to $-1/60$ this is the focal length of the equal which implies f is equal to minus 60 centimeter what does this mean this implies that the combination the combination

the combination here acts as a is a minus 60 centimeter

so acts as a concave lens has a concave lens of focal length focal length 60 centimeter

so the question is is the combination converging type or diverging type because it is a concave lens

so this implies its a diverging type of lens

so diverging type of lens whether we have 1 one first or 1 two first does it matter it does not matter

so long as the refractive index here and the refractive index here are the same

so long as the outside refractive indices are the same it does not matter

whether i place this one first and this one second or vice versa because what we have used is simply summing whether i place this 1 by 30 later or 1 by 20 this side it does not matter therefore it does not matter

so long as the refractive indices are the same on both sides of the ok this combination a very simple example and now let me show let me take up a second example let us take a second consider a linear object of height 1.

2 centimeter placed at a distance of 40 centimeter in front of a combination of two thin lenses in contact i have shown here diagram that

so as shown in the figure

so the figure shows 1 one and 1 two two lenses convex and concave and at forty centimeter in front of this combination an object a linear object of height 1. 2 centimeter is placed as shown in the figure given that the focal length of the convex lens is 20 centimeter and that of the concave lens is 10 centimeter determine the position and size of the image first second draw qualitatively the corresponding ray diagram showing the formation of the image

so to draw this we have to know what are the position and size that will help and therefore first let us determine the position and size of the image

so how do we go about this

so first we have to it's a combination therefore we have $\frac{1}{f}$ of the combination which i can write $\frac{1}{f_c}$ of the combination is equal to $\frac{1}{f_1} + \frac{1}{f_2}$ and f_1 is given

so this is 20 centimeter and the other one is 10 centimeter

so this is plus that is minus

so this is $\frac{1}{20} - \frac{1}{10}$

so that is equal to

so this is $\frac{1}{20} - \frac{2}{20}$ and therefore this is $-\frac{1}{20}$

so this is $-\frac{1}{20}$ and therefore this is $-\frac{1}{20}$ this implies f_c that is the focal length of the combination is minus 20 centimeter implies the combination acts like a concave lens

so concave lens this helps in drawing the image

so concave lens

so we have got the focal length now once we know the focal length of the combination we have to determine the position and size of the image and therefore lets go to determine the position and size of that

so its a concave lens

so i am now representing it as a concave lens i could as well keep it as a combination but now i am representing it as a concave lens and what is said is there is an object here at 40 centimeter from

so this is 40 centimeter and we have a convex lens of focal length 20 centimeter minus 20 centimeter

so where will be the position of the object

so we use the lens formula $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$ is equal to $\frac{1}{f}$

so this is therefore $\frac{1}{v}$ is equal to $\frac{1}{f}$ f is 20 centimeter minus 20 centimeter

so minus 20 plus u u is in front of the lens therefore this is minus 40
 centimeter and therefore plus one divided by minus forty two this is equal to
 so this is two by forty minus two by forty
 so minus is common
 so we have two by forty plus one by 40
 so this is 3 by 40
 so minus 3 by 40
 so this implies v is equal to minus 40 by 3 centimeters v is equal to
 so we have got v as minus 40 by 3 centimeters
 so once we have v we proceed further
 so let me show here v is minus 40 by 3 and therefore the second thing to be
 noted is as shown here we have to determine the position
 so we have got the position and then we need to determine the size of the image
 so we have v is equal to
 so v is equal to m the magnification is equal to h dash by h size of the image
 by size of the object is equal to v by u
 so v is equal to minus 40 by 3 divided by u is minus 40 here
 so that is equal to simply one third
 so we have m is equal to one third minus forty by three divided by forty by
 three
 so this implies size of the image size of the image is equal to one third into
 so it is given that the object height is 1.
 2 centimeter here
 so one third into 1.
 2 centimeter
 so that is equal to 0.
 4 centimeter
 so we have got the size of the image is equal to 0.
 4 centimeter
 so we have determined the position the position of the image v is minus 40 by
 so here we are determined the position of image v is minus 40 by 3 centimeter
 which means it is on this side here on this side and we have got the size as 0.
 4 centimeter
 so original object is of 1.
 2 centimeter height but the image is smaller somewhere here
 so now let us try to draw
 so let us now we can draw qualitatively the corresponding ray diagram showing
 the formation of the image
 so let us draw the ray diagram
 so let me try to draw it here itself now
 so here is the equivalent either we show both the lenses or we say that this is
 the equivalent lens the combination equivalent this has a focal length we have
 got the focal length of the combination we just calculated the focal length as
 minus 20 centimeters
 so this is minus 20.
 is the focal length f and the object is at minus 40 double the distance
 so o is here the object is here
 so this is minus 40 the object the focus and therefore when the object form
 so let me show a parallel ray here which will appear to go from the focus
 because focus is minus 20 therefore this would if i draw
 so this would travel in this direction the parallel ray would go like this
 please remember that this is the combination of one convex and one concave lens
 so here the parallel ray appears to come from the focus what about the
 secondary

so the second ray we can pass from here and therefore let me pass from the center here

so the second ray passes from the middle and therefore the point of intersection is here this is the point of intersection when you draw with a scale

so that it will be very clear and this point here is minus image distance image distance is this distance from here to here

so this is v

so v and v is equal to this point is minus 40 by 3 centimeter

so 40 by 3 is 13.

33 that is actually equal to minus three 13.

33 centimeter thirteen point obviously we can see that it is below twenty here is zero and here is minus ten minus twenty

so its approximately minus thirteen point three and we see that the size is smaller original object is here and now the size is smaller

so if we draw with a scale we can clearly see that yes our calculation is right that we are getting a smaller object demagnified image a smaller image demagnified image of size 0.

4 centimeter and at a distance at an image distance v is equal to minus three three centimeter

so here is the image which is swapped and the magnification is one by three which is positive which means we get an erect image here erect image at this point

so we have answered all the parts we have determined the position of the image size of the image and finally we have drawn the corresponding ray diagram draw it with a neat scale but it will qualitatively look exactly like this showing all the distances

so the distance 40 centimeter 20 centimeter and v as minus point three centimeter

so this as one point two centimeter and this as point four centimeter that will complete uh the ray diagram okay

so what i had considered is finally now ok we can it's a good idea to see what would happen if the lenses are separated

so i will leave this as a question

so what would happen what if what if the lenses are separated separated by a distance of they are not in contact anymore a distance of 5 centimeters the same principles have to be worked out

so one could work out this and i could give you the answer here

so i have worked out but

so let me give the answer that in this case the magnification m would come out to be two point two by five earlier we got one third

so this answer magnification would come out to be one third and v the position would come out to be minus 14 centimeters we had got in our problem it was minus 13.

33 minus 13.

33 now it slightly changed we got a magnification of 1 by 3 but with this you will get this one

so i would encourage you to work this out and work out more problems to get a better feel you