a very good morning to all of you we are discussing magnetic dipoles and let me recall in the last lecture we had looked at torques and energy of a magnetic dipole
 so we had defined a magnetic dipole by considering a a loop of wire carrying a current i and of radius r
 so the magnetic moment
 so magnetic dipole having a magnetic moment m is equal to i times a vector a area area vector in this case the current is propagating like this
 so the area vector is pointing up and the magnetic dipole moment is pointing up we also calculated the magnetic field due to a dipole and we have done this for ah field along axis b is equal to mu naught m by two pi times z cube where z is much much greater than the this other type of the of this of the coil
 so we are this magnetic field is on the axis far away from this dipole and it has the same direction as the magnetic dipole moment similarly we had done a calculation for field in the plane and b was equal to minus mu naught m by four pi x cube for x much greater than r
 so ah this is we are assumed this is the z direction this is x direction and
 so we far away from the dipole the magnetic dipole ah field along the axis is mu naught m by two pi z cube its parallel to the magnetic field its parallel to the magnetic dipole moment and the field in the plane is minus mu naught m by four to x cube
 so if i were to draw a figure here ah if this is the dipole m then this is the axis of the dipole and this is the plane perpendicular to the dipole
 so here the magnetic field is like this here the magnetic field is like this b is parallel to m and here the magnetic field is downward here the magnetic field is downward
 so b in the plane is ah minus of m and b in the axis is along the m direction
 so we had obtained these magnetic fields of a dipole far away from the dipole and also we had calculated the torque on a dipole due to an external magnetic field b as tau is equal to m cross b
 so the torque is m cross b and the torque on the dipole tends to align the dipole along with the magnetic field
 so the torque tries to align the magnetic dipole along the direction of the magnetic field we are also calculated the potential energy of the dipole in an external field u is equal to minus m dot b the potential energy and the zero of the potential energy is assumed to be when m and b are perpendicular to each other and the external field tends to align the dipole parallel to the magnetic field and where the potential energy is minimum and equal to minus m b when m and b are parallel the potential energy is minimum that is minus m b and when m and b are antiparallel the potential energy is maximum and that is plus mb
 so as the dipole goes from anti parallel to parallel
 so if the magnetic field is pointing up and the magnetic dipole is pointing down maximum potential energy and as it twists and comes in this direction parallel magnetic field the potential energy is minimum when the dipole is oriented along the magnetic field
 so whenever you have a dipole magnetic dipole the external field tends to apply a torque on the dipole tending to align the dipole along the magnetic field we started looking at one example in the last and end of the last class that is let me recall the example again we have a a loop current carrying current i let me assume this is the x axis this z axis and
 so the right handed system y axis is like this y axis is going inwards ah let me also assume there is a magnetic field uniform magnetic field in the direction
 so it is given that the radius of the coil is 5 centimeters the current through the loop is 5 amperes and the magnetic field the external magnetic field p is

equal to point one tesla and oriented along the x direction

so i am given a loop carrying current a loop of radius five centimeters carrying a current of five amperes and placed in an external magnetic field of strength point one tesla

so first let us calculate the magnetic moment of this loop magnetic moment of this loop m is equal to i times a and because the loop is carrying a current in this direction with a right handed rule the area vector points along the z direction

so this is equal to i into pi r square into k cap and

so we can substitute this

so 5 amperes into pi into r square which is 25 10 to the minus 4 k cap and that is equal to 1.
25 pi into 10 to the minus 2 k cap ampere meter square

so the magnetic moment dipole moment of this loop is one point two five pi ten to the minus two k cap amp meter square

so the moment dipole moment is pointing upwards along the z axis and this is now placed in a magnetic field pointed along the x direction

so as we have seen before the torque will be tau m cross b

so m is pointing upwards b is pointing this way

so if you look at m cross b the top will be oriented along the y direction

so we can calculate the torque on this loop torque on the loop tau is equal to m cross b which is equal to we have just calculated m one point two five by ten to the minus two k cap cross point one i cap

so this is equal to one point two five pi into ten to the minus three j k crack k cap cross i cap is j cap and as you can see there is a torque which is acting along the j cap direction

so j cap is in this direction

so the torque is tending to align the type the loop along the x axis the area of the loop to be along the x axis

so there is a torque acting on this on this loop which is tending to line this and along the and if the torque is oriented along the j cap direction now i can also calculate the potential energy change

so when change in potential energy when the coil when the loop goes from this position to a position which is minimizing the potential energy

so the loop is like this now it gets with ah the torque will try to align this and the top the loop will get aligned perpendicular to the x axis

so initial potential energy now is equal to zero because in this orientation m is along z axis b is along x axis and m dot b is zero the final potential energy minus m dot b which is equal to minus mb where m becomes parallel to b which is equal one to two five pi into ten to the minus three joules now the stock has a unit newton meter and this is one point two five pi minus one point two five five pi ten minus three joules that means the potential energy decreases as the loop gets aligned along the directional magnetic field and similarly if you have to i leave it a problem to you what is the work to be done to align the dipole not from this orientation to this orientation that means the dipole moment pointing along the minus x cap direction

so i must as you will see that whether i have to do work on the dipole or the field does work on the dipole you can calculate what is the work to be to be done in rotating the loop from this orientation to an orientation in which the magnetic dipole moment is pointing along the minus x cap direction

so i leave this as a simple problem to you to calculate what is the energy required for the change in potential energy in this process now we have done all this calculation for torques etcetera to finally understand what happens to the magnetic field in the presence of matter now in the case of electrostatics

remember we had discussed initially we looked at electric fields in free space and then we introduced the concept of dielectrics and said that when you place a dielectric inside in an electric field the electric field polarizes the dielectric that means creates small electric dipoles within the material and these small electric dipoles create their own electric field and what you observe is the sum of the electric field that you have applied and the electric field that the dipoles are generating

so in a similar fashion we need to understand what will happen if i place a medium in a magnetic field what is the effect of a magnetic field on the medium and whether the medium affects the magnetic field inside the medium outside the medium etcetera

so in for this we must recall that all matter consists of atoms and these atoms are actually made up of electrons and protons and neutrons and in all these atoms the electrons are in the simplest picture revolving around the the nucleus and these orbital motions of electrons constitute a current

so you have in the simplest picture i can assume that i have a nucleus and which the electron is evolving and this revolving electron has a constitutes a current in the in the system and that current will have its own magnetic moment and

so this magnetic moment will then try to generate a magnetic field outside

so please remember that this current is different from a current that you will flow in a wire if you have a wire if you have a conducting wire carrying current there are actual electrons flowing from one end of the wire to the other end thats something called conduction current

so electrons are actually flowing from one to the other end in an atom the electrons are revolving within the atom itself they are not freely flowing within the atom ah within the system and these atomic currents also constitute dipoles and these dipoles also create their known magnetic fields and what you need to understand is the total magnetic field generated by the conduction current as well as the bound atomic currents

so these currents bound currents do not actually get transported from one end to the other end they are just circulating around each of the nuclei and but they still constitute currents now in many materials these currents are producing magnetic dipoles which are randomly oriented and

so the material does not produce a a magnetic field outside the material there is no magnetic field generated because they are all randomly oriented now because you can represent each magnetic dipole as a current which is flowing like this and we can define

so we have magnetic dipoles small small dipoles miniature dipoles each atom represents a dipole and

so in the case just like in the case of dielectric we had introduced a concept called polarization

so if you have take a medium recall if you take a medium and put it in an electric field external electric field the electric field generates small small dipoles each atom becomes a dipole electric dipole and we then define the total dipole moment per unit volume electric dipole moment per unit volume which we had called polarization similarly we will introduce a new concept here which is called magnetization magnetization is the dipole moment this is magnetization m vector m vector is the type of magnetic dipole moment per unit volume

so you take a small element infinite decimal volume of the material the small volume should contain thousands of atoms and then you calculate the total magnetic moment of the small volume

so i take a volume delta v i sum up all the magnetic moments of all the constituting atoms to get the total magnetic moment please remember magnetic

moment is a vector
 so i must add all the magnetic vectors vectorially
 so i get the total magnetic moment of the small volume and find out the limit as the volume tends to zero
 so we will get a magnetization and then magnetization implies that the material has a magnetic moment per unit volume and a material which is ah which has this magnetic type of moment is is called magnetized magnetized medium
 so when you place a medium in an external magnetic field the external magnetic field alters the magnetic structure of the at atoms within the material and magnetizes the medium just like an external electric field polarizes a dielectric which means creates electric dipoles within the material a material placed in an external magnetic field also magnetizes the material medium and the medium is said to be magnetized in the presence of an external magnetic field
 so we will consider a very simple model to understand the magnetic moment of atoms this is the model which was proposed by niels bohr and in 1911 an atomic model in which the proposed proposal was i have a nucleus and i have electrons revolving around the nucleus please remember to describe the atoms i need quantum mechanics which is beyond the scope of this course here but in a simple picture i can assume that the atom consists of a nucleus at the center positively charged nucleus and the electron are revolving around the nucleus
 so this electron motion like this constitutes a current and i can calculate what is this current and once i have a current i can also calculate the magnetic dipole moment of this
 so let me assume this is an orbital circular of radius r
 so and let me assume the velocity of the electron is equal to v radius of the orbit is called r
 so i have an electron circulating around the nucleus iterations are from the nucleus and let me assume that the orbit is circular
 so the time taken for one revolution of the electron t is equal to
 so if the electron starts from here and goes one full circle it has travelled a distance two pi r with a velocity v
 so the time taken is two pi r by v
 so the time taken for one revolution is two pi r by v
 so i can calculate the number of revolutions per unit time is equal to one by t which is equal to v by two pi r it takes a time t for one revolution
 so the number of revolutions per unit time is one by t which is v by two by r
 so this that means if i am positioning myself at a point here
 so many times the charge will cross b and because the charge of the electron is e this will constitute constitute a current
 so i can calculate the current as the charge multiplied by the number of revolution per second
 so the charge crosses this point any point on the circle one by t times per second each time the charge crosses the charge crossing is e
 so the current is essentially the charge crossing per unit time which is e by t
 so this is nothing but e b by two pi r
 so that is a current let me call it i
 so this electron orbiting around the nucleus constitutes a current given by e v by two pi r now if you have a current in a loop like this we know that this also constitutes a magnetic dipole
 so i can immediately calculate the dipole moment magnetic dipole moment m is equal to current into area i am calculating the magnitude of the dipole moment
 so at every point there is a current which is i and the current has a is a loop of radius r
 so the magnetic dipole moment is i times pi r square which is equal to e b by

two pi r into pi r square which is equal to e b r by two pi cancels over and r cancels over e v r by two

so that is the magnetic dipole moment of the ah of this loop

so this dipole moment will then generate a magnetic field and we have already seen what is the magnetic field generated by a dipole along the axis or in the plane perpendicular and in principle you you should be able to calculate the magnetic field generated by the dipole at all points but

so this magnetic dipole will generate its own electric field its magnetic field and i can relate this ah dipole moment to the angular momentum of the of the type of the spinning electron

so what is the angular momentum l is equal to mass of the electron which i call m e into v times r m v r is the angular momentum that is equal to mass of electron

so m e is the mass of the electron here please note m is representing the dipole moment and m e represents the mass of electron

so i can use these two equations to write relationship between dipole moment and angular momentum

so m is equal to e by two m e times l

so i have replaced i have replaced v r by l by m e and i get e by two m e into l now magnetic dipole moment is a vector angular momentum is a vector

so let me convert this into a vector equation

so now see here the electron is spinning like this in this direction and electron is a negatively charged particle

so actually the current is going in this direction

so when the current goes like this dipole moment is pointing downward a con current constituted like this will will consider will constitute a magnetic dipole moment which is pointing downward but the electron is spinning like this

so the angular momentum is pointing upward please note electron is spinning like this

so it has an angular momentum pointing upward electron spinning like this constitutes a current which is in this direction in the opposite direction and the current going like this will produce a magnetic dipole moment which is pointing downward which means in this case the dipole moment and angular momentum are in opposite directions

so in a vector form i can write m is equal to minus e by two m e times l vector

so dipole moment and the angular momentum are related to this equation and this equation we have obtained classically by ah looking at the atom to be consisting of electrons which are revolving around the nucleus and i get a relationship connecting the dipole moment and the angular momentum now i need to bring in a little bit of quantum mechanics here it is found using quantum mechanical principles that angular momentum cannot have arbitrary values now this is not obtained classically by this argument but if i use quantum mechanics i find that the angular momentum cannot have arbitrary values but

so according to quantum mechanics l can have only l b can only be multiples of this quantity which is equal to n x by two pi and n is an integer that means the dipo the angular momentum can only be integral multiples of this h cross which is h by two pi h is the planck's constant which is equal to approximately 6. 626 10 to the minus 34 joule second now this is a relationship from quantum mechanics that the angular momentum of the electron can only be multiples of h cross and that is nh cross and

so i also find now here that if l can has to be of the form this i can write down the smallest value of magnetic dipole moment

so fundamental unit of magnetic dipole moment m is equal to

so i had e by two m e into a a into l till smallest value of l is h by two pi

so i will have l e by two m e into h by two pi which gives me e h by four pi m e fundamental unit of magnetic dipole moment is e h by four pi m e this is called the bohr magnetotone
 so you can substitute
 so i can write the board magnetron as m b you can substitute the electronic charge the planck's constant and the mass of electron and you will find this approximately nine point two seven four into ten to the minus twenty four ampere meter square
 so what we find is the dipole moment is a multiple of this quantity which is the fundamental unit of dipole moment and
 so the i can associate with the orbital motion of the electron in an atom an orbital dipole moment which is represented by the board magneton
 so orbiting electrons electrons which are orbiting around the nucleus have their own magnetic moment which is also referred to as orbital magnetic moment these are called orbital magnetic moment each of the circulating electrons within the atom has an orbital angular moment and the total moment can be obtained by adding the vectorially the orbital magnetic magnetic moments of each of the individual atoms now it is also found that apart from this magnetic moment electrons also possess another very important quantity which is called the spin angular moment spin magnetic moment now spin is an intrinsic interesting quantity much lies much like charge and mass of the of the particle and associated with this pin is a magnetic moment and the magnetic moment spin magnetic moment has a magnitude of almost one more magnetron
 so in an atom you have electrons which are orbiting the nucleus we associate a magnetic moment with the orbital motion called the orbital magnetic moment each of the electron is characterized by a spin an intrinsic quantity called spin and along with this plane we associate another magnetic moment called the spin magnetic moment
 so the total magnetic moment of the atom will actually be obtained by vectorially adding the orbital angular momentum of all the electrons and the spin angular momentum moment of the all the electrons to get the total magnetic moment of the atom
 so it is these magnetic moments of the atom which constitutes which constitute the dipole inside the material and these dipoles may produce their own magnetic field
 so when you place a medium inside a magnetic field we are actually modifying the magnetic property of the atoms and that leads to ah and the medium itself magnetic property of medium and that leads to a generation of magnetic field by the medium and what you observe total magnetic field is the sum of the applied magnetic field and the magnetic field generated by this magnetized medium now i want to look at physical interpretation of this magnetization
 so what is the physical picture of a uniformly magnetized medium remember in the case of electrostatics we had a physical picture of what is the meaning of a uniformly polarized medium we showed that a uniformly polarized medium ah is equivalent to generation of surface charges ah at the surfaces of the medium and those surface charges essentially generate bound charges
 so they really generate a magnetic electric field and we calculated at the total electric field and use them in gauss's law in a similar picture i want to understand what happens what is the physical mechanism what is the physical understanding of a magnetized uniformly magnetized medium now
 so let me consider a uniformly magnetized medium with magnetization m
 so what it implies is that the medium consists of small atomic dipoles magnetic dipoles and
 so let me try to represent this dipole

so i have a let me take a medium like this and

so let me look at i am looking at the top picture of the medium and i have atomic dipoles

so let me assume that magnetic magnetization is pointing towards me

so there are atomic dipoles like this highly magnified picture i am trying to draw here

so the these are all atomic currents there are circulating currents and each one of them is a small magnetic tiny magnetic dipole

so the material consists of a large number of these magnetic dipoles and because it is uniformly magnetized what hack what you can see is at any point inside for example this point you have a current flowing like this because of the upper loop and a current flowing the reverse direction because of the lower loop and the currents are equal

so the net current at any point inside the medium is zero at any point you see there is a current flowing clockwise and there is a current flowing in the reverse direction at the same point with the net current being zero

so in a uniformly magnetized medium there seems to be no effective current within the medium but look at the surface at the surface there is a current flowing like this being this there is a current flowing like this here there is a current flowing like this here

so this becomes equivalent to a current flowing in the outside in the surface like this i am picturizing a magnetized uniformly magnetized medium a uniformly magnetized medium means that there are tiny dipoles in the medium and if the magnetization is pointing up these tiny dipoles constitute current flowing like this in small loops and its uniformly magnetic medium

so these currents are all equal and at any point if you see here there is a current flowing to the right and there is also current flowing to the left because of the lower loop

so the net current crossing this point is zero similarly if you take any point within the medium you will find that the net current passing through that point is zero

so this cancellation is there within the volume of the medium but at the surface for example on this surface you see that there is a current flowing like this here there is another loop there is the current flowing like this here this current flowing like this here

so this becomes effectively equivalent to current flowing on the surface

so a uniformly magnetized medium is sort of equivalent to a a medium in which there is a surface current current flowing on the surface of the medium

so let me try to relate this surface current let me try to find out what is the surface current what is the relationship of surface current to the magnetization

so to do this we will take a cylindrical sample of area a and thickness t t polarized sorry magnetized uniformly magnetized along its axis

so it is like this something like this

so magnetization is pointing up this thickness is t and this area is a

so let me draw the ah side picture there is this medium here this thickness is t and magnetization is pointing upwards uniformly magnesium

so i have a cylindrical sample uniformly magnetized parallel to the axis the axis of the cylinder is vertical of thickness t and cross sectional area a now remember magnetization is the type magnetic dipole moment per unit volume this sample has a volume a times t

so the type magnetic dipole moment of the sample of the sample is equal to m times a times t magnetization is dipole magnetic dipole moment per unit volume

so magnetic dipole moment per unit volume into volume of the sample gives me the magnetic dipole moment of the sample now i have just now shown you that a

uniformly magnetized sample is equivalent to a current passing on the surface
 so this must be equal to
 so if i have a uniformly magnetized sample like this this must be equivalent to current going like this please remember this is not an actual current which is flowing this is not a conduction current these are bound currents these are current generated by the bound electrons in the atom
 so let me recall here these are currents which are current generated within the medium with the part of the part of the atoms it is not that one single electron is flowing like this or in the other direction it is made up of tiny currents and net the net effect is effect is is to have a current in on the surface of the sample
 so if i look at my problem which i am considering this sample of radius a of thickness t is equivalent to a sample of thickness t and area a in which the current is flowing like this this remember there will be loops like this these loops are cancelling off everywhere inside the medium except on the surface
 so there seems to be a current flowing like this
 so i can write the magnetic moment also as current into area the area of the sample is a magnetization is like this this is magnetization into volume is the magnetic dipole moment the magnetized sample is equivalent to a surface current flowing like this magnetic dipole moment is also sub the current into the area the current is flowing like this area is in this direction here and
 so i can equate these two quantities to find out m times a times t must be equal to i times a and this gives me this implies magnetization is equal to i by t
 so magnetization is nothing but current per unit length on the surface please note that this surface is perpendicular to magnetization if you go back to the earlier picture here ah this picture here here the there is no current in the upper and lower surfaces the current is only on the side surface because the currents are in this orientation and if you if you can imagine the current is actually the net effective current is flowing on the surface and there is no effective current on the upper surface
 so please remember the surface along with the equivalent current is flowing is perpendicular to the magnetization here
 so magnetization is nothing but current per unit length
 so in this example of a magnetized sample which is magnetized like this this is magnetization here and the effective current is like this and this magnetization corresponds to a current per unit length of i by t now this gives me a very nice way to ah to imagine ah to calculate the mag to estimate the magnetic field of this and let me go back and recall a solenoid solenoid having n turns per unit length and carrying current i
 so let me draw the solenoid here
 so you had we had considered this earlier
 so these are current carrying wire current current is going like this this is my z axis and we have calculated the magnetic field b is equal to mu naught n i k cap uniform magnetic field within the solenoid is inside and zero outside an infinitely long solenoid creates a uniform magnetic field within the solenoid of mu naught ni k cap outside the solenoid the magnetic field is zero we had calculated this now this solenoid is going to be very closely bound
 so i can imagine as if the solenoid has a current going like this these are wires carrying actual actual current
 so if you take a unit length what will be the current per unit length in a unit length there will be n turns each turn carrying a current i
 so current per unit length will be n i please note if i take unit length of the solenoid there will be n turns each turn carrying a current i

so the total current crossing a unit length in this direction is n times i
so this n times i is nothing but current per unit length of the solenoid
so the magnetic field produced by solenoid is mu naught times current per unit length into k cap inside and zero outside now this gives me an idea that because a uniformly magnetized sample suppose let me take a uniformly magnetized cylinder magnetized in this direction this magnetized sample is equivalent to a current per unit length of m
so comparing with a solenoid this is very similar to a solenoid in a solenoid i had a current per unit length of n i produce a magnetic field which is mu naught times n i into k cap a uniformly magnetized cylinder magnetized parallel to the axis is equivalent to a solenoid because both of them have a current passing along the surface in a solenoid the current per unit length is ni in a uniformly magnetized cylinder the current per unit length is m
so i can immediately write for the current the magnetic field of a magnetized magnetic field of a uniformly magnetized cylinder magnetized parallel to the axis p is equal to mu naught times m times k cap which is nothing but mu naught times m because m is along the k cap direction m k cap is m vector
so first of all i have tried to show that a uniformly magnetized object is equivalent to a current on the surface the current per unit length is simply magnetization this remove the surface is perpendicular to the magnetization i am considering
so i have i have equated a magnetized sample to a surface current and this currents again let me emphasize these currents are not conduction current these are bound currents these are currents which are bound to the atoms each atom has its own current its like the bound charges in polarization the dielectric these are bound currents
so i first showed you that magnetized magnetization gives me a surface current uniformly magnetized sample has a surface current then i showed that the surface current is actually nothing but magnetization
so a uniformly magnetized sample has a surface current which is m on the surface which is perpendicular to m vector then i am having an analogy of this problem with a solenoid because for a solenoid i know the magnetic field i know the magnetic field of a solenoid is given by this equation and i can interpret this quantity n times i as nothing but the current per unit length because if i take a unit length of the solenoid in a unit length i have n turns and each turn carrying a current i
so the current per unit length is n times i
so all i need to do to calculate the magnetic field of a uniformly magnetized cylindrical sample magnetized parallel to the axis is i know that this is equivalent to a surface current of m and that gives me a magnetic field which is u b is equal to mu naught times m vector
so this particular sample this cylindrical sample which is magnetized parallel to the axis creates a magnetic field mu naught m inside and is equal to zero outside i am assuming ah effectively infinitely long magnetized sample
so inside the sample the magnetization the magnetic field is mu naught m and outside the sample it is zero now i can extend this argument to look at the following problem i have a sample and i bound wires on it i found wires on a sample now
so this is now a solenoid containing a medium inside now
so this is the medium
so i have a current flowing in like this and flowing out like this
so ah solenoid n turns per unit length carrying current i now i wish to calculate what is the magnetic field inside now this external magnetic field generated by the solenoid will magnetize the medium that means it will generate

a magnetic dipole moment per unit volume inside the medium and that magnetic dipole moment will be equivalent to a magnetization and

so let me call the magnetization m the magnetic field is parallel to the axis in the simplest example the magnetization is also parallel to the axis and

so what is the total magnetic field inside p is equal to now the magnetic field because of the conduction current is mu naught times n i times k cap the magnetic field due to the magnetization is mu naught m please note there are two components of magnetic field now the conduction current which is flowing in the wire is actually producing magnetic field mu naught n i k inside this magnetic field magnetizes the medium which means it makes we will come to more discussion of the properties of media magnetic properties of the media but the magnetic field external magnetic field when magnetized the medium just like an electric field polarizes the medium bipolar is a dielectric an external magnetic field magnetizes the medium and i get a magnetization m

so the total field is given by the sum of the field generated by the conduction current for flowing in the wire and the magnetization

so i can write this equation as b by mu naught minus m is equal to n i k now i introduce a new vector we defined x is equal to b by mu naught minus n we define a new vector h vector which is b by mu naught minus m

so i can substitute x vector into this equation and i get h is equal to n i times k k now please remember h vector contains the properties of the medium through the magnetization and on the right hand side there is no medium there is no aspect of medium at all on the right hand side i have defined a new vector h vector which contains the medium property of embedded

so i get a new form of ampere's law which is integral h dot d l i f is equal to free current

so if this is new form of ampere's law we will discuss some examples with this and this is very similar to modification of gauss's law from electric field form to displacement current form and this is a very very interesting form of ampere's law we will discuss some a few examples and then discuss about magnetic properties of different kinds of materials you