Condensed Matter Physics
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Lecture - 11
Thermal Conductivity of Metals – Worked Examples

Today, we continue discussing problems relating to thermal conductivity of metals. The first problem that we are going to do today is rather elementary which the based on the definition of thermal conductivity why are the Fourier equations, stead state equation.

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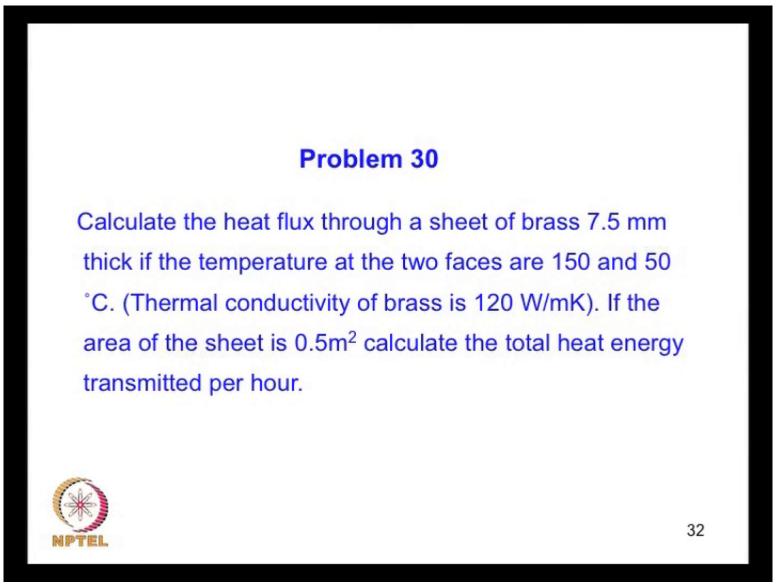

So, we are ask to calculate.

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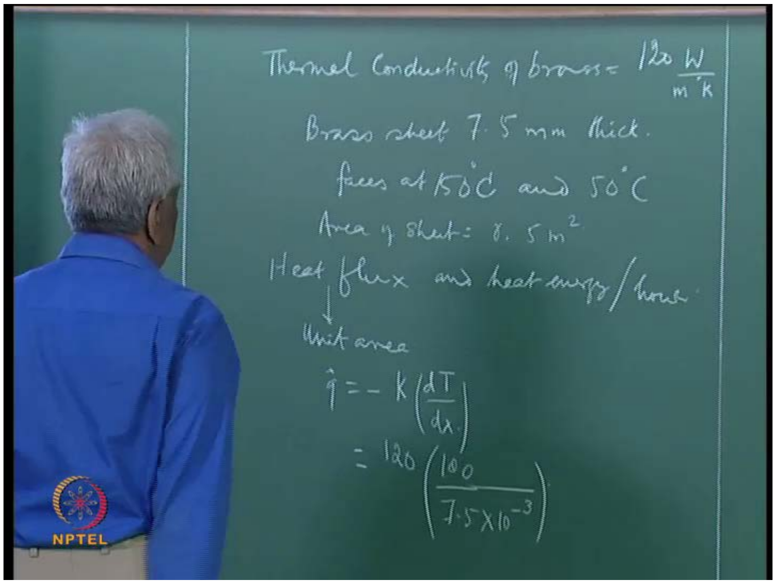

The heat flux through a sheet of brass brass sheet 7.5 millimeter thick, faces at 150 Celsius and 50 Celsius, thermal conductivity of brass is given to be 120 watts per meter Kelvin, area of the sheet 0.5 meters square. So we have the standard equation, we are ask to calculate heat energy heat flux and heat energy wherever. Heat flux is defined with respect to unit area, so it is given by q dot is a minus K d t by d x, where this is the temperature gradient, so we are given we have thermal conductivity which I 120 and then d t by d x across 7.5 we have a gradient of millimeter, so into 10 to the power minus 3.

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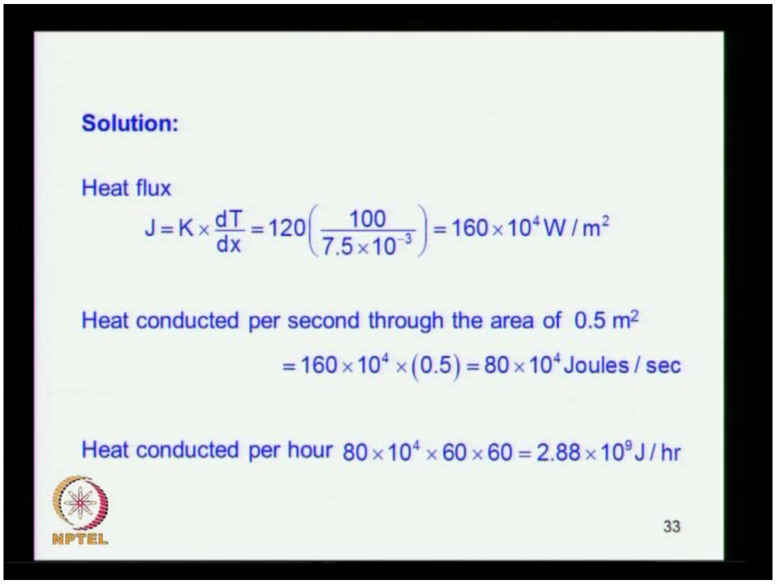

That would work out to be 8 into 10 to the power 4 joules per second.

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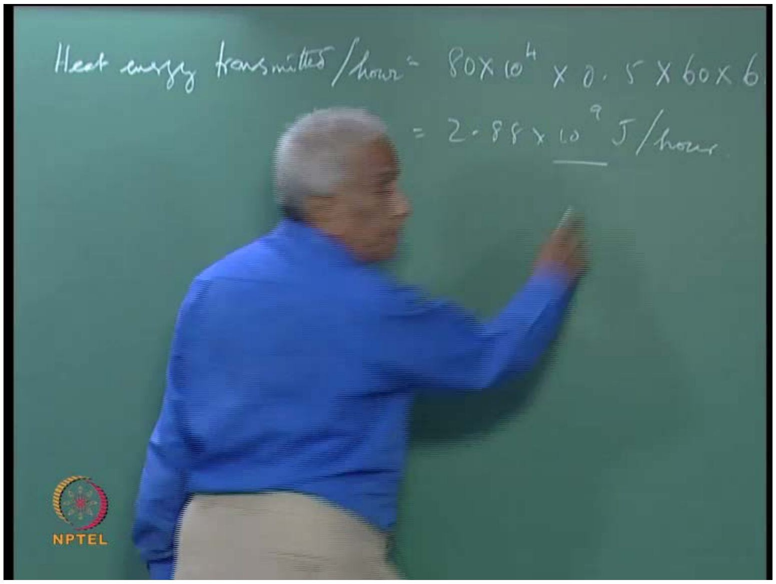

And taking area into consideration, the heat energy transmitted per hour is just a this quantity into the area which is 0.5, so that would give that is per second into 60 into 60 per hour, so that will be 2.88 into 10 power 9 joules per hour.

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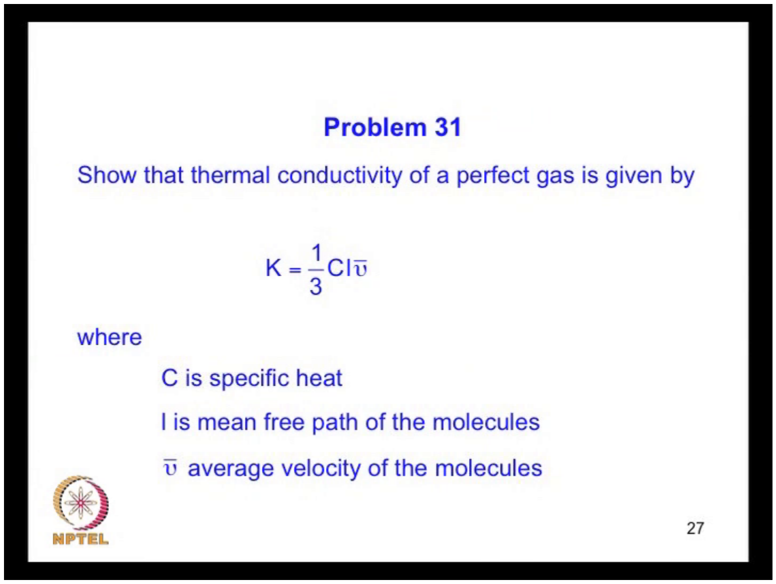

The next question is on thermal conductivity of metals.

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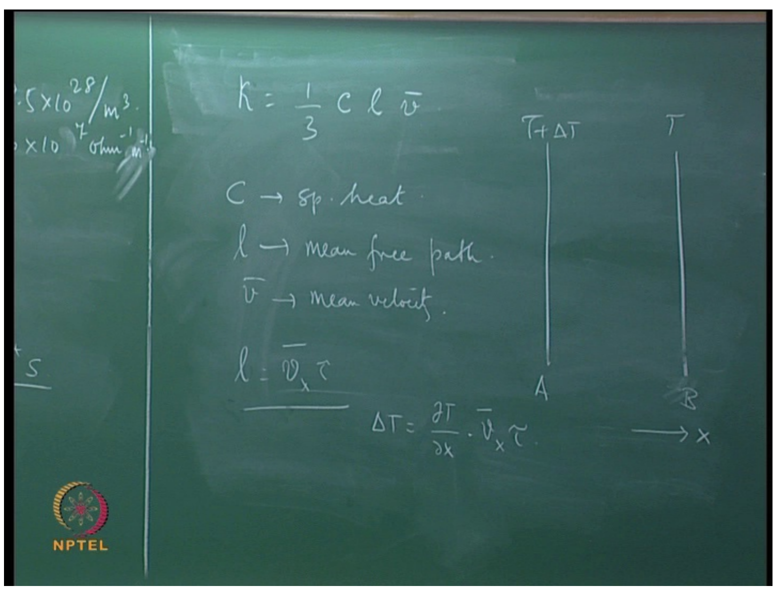

We ask to prove the thermal conductivity the kinetic theory expression of thermal conductivity for a perfect gas as one third C l v bar; where C is the specific heat, l is the mean free path, and v bar is the average mean velocity of the gas molecules. So this is the expression that we will adapt for discussing thermal conductivity of metal as well.

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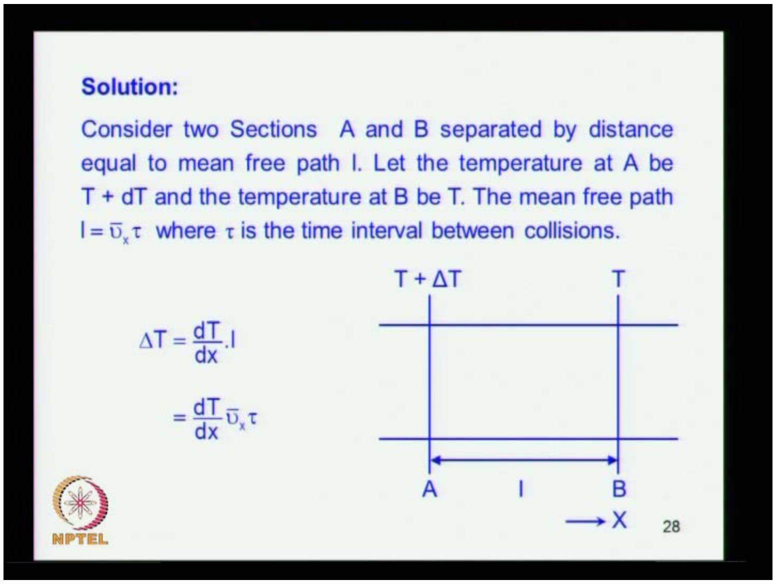

So we consider two sections at temperatures T and T plus delta T, so there is a temperature gradient along this direction, so let us call this x direction. So there is a temperature gradient and let us take these two sections call them A and B. And the mean free path l is v x and tau, where tau is the relaxation time or collision time; and v x is the average x component of the speed. Therefore, if this section is separated by a mean free path, then delta t is d T by d x times v x bar tau.

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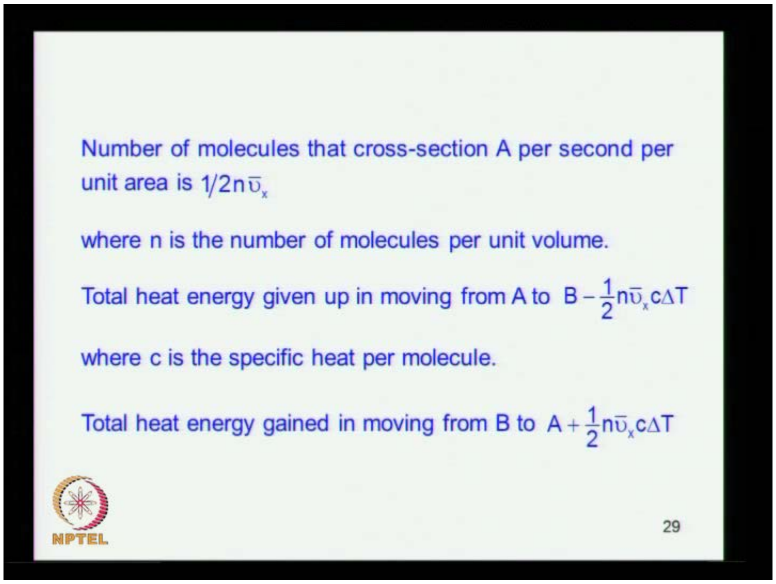

Now we calculate the number of molecules which transport energy thermal energy to the two sections by moving by carrying heat along the x directions.

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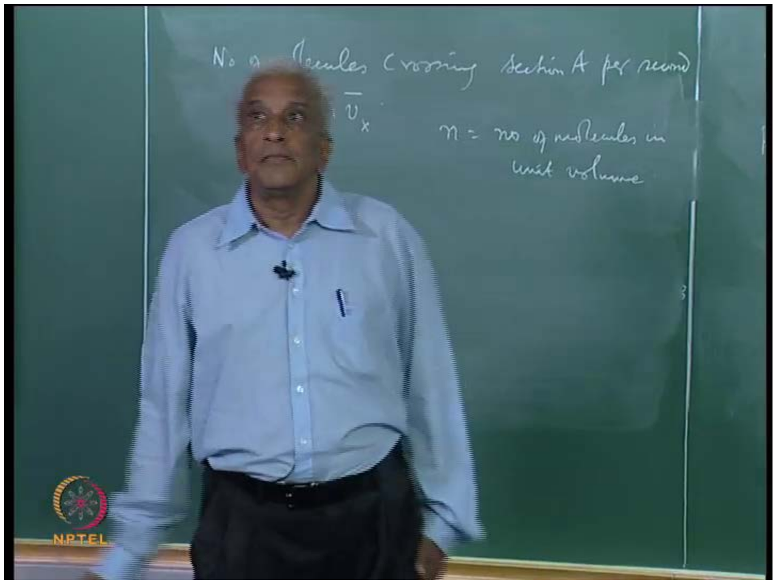

So number of molecule that across the section A crossing section A per second, this is we know that is half-n v x bar. And these where n is the number of molecules in unit volume. Now therefore the heat energy.

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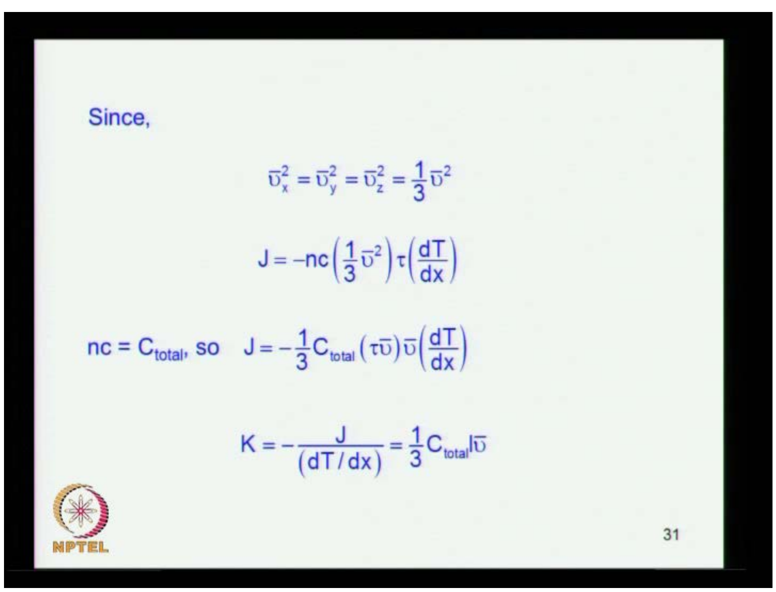

And then per unit temperature gradient K – J by since.

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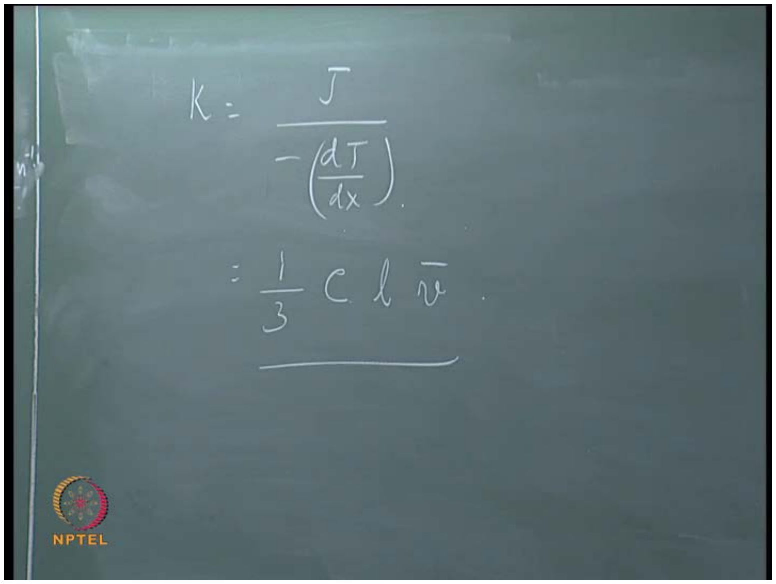

We are consider unit area already so this is just this and therefore, it just comes as. And v bar tau is l, so it is 1 3 C l v bar which is what we are took true.