Thermodynamics
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Tutorial Problem - Part 2

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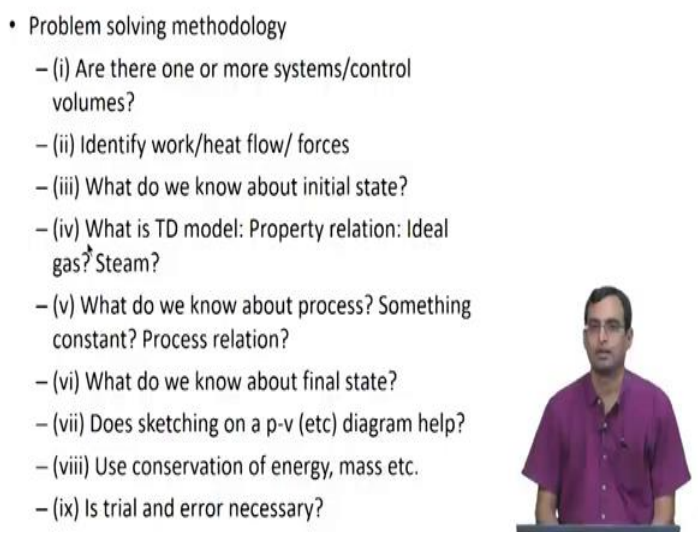

Problem solving methodology

1. Identify system(s)/control volume(s)

2. Identify work or heat interactions or forces acting on the system or control volume

3. Collect the information regarding the initial state of the system or control volume

4. Collect the information regarding the process the system is undergoing. Obtain the information regarding property relations.

5. Collect the information regarding the final state of the system or control volume.

6. Draw state diagrams (p-V, p-T, etc.) if it helps.

7. Use conservation laws, e.g., conservation of mass, energy, etc.

8. Is trial and error necessary?

We may have to go through these steps more than once.

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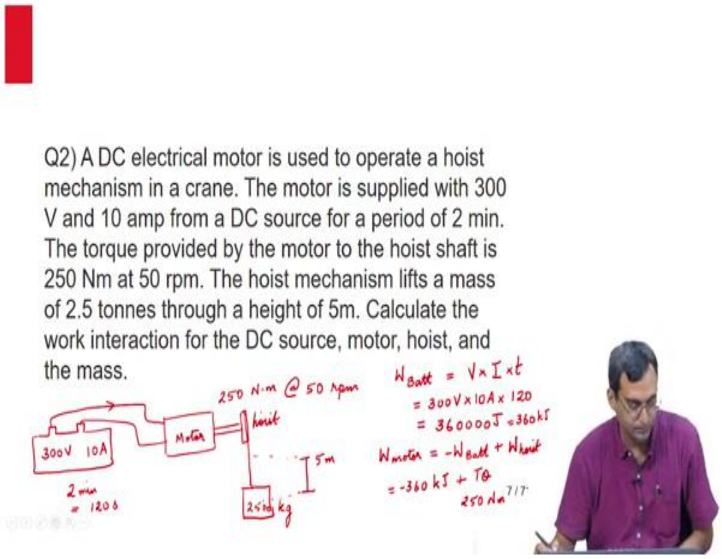

Figure 1

Solution of the problem given in Fig. 1:

The battery does work on the motor. The motor does work on the hoist. The hoist does work on the mass. If we consider the motor and the hoist as separate systems, both are receiving work as well as doing work. If we consider the battery as a system, it is doing work. If we consider the mass as a system, work is being done on the system.

Work interaction for the battery: $W_{battery} = VIt = 300 \times 10 \times 120 = 360\ kJ$

The motor does work on the hoist and receives work from the battery.

Work interaction for the motor: $W_{motor} = -W_{battery} + W_{motor-hoist} = -360\ kJ + T\theta = -360\ kJ + T(2\pi N t) = -360\ kJ + (2\pi N T)t = -360 + 2 \times 3.1415 \times \left(\frac{50}{60}\right) \times 250 \times 120 \times 0.001 = -360\ kJ + 157\ kJ = -203\ kJ$

The work interaction for the motor is negative. It means that work is being done on the motor. There are friction losses in the motor. Some of the work it receives from the battery through the work interaction is dissipated as heat energy because of frictional losses.

The hoist does work on the mass and receives work from the motor.

Work interaction for the hoist: $W_{hoist} = -W_{motor-hoist} + W_{hoist-mass} = -157\ kJ + mgh = -157 + 2500 \times 9.81 \times 5 = -157 + 122.6 = -34.4\ kJ$

The work interaction for the hoist is negative. The hoist has friction losses. Some work it receives from the motor gets dissipated as heat loss because of friction.

Work is done on the mass.

Work interaction for the mass: $W_{mass} = -mgh = -122.6\ kJ$

Sum of work interactions for all the components should be zero.

$W_{battery} + W_{motor} + W_{hoist} + W_{mass} = 360\ kJ + (-203\ kJ) + (-34.4\ kJ) + (-122.6\ kJ) = 0$ kJ

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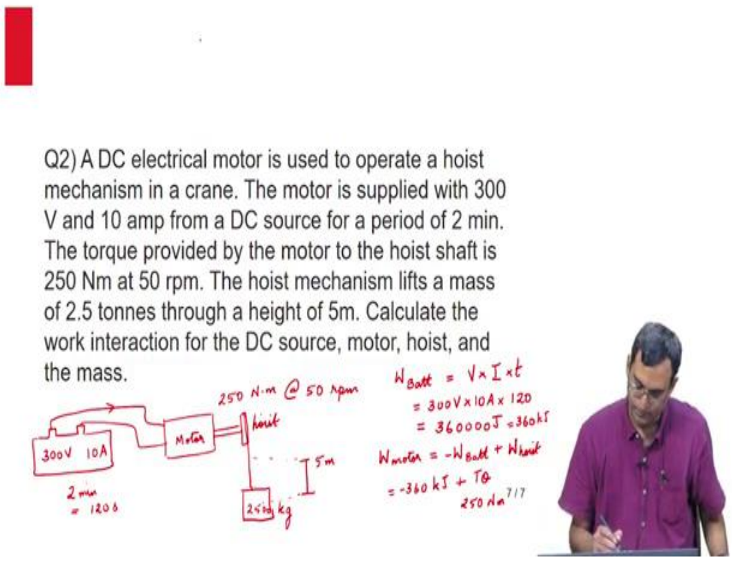

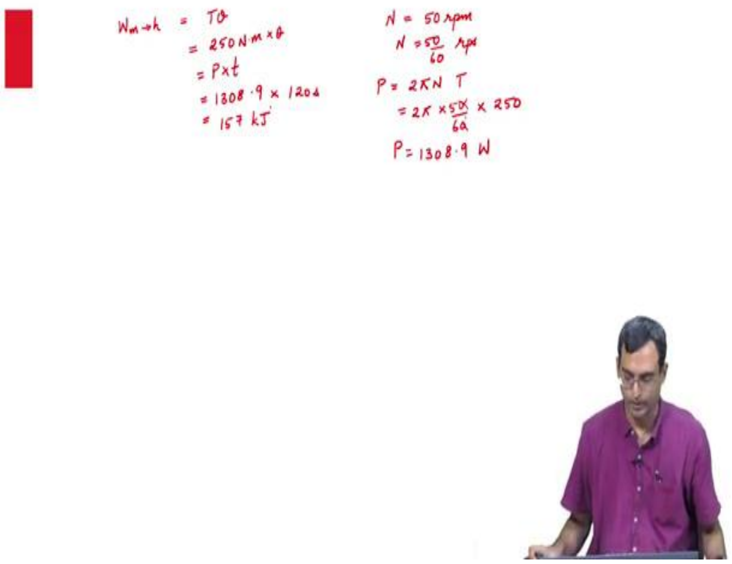

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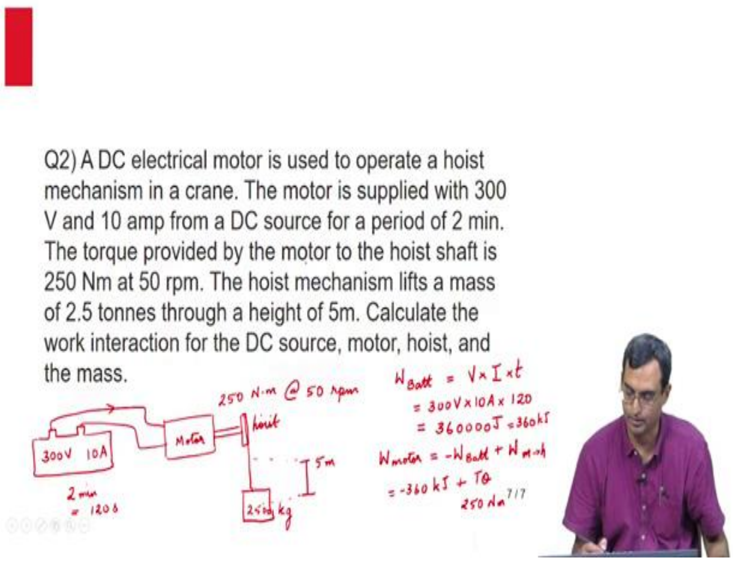

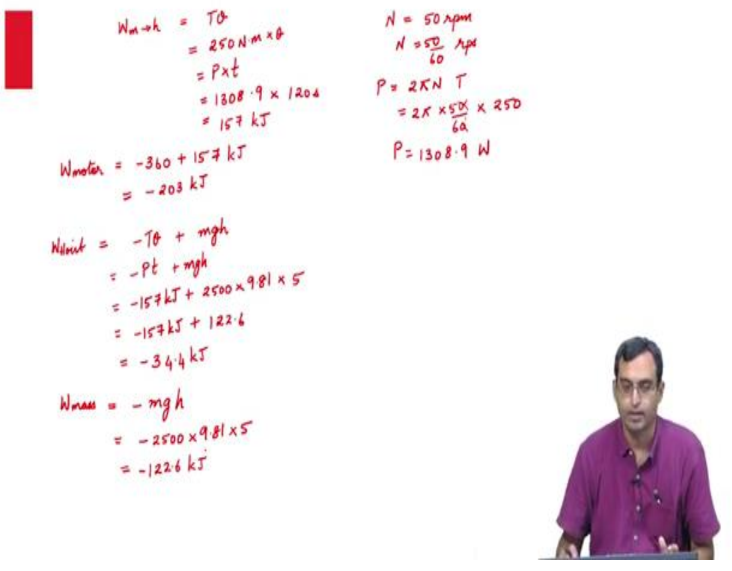

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