HEAT AND MASS TRANSFER

1. The first and second laws of thermodynamics; internal energy; enthalpy; heat; work; entropy.
2. The equation of state of an ideal gas; universal and specific gas constants (numerical values for air and water vapor); specific heat capacities (isobaric and isochoric).
3. Thermodynamic cycles for engines and other mechanical devices (e.g. compressor) in pressure-volume (*p*-*v*) and temperature-entropy (*T*-*s*) diagrams.
4. Cycle thermal efficiency; total system efficiency (of energy source)
5. Thermodynamic cycles: Carnot, Brayton (Joule), Clausius-Rankine.
6. Heat pump and refrigeration cycles; coefficient of performance (COP); energy efficiency ratio (EER).
7. Dalton's law for a mixture of ideal gases.
8. Heat transfer by conduction; Fourier's law; thermal conductivity and thermal diffusivity; steady-state heat conduction through plane or cylindrical wall.
9. Typical values of thermal conductivity for air, water, metals (steel, copper), building construction materials, thermal insulations.
10. Heat transfer by convection; Newton's cooling law; natural convection; forced convection; dimensionless similarity numbers (*Nusselt*, *Reynolds*, *Grashof*, *Prandtl*).
11. Typical values of heat transfer coefficients for forced convection in water and for natural or forced convection in air.
12. Overall heat transfer coefficient (*U-value*) for a multilayer wall (plane or cylindrical wall).
13. Heat exchangers; parallel-flow and counter-flow heat exchanger; temperature diagram; heat balance equation; heat transfer rate equation; mean temperature difference.
14. Heat transfer by radiation; Planck's and Wien's laws for the spectral emissive power (diagram); Stefan-Boltzmann law for the total emissive power.
15. Heat radiation emitted by black surface, grey surface or real surface; typical values of emissivity for different types of indoor surfaces.
16. Heat radiation between two grey surfaces; view factor; mean radiant temperature in rooms.
17. Solar radiation – solar constant; direct and diffuse solar irradiation on the ground, building walls, roofs, solar collectors etc.
18. Water vapor transport in air and in building constructions; evaporation and condensation; analogy in heat and water vapor transport.

ENVIRONMENTAL ENGINEERING

1. State of the environment – outdoor environment, indoor environment (microenvironment).
2. Calculation of heating loads in buildings.
3. Calculation of cooling loads in buildings.
4. Energy need for heating and cooling of buildings.
5. Contaminant mass balance in a ventilated room with constant contaminant source; heat balance of a ventilated room.
6. Air flow in a ventilated room, indoor air flow patterns.
7. Air supply openings and isothermal air jet characteristics.
8. Natural ventilation – wind-pressure driven ventilation, buoyancy driven ventilation, shaft ventilation, intermittent ventilation by windows, infiltration.
9. Mechanical ventilation – total ventilation, local ventilation.
10. Moist air, water vapor concentration, partial pressure, humidity ration, “h-x” (enthalpy – humidity ratio) diagram of moist air.
11. Air-conditioning systems, sizing of air-conditioning equipment.
12. Heat recovery from exhaust air.
13. Pressure losses in air ducts, pressure distribution in a ductwork system with ventilating fan.
14. Legislation in air pollution control, emissions of air pollutants, exposure to air pollutants (imissions).
15. Properties of dust, dust separation principles.
16. Desulfurization methods in air pollution control; nitrogen-oxides (NOx) pollution sources; denitrification methods in air pollution control.
17. Water-based, predominantly convective heating systems.
18. Sizing of a heating pipework system (buoyancy-driven or pump-driven).
19. Water pump and pipework system; pressure distribution in a heating system.
20. Heating appliances – basic types, heating output and design.
21. Heat sources for heating, expansion and safety devices.
22. Water-based, predominantly radiative heating systems.
23. District heating systems.
24. Fundamental acoustic variables, noise propagation in open space.
25. Noise propagation in enclosed space.
26. Mechanical sources of noise
27. Aerodynamic sources of noise.
28. Methods of noise control.

FLUID MECHANICS

1. Variation of viscosity with pressure and temperature (gases vs. liquids), variation of density with temperature and pressure (thermal expansion coefficient, buoyancy in fluids).
2. Continuity equation in fluid mechanics (application in pipe flow).
3. Bernoulli equation and its application in pipe flow.
4. Linear momentum equation in fluid mechanics.
5. Liquid discharge from a tank through a small orifice; coefficient of velocity, coefficient of contraction, discharge coefficient.
6. Laminar and turbulent flow in pipes; Reynolds number and its critical value.
7. Pressure loss due to friction in a circular or rectangular pipe.
8. Local pressure losses in pipes; Borda equation for sudden expansion or sudden contraction of a pipe.
9. Velocity measurement using Pitot-static tube in a pipe (at positive or negative gauge pressure).
10. Pressure measurement using inclined-tube micromanometer.
11. Evaluation of the mean velocity in pipe flow.
12. Principles of flow rate measurements using orifice or Venturi flowmeters.
13. Typical velocities of water, air and steam in pipes or ducts (in HVAC applications).
14. Principles of pipe or duct sizing in heating and ventilation design.
15. Propagation of air jets from air supply openings and elements into the ventilated space.
16. Velocity field near exhaust openings.
17. Derive the formulae to calculate the stack pressure in a building (with heating operated in winter).
18. Wind pressure distribution on a building envelope; interaction of wind pressure and stack pressure (building with heating in winter).