**Engineering Thermodynamics**
**Tutorial – 1**

1. A force of 125 N is applied to a mass of 12 kg in addition to the standard gravitation. If the direction of the force is vertical up find the acceleration of the mass.

2. A bucket of concrete of total mass 200 kg is raised by a crane with an acceleration of 2 m/s2 relative to the ground at a location where the local gravitational acceleration is 9.5 m/s2. Find the required force.

3. A piston/cylinder with cross sectional area of 0.01 m2 has a piston mass of 100 kg resting on the stops. With an outside atmospheric pressure of 100 kPa, what should the water pressure be to lift the piston?

4. A valve in a cylinder has a cross sectional area of 11 cm2 with a pressure of 735 kPa inside the cylinder and 99 kPa outside. How large a force is needed to open the valve?

5. Liquid water with density ρ is filled on top of a thin piston in a cylinder with cross-sectional area A and total height H. Air is let in under the piston so it pushes up, spilling the water over the edge. Deduce the formula for the air pressure as a function of the piston elevation from the bottom, h.

6. A disk-shaped flywheel, of uniform density r, outer radius *R*, and thickness *w*, rotates with an angular velocity v, in rad/s. Show that the moment of inertia, $I=\int \rho r^2 dV$, can be expressed as $I = \pi \rho w R^4/2$ and the kinetic energy can be expressed as KE $= I\omega^2/2$.

7. Two objects having different masses fall freely under the influence of gravity from rest and the same initial elevation. Ignoring the effect of air resistance, find the magnitudes of the velocities of the objects at the moment just before they strike the earth.

8. A system with a mass of 5 kg, initially moving horizontally with a velocity of 40 m/s, experiences a constant horizontal deceleration of 2 $m/s^2$ due to the action of a resultant force. As a result, the system comes to rest. Determine the magnitude of the resultant force, in N, the amount of energy transfer by work, in kJ, and the time.

9. A major force opposing the motion of a vehicle is the rolling resistance of the tires, $F_r$, given by $F_r$ = fw where f is a constant called the rolling resistance coefficient and w is the vehicle weight. Determine the power, in kW, required to overcome rolling resistance for a truck weighing 322.5 kN that is moving at 110 km/h. Let f = 0.0069.

10. One fourth kg of a gas contained within a piston-cylinder arrangement undergoes a constant pressure process at 5 bar beginning at v1=0.2 m3/kg. For the gas as the system, the work is -15 kJ. Determine the final volume of the gas.

11. A gas is compressed from 0.3 m3, 1 bar to 0.1 m3 and 3 bar. Pressure and volume are related linearly during the process. For the gas, find the work.

12. Warm air is contained in a horizontal piston-cylinder arrangement. The air cools slowly from an initial volume of 0.003 m3 to a final volume of 0.002 m3. During the process, the spring exerts a force that varies linearly from an initial value of 900N to a final value of zero. The atmospheric pressure is 100 kPa, and the area of the piston face is 0.018 m2. Friction between the piston and cylinder wall can be neglected. For the air, determine the initial and final pressures, and the work.

13. The drive shaft of a buildings air handling fan is turned at 300 rpm by a belt running on a 300 rpm by a belt running on a 0.3 m diameter pulley. The net force applied by the belt on the pulley is 2000 N. determine the torque applied by the belt on the pulley and the power transmitted.

14. A 5-kg piston in a cylinder with diameter of 100 mm is loaded with a linear spring and the outside atmospheric pressure of 100 kPa. The spring exerts no force on the piston when it is at the bottom of the cylinder and for the state shown, the pressure is 400 kPa with volume 0.4 L. The valve is opened to let some air in, causing the piston to rise 2 cm. Find the new pressure.

15. Helium gas expands from 125 kPa, 350 K and 0.25 m3 to 100 kPa in a polytropic process with n = 1.667. Is the work positive, negative or zero?

16. Show how the polytropic exponent n can be evaluated if you know the end state properties, (P1, V1) and (P2, V2).

17. A bulldozer pushes 500 kg of dirt 100 m with a force of 1500 N. It then lifts the dirt 3 m up to put it in a dump truck. How much work did it do in each situation?

18. A 400-L tank A, contains argon gas at 250 kPa, 30oC. Cylinder B, having a frictionless piston of such mass that a pressure of 150 kPa will float it, is initially empty. The valve is opened and argon flows into B and eventually reaches a uniform state of 150 kPa, 30oC throughout. What is the work done by the argon?

19. A balloon behaves so the pressure is $P = C_2 V^{1/3}$, $C_2$ = 100 kPa/m. The balloon is blown up with air from a starting volume of 1 m3 to a volume of 3 m3. Find the final mass of air assuming it is at 25oC and the work done by the air.

20. A film of ethanol at 20°C has a surface tension of 22.3 mN/m and is maintained on a wire frame as shown in Fig. P4.73. Consider the film with two surfaces as a control mass and find the work done when the wire is moved 10 mm to make the film 20 × 40 mm.