**An assignment for**

Applied Thermodynamics

**(3161910)**

**B.E. Semester 6 (Mechanical)**

**Directorate of Technical Education, Gandhinagar, Gujarat**

**Institute Name**

**Certificate**

This is to certify that Mr./Ms. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_ Enrollment No. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of B.E. Semester \_\_\_\_\_ Mechanical Engineering of this Institute (GTU Code: \_\_\_\_\_\_\_\_\_\_\_ ) has satisfactorily completed the Practical / Tutorial work for the subject **Applied Thermodynamics (3161910)** for the academic year \_\_\_\_\_\_\_\_\_\_.

Place: \_\_\_\_\_\_\_\_\_\_

Date: \_\_\_\_\_\_\_\_\_\_

**Name and Sign of Faculty member**

**Head of the Department**

**Preface**

Main motto of any laboratory/practical/field work is for enhancing required skills as well as creating ability amongst students to solve real time problem by developing relevant competencies in psychomotor domain. By keeping in view, GTU has designed competency focused outcome-based curriculum for engineering degree programs where sufficient weightage is given to practical work. It shows importance of enhancement of skills amongst the students and it pays attention to utilize every second of time allotted for practical amongst students, instructors and faculty members to achieve relevant outcomes by performing the experiments rather than having merely study type experiments. It is must for effective implementation of competency focused outcome-based curriculum that every practical is keenly designed to serve as a tool to develop and enhance relevant competency required by the various industry among every student. These psychomotor skills are very difficult to develop through traditional chalk and board content delivery method in the classroom. Accordingly, this lab manual is designed to focus on the industry defined relevant outcomes, rather than old practice of conducting practical to prove concept and theory.

By using this lab manual students can go through the relevant theory and procedure in advance before the actual performance which creates an interest and students can have basic idea prior to performance. This in turn enhances pre-determined outcomes amongst students. Each experiment in this manual begins with competency, industry relevant skills, course outcomes as well as practical outcomes (objectives). The students will also achieve safety and necessary precautions to be taken while performing practical.

This manual also provides guidelines to faculty members to facilitate student centric lab activities through each experiment by arranging and managing necessary resources in order that the students follow the procedures with required safety and necessary precautions to achieve the outcomes. It also gives an idea that how students will be assessed by providing rubrics.

Applied thermodynamics is the course which provides an understanding of Refrigeration and Air-conditioning, Internal combustion engines and fluid power engineering fundamentals. The course consists of different internal combustion engines, fluid power engines and refrigeration cycles, types, components and understanding of its components. Further, the psychromtry for producing comfort air-conditioning and fundamentals of compressible fluid flow also addressed in this course.

Utmost care has been taken while preparing this lab manual however always there is chances of improvement. Therefore, we welcome constructive suggestions for improvement and removal of errors if any.

**Practical – Course Outcome matrix**

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| --- |
| **Course Outcomes (COs):****CO-1:** To apply various gas laws of real gas and their mixture, to make use of psychrometric properties to identify basic psychrometric processes. **CO-2:** To experiment with vapor compression and vapor absorption systems. **CO-3:** To explain fuel-air and actual cycles for IC engines and to develop understanding of IC engines testing and their emission norms. **CO-4:** To apply fundamental of compressible fluid flow. **CO-5:** To demonstrate various air compressors and experiment with them. |

**Industry Relevant Skills**

The following industry relevant competencies are expected to be developed in the student by undertaking the practical work of this laboratory.

1. Testing the performance of I.C. Engines, Compressors, Refrigeration and Air Conditioning devices.
2. Selecting the material for the required I.C. Engines, Compressors, RAC system and its layout.

**Guidelines for Faculty members**

1. Teacher should provide the guideline with demonstration of practical to the students with all features.
2. Teacher shall explain basic concepts/theory related to the experiment to the students before starting of each practical
3. Involve all the students in performance of each experiment.
4. Teacher is expected to share the skills and competencies to be developed in the students and ensure that the respective skills and competencies are developed in the students after the completion of the experimentation.
5. Teachers should give opportunity to students for hands-on experience after the demonstration.
6. Teacher may provide additional knowledge and skills to the students even though not covered in the manual but are expected from the students by concerned industry.
7. Give practical assignment and assess the performance of students based on task assigned to check whether it is as per the instructions or not.
8. Teacher is expected to refer complete curriculum of the course and follow the guidelines for implementation.

**Instructions for Students**

1. Students are expected to carefully listen to all the theory classes delivered by the faculty members and understand the COs, content of the course, teaching and examination scheme, skill set to be developed etc.
2. Students shall organize the work in the group and make record of all observations.
3. Students shall develop maintenance skill as expected by industries.
4. Student shall attempt to develop related hand-on skills and build confidence.
5. Student shall develop the habits of evolving more ideas, innovations, skills etc. apart from those included in scope of manual.
6. Student shall refer technical magazines and ASHRAE design data books.
7. Student should develop a habit of submitting the experimentation work as per the schedule and should be well prepared for the same.

**Common Safety Instructions**

1. Students are expected to carefully wear goggles and gloves while charging refrigerants to the system.
2. Maintain laboratory clean and organized.
3. Switch off the main power supply to the experimental set up on completion of experiment.
4. Loose clothing and jewellery are prohibited.
5. Do not leave any running experimental set up unattended.

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**(Progressive Assessment Sheet)**

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| 3 | 3 |  |  |  |  |  |  |
| 4 | 4 |  |  |  |  |  |  |
| 5 | 5 |  |  |  |  |  |  |
|  Total |  |  |  |

Assignment - 1

(CO1)

1. An air conditioning plant is required to supply 60 m of air per minute at a DBT of 21°C and 55% RH. The outside air is at DBT of 28°C and 60% RH. Determine the mass of water drained and capacity of the cooling coil. Assume the air conditioning plant first to dehumidify and then to cool the air.
2. The readings from a sling psychrometer are as follows dry bulb temperature = 30° C ; Barometer reading 740mm of Hg Using steam tables, determine :

 I. Dew point temperature ;

 2. Relative humidity ;

 3. Specific humidity ;

 4. Degree of-saturation ;

 5. Vapour density ; and

 6. Enthalpy of mixture per kg of dry air.

1. The humidity ratio of atmospheric air at 28°C dry bulb temperature and 760 mm of mercury is 0.016 kg / kg of dry air. Determine:

 1. partial pressure of Water vapour;

 2.relative humidity;

 3. dew point temperature;

 4. specific enthalpy; and

 5. vapour density.

Assignment - 2

(CO2)

1. Refrigerant-134a is the working fluid in an ideal compression refrigeration cycle. The refrigerant leaves the evaporator at -20o C and has a condenser pressure of 0.9 MPa. The mass flow rate is 3 kg/min. Find COPR and COPR, Carnot for the same Tmax and Tmin, and the tons of refrigeration.
2. In an ammonia vapour compression system, the pressure in the evaporator is 2 bar. Ammonia at exit is 0.85 dry and at entry its dryness fraction is 0.19. During compression, the work done per kg of ammonia is 150 kJ. Calculate the C.O.P. and the volume of vapour entering the compressor per minute, if the rate of ammonia circulation is 4.5 kg/min. The latent heat and specific volume at 2 bar are 1325 kJ/kg and 0.58 m3 /kg respectively.
3. A vapour compression refrigerator works between the pressure limits of 60 bar and 25 bar. The working fluid is just dry at the end of compression and there is no under-cooling of the liquid before the expansion valve. Determine :

 1. C.O.P. of the cycle ; and

 2. Capacity of the refrigerator if the fluid flow is at the rate of 5 kg/min.

Assignment - 3

(CO3)

1. Write brief note on Euro Norms and Testing of IC engine as per IS.
2. Describe heat balance sheet in details with your comment.
3. Procedure of Willan’s Line method and Morse test for IC engine state your understanding from it.
4. Following observations were recorded during a test on a single cylinder 4- stroke oil engine Bore =300mm; Stroke = 450mm; Speed =300rpm; imep = 6bar;   Net brake load = 1.5 kN;, Brake drum diameter = 1.8m; Brake rope diameter = 2 cm.

 Calculate: (i) Indicated Power

                 (ii) Brake Power

   (iii) Mechanical Efficiency

1. The following data refers to a petrol engine working on OTTO four stroke cycle.

 Brake Power = 14.7 kW, Suction Pressure = 0.9 bar, Mech. Efficiency = 80%, Compression Ratio = 5, Index of Compression curve = 1.35, Index of expansion curve = 1.3, Maximum Explosion pressure = 24 bar, Engine Speed = 1000 r.p.m.,  Ratio of stroke to bore = 1.5, Find the diameter and stroke of piston.

1. A four cylinder two stroke cycle petrol engine develops 30 KW at 2500rpm. The mean effective pressure on each piston is 8 bars and mechanical efficiency is 80%. Calculate the diameter and stroke of each cylinder with stroke bore ratio 1.5. Also calculate the fuel consumption of the engine, if brake thermal efficiency is 28%. The calorific value of fuel is 43900 kJ/ kg.
2. A four cylinder engine running at 1200 rpm delivers 20 kW. The average torque when one cylinder was cut is 110 Nm. Find the indicated thermal efficiency if the calorific value of the fuel is 43 MJ/kg and the engine uses 360 grams of gasoline per kWh.

Assignment - 4

(CO4)

1. Define Stagnation temperature.
a) The temperature at zero velocity
b) The temperature at zero pressure
c) The temperature at zero heat transfer
d) The temperature at zero volume
2. Calculate the pressure at a height of 6500m above the sea level if the atmospheric pressure is 10.145 N/cm2 and temperature is 25℃ assuming air is incompressible. Take density of air as 1.2 kg/m3. Neglect variation of g.
a) 4.98 N/cm2
b) 2.49 N/cm2
c) 1.24 N/cm2
d) None of the mentioned
3. Pressure variation for compressible fluid is maximum for which kind of process?
a) Isothermal
b) Adiabatic
c) Quasi Static
d) None of the mentioned
4. Why can’t the density be assumed as constant for compressible fluids?
a) It shows variation with temperature and pressure
b) It remains constant with temperature and pressure
c) It becomes almost constant at very high temperature
d) None of the mentioned
5. For dynamic fluid motion in a pipe, the pressure measurement cannot be carried out accurately by manometer.
a) True
b) False
6. A simple U tube manometer connected to a pipe in which liquid is flowing with uniform speed will give which kind of pressure?
a) Absolute Pressure
b) Vacuum Pressure
c) Gauge Pressure
d) None of the mentioned
7. With the increase in pressure, the exit velocity \_\_\_\_\_\_\_\_\_
a) Decreases
b) Increases
c) Same
d) Independent
8. Compressible flow is a flow that deals with \_\_\_\_\_\_
a) Fluid temperature
b) Fluid pressure
c) Fluid density
d) Fluid geometry
9. Which among the following is an assumption of the compressible flow?
a) Resistance to flow of object
b) No-slip condition
c) Known mass flow rate
d) Resistance to flow of heat
10. The definition of flow being compressible is\_\_\_\_\_\_
a) M > 0.3
b) M > 0.5
c) Depends on precision required
d) Another name for supersonic flows\
11. Differentiate between the compressible and incompressible flow. Mention some of the flow situations where compressibility of the fluid has to be considered.
12. Explain the terms: Mach number, Mach cone, Mach Line and Mach angle in the context of compressible flow.
13. Obtain Bernoulli's equation for compressible flow undergoing adiabatic process.
14. Show that for steady, one-dimensional, isentropic compressible flow through a duct



1. Explain compressibility correction factor
2. The speed of supersonic aircraft flying at an altitude of 1100 m corresponds to a mach number of 2.5. Estimate the time elapsed between the instant the aircraft was directly over head of an observer instant the observer feel the disturbance due to aircraft. Consider the following three cases and presume that the temperature at the given height is 208 K. (a) when the observer is stationary, (b) when the observer is moving in the direction of aircraft at M = 0.5 c) when the observer is moving in the opposite direction with M = 0.5.Take γ = 1.4 and R = 287 J/kgK
3. A gas with a velocity of 300 m/s is flowing through a horizontal pipe at a section where pressure is 7.8 kN/m2 absolute and temperature 40 ° C. The pipe changes in diameter and at this section the pressure is 11.7 kN/m2 absolute. Find the velocity of the gas at this section if the flow of the gas is adiabatic. Take γ = 1.4 and R = 287 J/kgK.

Assignment - 5

(CO5)

1. Brief multistage conditions for minimum work and Intercooling in reciprocating compressors.
2. Draw a neat sketch and explain construction features as well as parts of centrifugal compressors in details.
3. What do you understand from velocity diagram of centrifugal compressor?
4. State phenomenon of surging and chocking with its effects on centrifugal compressor.
5. Elaborate lift and drag in reference to axial flow compressor.
6. Write a note on performance characteristics for axial flow compressor.
7. A single stage double acting air comptrssor of 150 KW power takes air in at 16 bar & delivers at 6 bar. The compression follows the law PV 1.4 = Constant. The compressor runs at 160 rpm with average piston speed of 150 m /min. Determine the size of the cylinder.
8. A single stage single acting reciprocating air compressor is required to handle 30m3   of free air per hour measured at 1 bar. The delivery pressure is 6.5 bar and the s peed is 450 r.p.m allowing volumetric efficienc y of 75%;an isothermal   efficiency  of   76%  and mechanical efficiency  of 80%.  Find the indicated mean effective pressure and the power required  the compressor.
9. A two stages, single acting air compressor compresses air to 20bar. The air enters the L.P cylinder at 1bar and 27oc and leaves it at 4.7bar. The air enters the H.P. cylinder at 4.5bar and 27oc. the size of the L.P cylind er is 400mm diameter and 500mm stroke. The clearance volume In both cylinder is 4% of the respective stroke volume. The compressor runs at 200rpm, taking index of compression and expansion in the two cylinders as 1.3, estimate the indicated power required to run the compressor;

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