جامعة الملك فهد للبترول و المعادن
King Fahd University of Petroleum & Minerals
College of Environmental Design
Architectural Engineering Department

ARE 322
Building Mechanical Systems

LAB EXERSISES MANUAL

Prepared
By
Dr. Mohammad S. Al-Homoud
Associate Professor
Architectural Engineering Department

Student Name: ……………………..………….

Student ID # : ………………………………..

Fall 2004
(041)

CONTECNT

Introduction:

The following set of lab exercises are conducted by the students taking ARE 322, Building Mechanical Systems Course. The nature of the lab of this course is more of building systems design oriented more than an experimental nature. Therefore, the number of experiments is limited and most of the lab is utilized in solving design problems for selected buildings in the class and/or in the computer lab. The lab exercises were designed to be as practical as possible and addresses the real building systems design issues of air-conditioning, fire safety, water systems, and elevator systems.

Objectives:

This course is intended to provide Architectural Engineering and Architecture students with the fundamental principles and basic concepts in the analysis and design of building mechanical systems. The knowledge acquired in this course is intended to prepare students to integrate mechanical systems into their designs as well as being able to communicate with design professionals in the field in a positive, cooperative and knowledgeable manner. The course also provides students with the necessary knowledge required for advanced and creative building mechanical systems analysis and design.

The laboratory is an important part of the course. It is an opportunity for detailed discussion of some materials presented in the lecture as well as practical applications of theories gained from readings and class presentation.

King Fahd University of Petroleum & Minerals
College of Environmental design
Architectural Engineering Department

Building Mechanical Systems
ARE 322

LAB EXERCISE # 1

INTRODUCTION TO
FIRE SAFETY SYSTEMS IN BUILDINGS

INTRODUCTION TO
FIRE SAFETY SYSTEMS IN BUILDINGS

In groups of two students each, you need to tour the CED building #19 and take notes of all fire safety related design and operation aspects. Note down all positive as well as negative aspects of the fire safety systems in the building. You need to investigate all active and passive systems in the building including:

- Exits and access to exits
- Stairs
- Fire rated materials
- Smoke detectors
- Fire alarm systems
- Fire extinguishers
- Fire hoses and standpipes
- Smoke control systems
- Access for fire fighting
- Etc.

Critique the existing fire safety system design and operation in the building and provide your recommendations for its improvement. Use sketches when appropriate.

Submit your findings in a typed, summarized, neat report that can be presented to the whole class.

King Fahd University of Petroleum & Minerals
College of Environmental design
Architectural Engineering Department

Building Mechanical Systems
ARE 322

LAB EXERCISE # 2

FIRE SAFETY
SYSTEMS DESIGN IN BUILDINGS

FIRE SAFETY
SYSTEMS DESIGN IN BUILDINGS

The office building shown in the attached **Figure**, has the following characteristics:

- First floor: Retail (small shops)
- Floors 2 through 9 (typical): Open office space
- Combustible construction sheathed with plaster.
- Suspended ceiling.
- Floor-to-floor height = 3.5 m.
- Ceiling height = 2.8 m.

Using your notes, handouts, the provided information and tables in your textbook (Part IV), and local and international safety codes and standards to perform the following:

For the first floor and a typical floor plan of the building:

1. Provide the required vertical and horizontal safety exits with the proper sizes.
2. Show all water supply tanks, risers, mains and branches for sprinklers and hoses
3. Show the location of all standpipes.
4. Choose the proper fire extinguishers and explain why? Indicate their proper locations.
5. Indicate all fire rated walls.
6. Classify the fire hazard of the building.
7. Specify the area coverage per sprinkler.
8. Specify the distance between sprinkler heads.
9. Draw sprinklers layout on building plan according to the specs. of items 7 and 8 above.
10. Draw a section through the whole building showing main supply of water. Also show a section for part of the ceiling showing the piping and sprinkler heads arrangement.

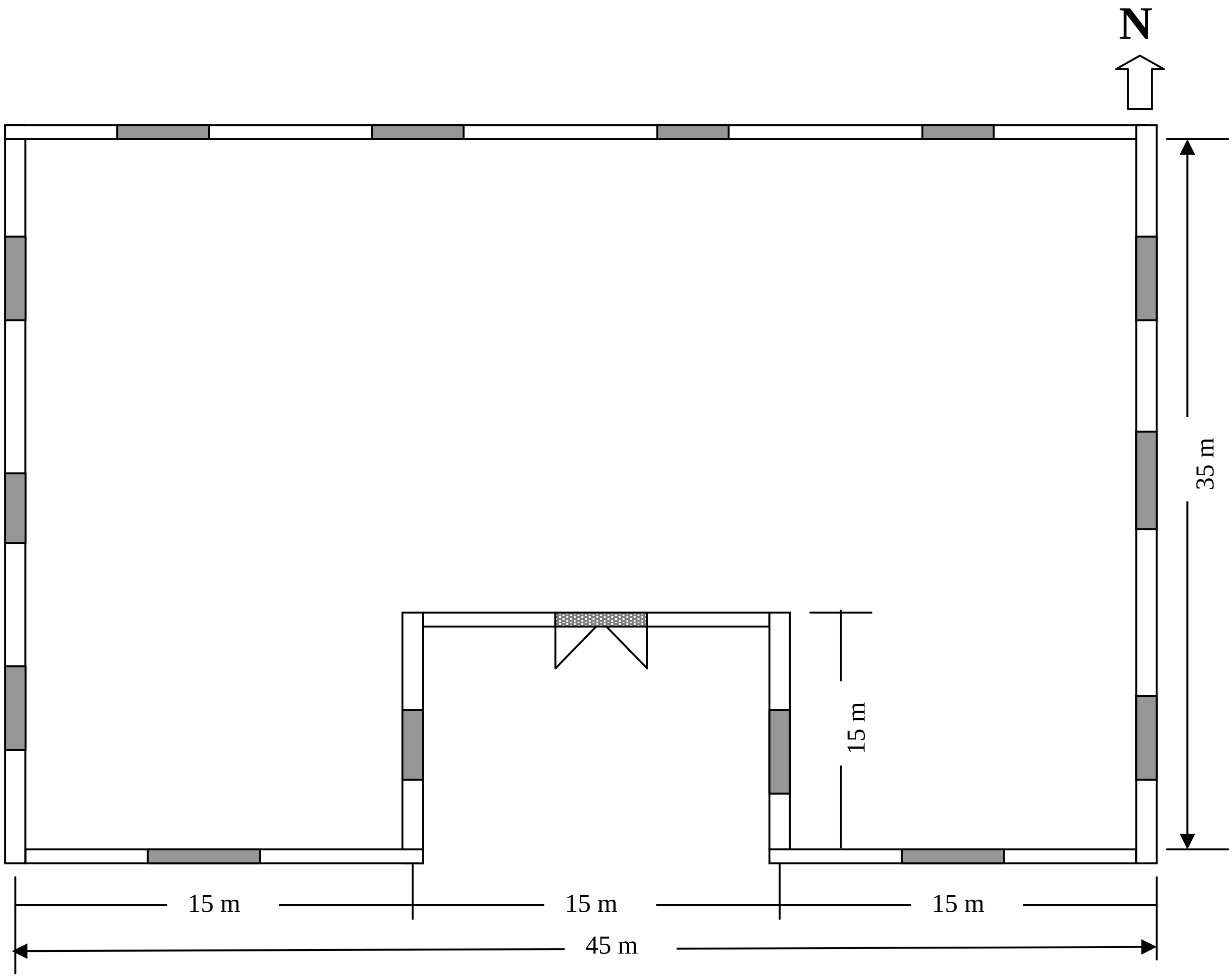

Figure 1. Office Building Plan

Building Physical Characteristics:

- First floor: Retail (small shops)
- Floors 2 through 9 (typical): open office space
- Combustible construction sheathed with plaster.
- Suspended ceiling.
- Floor-to-floor height = **3.5 m**.
- Ceiling height = **2.8 m**.
- Main door is **3m** wide by **2.5m** high (**7.5 m^2**)
- Windows are **15m^2** each

King Fahd University of Petroleum & Minerals
College of Environmental design
Architectural Engineering Department

Building Mechanical Systems
ARE 322

LAB EXERCISE # 3

SMOKE CONTROL IN BUILDINGS

SMOKE CONTROL IN BUILDINGS

The office building shown in the attached **Figure**, has the following characteristics:

- First floor: Retail (small shops)
- Floors 2 through 9 (typical): Open office space
- Combustible construction sheathed with plaster.
- Suspended ceiling.
- Floor-to-floor height = 3.5 m.
- Ceiling height = 2.8 m.

Using your notes, handouts, the provided information and tables in your textbook (Part IV), and local and international safety codes and standards perform the following:

Consider all possible combinations of smoke control systems for the building and provide, at least, the following:

1. Show a section through shafts with considerations for smoke control.

2. Show a section through stairwells with pressurization fans and dampers for smoke control

3. Consider HVAC system with smoke control capabilities and show a typical sequence of operation for the system controls if a smoke is detected in a middle floor of the building. Show the sequence for the fire zone and at least two floors above and two floors below.

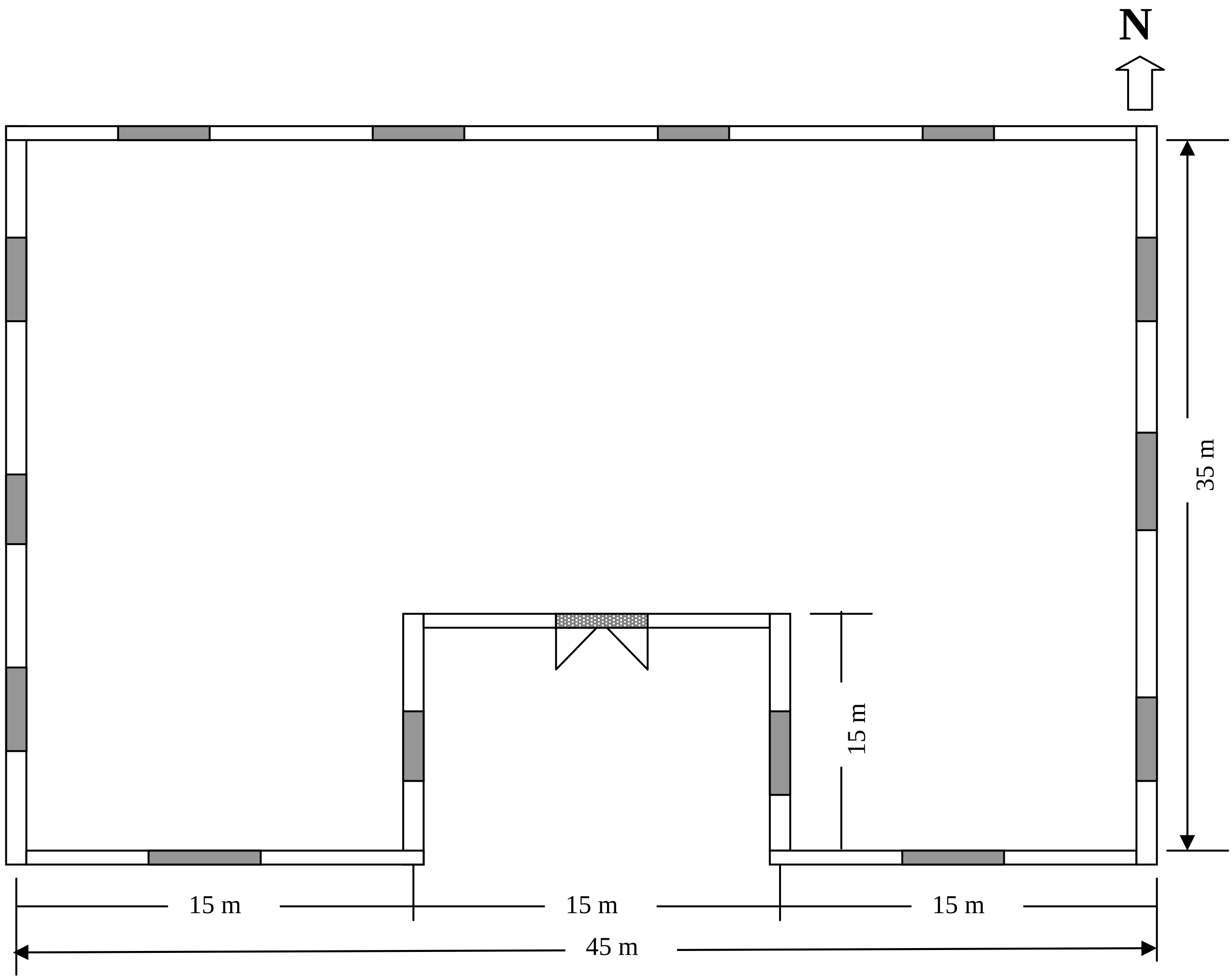

Figure 1. Office Building Plan

Building Physical Characteristics:

- First floor: Retail (small shops)
- Floors 2 through 9 (typical): open office space
- Combustible construction sheathed with plaster.
- Suspended ceiling.
- Floor-to-floor height = **3.5 m**.
- Ceiling height = **2.8 m**.
- Main door is **3m** wide by **2.5m** high (**7.5 m^2**)
- Windows are **15m^2** each

King Fahd University of Petroleum & Minerals
College of Environmental design
Architectural Engineering Department

Building Mechanical Systems
ARE 322

LAB EXERCISE # 4

BUILDINGS SERVICE WATER PIPING DISTRIBUTION & SIZING

BUILDINGS SERVICE WATER PIPING DISTRIBUTION & SIZING

The office building shown in the attached **Figure**, has the following characteristics:

- First floor: Retail (small shops)
- Floors 2 through 9 (typical): Open office space
- Suspended ceiling.
- Floor-to-floor height = 3.5 m.
- Ceiling height = 2.8 m.
- Minimum street main pressure = 400 kPa
- 8 toilets and 8 ordinary basin faucets on each of the two ends of stairs at the first floor.
- 4 toilets, 5 ordinary basin faucets, and service sink (15 mm) on each stair end for typical floors

Using your notes, handouts and the provided information and tables in your textbook (Chapter # 9) perform the following:

I. WATER SUPPLY & DISTRIBUTION:

Provide main water supply and branch for service water use as needed for the building and provide the following:

1. Determine the water distribution systems used and why?
2. Show the main water supply from the street public main to the top the building
3. Show section of the building with piping distribution throughout the building.
4. Show all storage tanks, suction tanks, pumps, and other accessories (if available)
5. Determine the required flow rate to the building.
6. Determine the total water demand in fixture units.
7. Determine the equivalent length of pipe in the main line of the building.
8. Determine the approximate design pressure drop per unit length (kPa/m).
9. Determine the pipe sizes of the main line and typical branches.

Show all steps of the distribution and sizing process. Indicate all assumptions and justifications for your design.

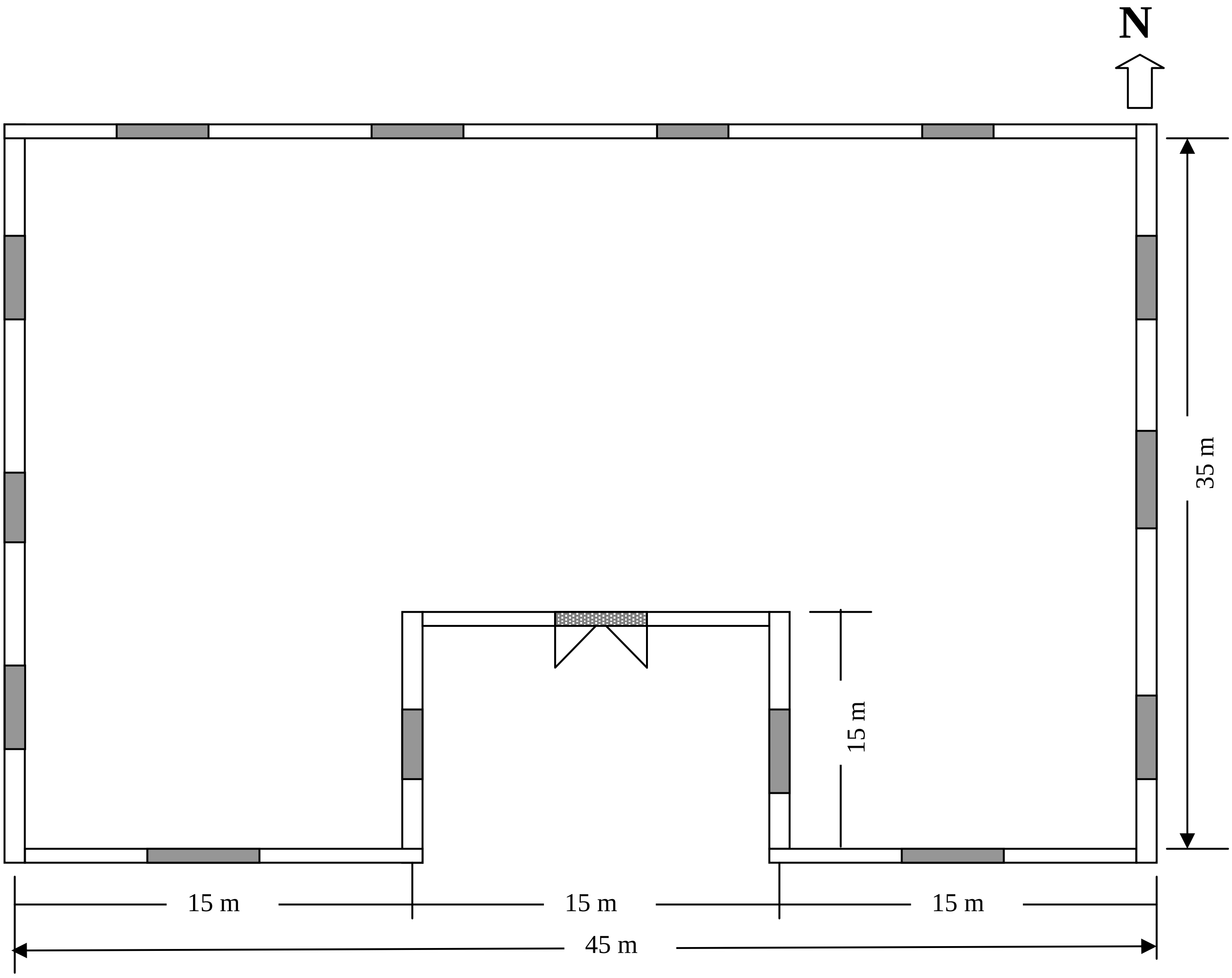

Figure 1. Office Building Plan

Building Physical Characteristics:

- First floor: Retail (small shops)
- Floors 2 through 9 (typical): open office space
- Combustible construction sheathed with plaster.
- Suspended ceiling.
- Floor-to-floor height = **3.5 m**.
- Ceiling height = **2.8 m**.
- Main door is **3m** wide by **2.5m** high (**7.5 m^2**)
- Windows are **15m^2** each

King Fahd University of Petroleum & Minerals
College of Environmental design
Architectural Engineering Department

Building Mechanical Systems
ARE 322

LAB EXERCISE # 5

ELEVATOR SELECTION

ELEVATOR SELECTION

The office building shown in the attached **Figure**, is located in downtown **Al-Khobar** and has the following characteristics:

- First floor: Retail (small shops)
- Floors 2 through 9 (typical): open office space to be rented to different interested organizations;
- Suspended ceiling.
- Floor-to-floor height = 3.5 m.
- Ceiling height = 2.8 m.

Using your notes, handouts and the provided information and tables in your textbook (Chapter 23), provide the following:

1. Proper number and location of stairs for the whole building

2. Proper size, capacity and number of elevators to serve the building.

3. Lobby and core service area design and elevators layout on the building plans.

4. A section through the building showing vertical transportation system (stairs, elevator shafts, and elevator machine rooms, etc.) with the necessary information.

Show *__all steps of calculations__*. Indicate all *__assumptions__* and *__justifications__* for your design. Present your work, calculations and drawings in a neat and clear format.

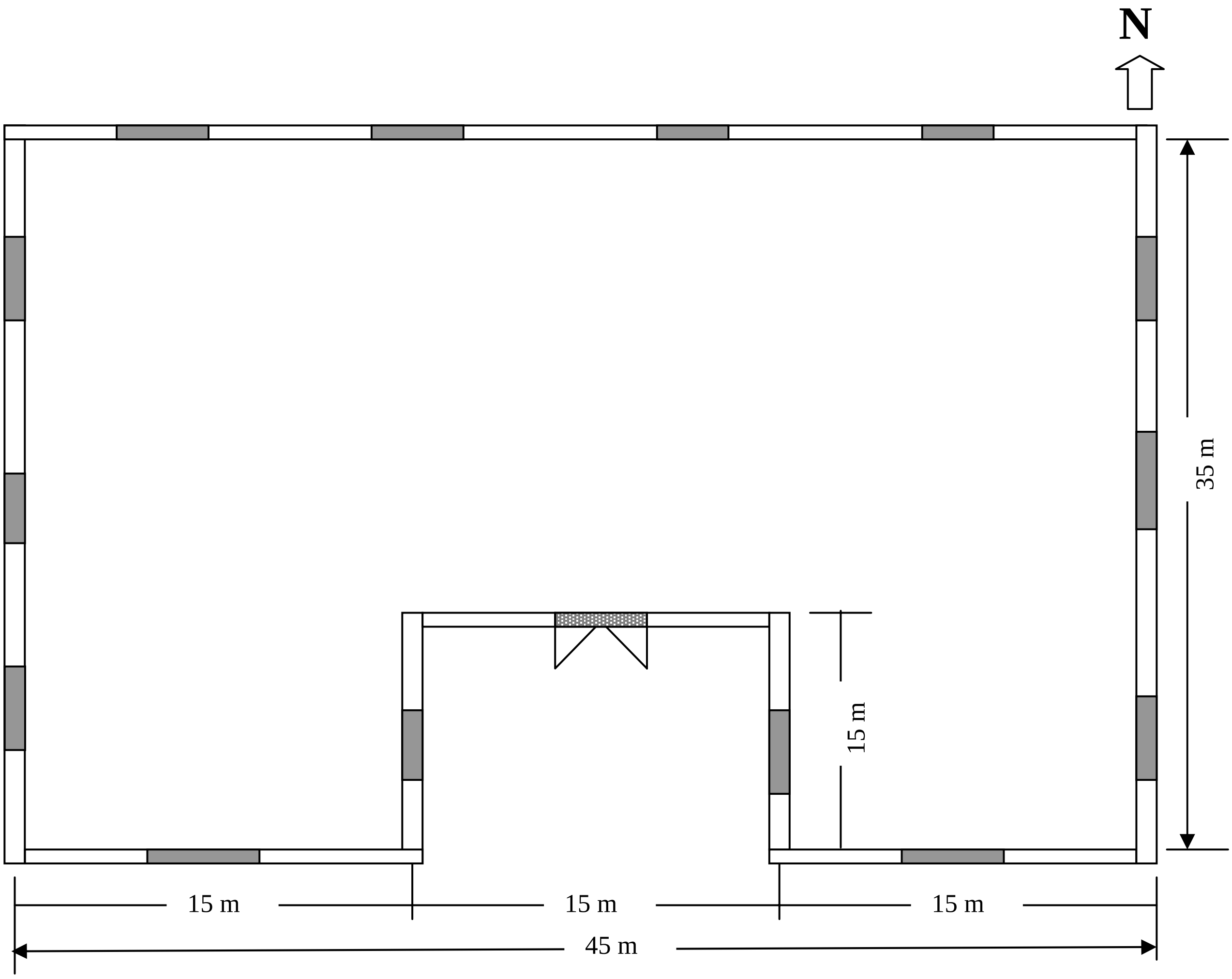

Figure 1. Office Building Plan

Building Physical Characteristics:

- First floor: Retail (small shops)
- Floors 2 through 9 (typical): open office space
- Combustible construction sheathed with plaster.
- Suspended ceiling.
- Floor-to-floor height = **3.5 m**.
- Ceiling height = **2.8 m**.
- Main door is **3m** wide by **2.5m** high (**7.5 m^2**)
- Windows are **15m^2** each

King Fahd University of Petroleum & Minerals
College of Environmental design
Architectural Engineering Department

Building Mechanical Systems
ARE 322

LAB EXERCISE # 6

BUILDING MECHANICAL SYSTEMS TOUR

BUILDING MECHANICAL SYSTEMS TOUR

You will be taken on a tour to visit some of **the Building Mechanical Systems** which you have been introduced to. The tour will be guided by a professional from the department concerned in the building site who will explain things and answer your questions.

Prepare yourself for the tour and be ready to take notes as well as sketches of the facilities and equipment to be visited. Do not hesitate to ask any questions about things you don't understand.

Prepare a **report** about your **observations** of the tour, the type of systems/equipment you visited and how do they function along with the necessary sketches. Critic the systems/equipment use and suitability for the building which they serve. Include any additional comments or ideas to the current systems. **Submit your report in a neat and understandable format.**

King Fahd University of Petroleum & Minerals
College of Environmental design
Architectural Engineering Department

Building Mechanical Systems
ARE 322

LAB EXERCISE # 7

THERMAL COMFORT EVALUATION

THERMAL COMFORT EVALUATION

Objectives:

To familiarize students with the use of various environmental parameters measuring instruments. Also to make them appreciate their thermal environment, human sensation to it, and have a sense of the magnitude of the thermal comfort influencing environmental parameters.

Detailed Procedure

Part I.

a). Select **three** (one indoor and two outdoor) different spaces within KFUPM campus (*other than building #19 or the plaza in front of it*) to evaluate the thermal conditions in those spaces. **Use the Solomat 500e Meter and the Datametrics Airflow Meter** available in the Building Science Lab. to measure the thermal environmental parameters of ***dry bulb temperature***, ***relative humidity***, ***dew point temperature***, and ***air motion*** in every space. For proper use of the measuring instruments, make sure to read the attached operating instructions.

b). Use the **sling psychrometer** available in the lab. to measure the ***dry bulb temperature*** and ***wet-bulb temperature*** in all spaces. ***Comment*** on the differences in dry-bulb temperature values from previous measurements in (a) above if any.
To use the meter, wet the wick of the meter, rotate the sling psychrometer and check temperatures in about twenty seconds intervals until constant readings are obtained then record them.

c). Write down the **measured** values and **answer** the questions in the attached sheets for each space. Make sure to return the instruments to the lab. technician at the end of the lab session.

d). Keep record of all **measured** parameters for use in the next lab. assignment.

Part II.

Observe thermal conditions in **two** (one indoor and one outdoor) other different spaces within KFUPM campus and estimate (without the measuring meters) the same thermal environmental parameters of ***dry bulb temperature***, ***relative humidity***, and ***air motion.*** Then, **answer** the questions in the attached sheets for each space.

NOTE:

Write your answers in ***a clear and to the point statements***. Draw your sketches neatly and write down any comments that you might have.

Comments / Discussion on any new and useful findings

____

____

____

____

____

____

Student name : ______________________________
Group mate(s) : ______________________________
Evaluated space : ______________________________
Evaluation date & time: ______________________________

MEASURED PARAMETERS

ANSWER THE FOLLOWING QUESTIONS FOR EACH SPACE:

1. ***Describe*** the **space** you are evaluating and the **neighboring surroundings**: surfaces, structures and/or landscaping that might affect thermal conditions in the space:

2. ***Describe*** **weather conditions** at the time of your observation (e.g. sky conditions, rain,…etc.):

3. ***Measure*** the following thermal environmental parameters:

	Measured		***Comments***
dry-bulb temperature	______/______	^oC	______________________________
relative humidity	_____________	%	______________________________
air motion	_____________	m/s	______________________________
dew point temperature	_____________	^oC	______________________________
wet-bulb temperature	_____________	^oC	______________________________

4. What is the **most** predominant (influential) thermal environmental parameter?

5. What is the **least** predominant (influential) thermal environmental parameter?

6. What is your **overall thermal comfort evaluation** of the space:

____cold ____cool ____slightly cool ___neutral ____slightly warm ____warm ____hot

7. ***Locate*** the condition of the space **on the psychrometric chart**. Is the thermal environment within the thermal comfort zone or not? If not, what specifically would you recommend to bring the conditions in this space into the thermal comfort zone? ***Compare*** to your own thermal sensation of the space in question #6 above.

8. ***sketch*** the space and its surroundings on the back side of this sheet ***Neatly***.

Student name	: ____________________________
Group mate(s)	: ____________________________
Evaluated space	: ____________________________
Evaluation date & time	: ____________________________

ESTIMATED PARAMETERS

ANSWER THE FOLLOWING QUESTIONS FOR EACH SPACE:

1. ***Describe*** the **space** you are evaluating and the **neighboring surroundings**: surfaces, structures and/or landscaping that might affect thermal conditions in the space:

2. ***Describe*** **weather conditions** at the time of your observation (e.g. sky conditions, rain,..etc.):

3. ***Estimate*** the following thermal environmental parameters:

	Estimated		***Comments***
dry-bulb temperature	_____________	^{o}C	______________________________
relative humidity	_____________	%	______________________________
air motion	_____________	m/s	______________________________

4. What is the **most** predominant (influential) thermal environmental parameter?

5. What is the **least** predominant (influential) thermal environmental parameter?

6. What is your **overall thermal comfort evaluation** of the space:

____cold ____cool ____slightly cool ___neutral ____slightly warm ____warm ____hot

7. ***Locate*** the condition of the space **on the psychrometric chart**. Is the thermal environment within the thermal comfort zone or not? If not, what specifically would you recommend to bring the conditions in this space into the thermal comfort zone? ***Compare*** to your own thermal sensation of the space in question #6 above.

8. ***sketch*** the space and its surroundings on the back side of this sheet ***Neatly***.

EQUIPMENT

<u>Solomate Meter</u>

Model # MPM 500e

Operating Instruction:

Before Operation:

A-Check battery charge by turning power on and noting the digital disply i.e if all the segments and battery symbol appear then BATTERY is OK

otherwise check with the lab Engineer.

<u>TO MEASURE TEMPERATURE & HUMIDITY.</u>

Using single probe: Thermo hygrometer probe (with built in pt100 sensor)

B- Plug the Thermo hygrometer probe into the right hand 9- PIN socket as shown in the figure below, make sure the sensor cover is removed. Then;

1. **To Measure Temperature**:

   Select pt100 on the ROTARY FUNCTION SELECTOR,the meter should display the ambient temperature.

   Choose between C or F by changing the SYMBOL SWITCH.

2. **To Measure Humidity**

   Select % RH on the ROTARY FUNCTION SELECTOR, the meter should display the Relative Humidity.

   To read the dew point temperature press the SYMBOL SWITCH, Then dew point Temperature in either C or F will be displayed, press the SYMBOL SWITCH once more to get the reading in the other units.

   Repeat the procedure for different readings

SLING PSYCHROMETER.

Operating instructions:

BEFORE OPERATION:

A- Remove END CAP and immense psychrometer Body in the water up to mercury reservoir on the thermometers until WICK is thoroughly wetted. Fill END CAP with water and return back; tighten enough to prevent leakage.

B-.Make sure that WICK is wet and covers mercury reservoir on WET BULB THERMOMETER and other THERMOMETER is dry.

TO MEASURE WET &DRY BULB TEMPERATURES (C)

PULL body from the COVER TUBE until body hangs free.

Holding COVER TUBE as handle; rotate body two to three revolutions per second. Continue rotating until temperature stabilizes about 1 1/2 minutes.

Immediately read WET BULB THERMOMETER and then DRY BULB THERMOMETER. Note down the readings, return BODY back in the COVER TUBE.

Repeat the procedures for different readings

CONVERSION

F= 9/5C+32 C= 5/9(F-32)

DATAMETRICS

Air velocity & Temperature Meter

Model #1OOVT

Operating Instructions:

Before Operation:

A-_Check battery charge by turning power on and noting if pointer is in "BATTERY OK" zone, if not charge it.

B- Check zero velocity reading by turning power on while covering tip completely with shield Function Switch on LOW VELOCITY and holding probe horizontal with scribe line down. set meter reading to exactly zero by means of ZERO KNOB, as shown in the figure below.

ONCE THE ZERO SETTING IS OVER REMOVE THE SHIELD COVER.

1. TO MEASURE TEMPERATURE (F)

Set Function Switch to TEMP and position probe tip in the zone to be measured. The pointer indicates the TEMP in F

2. TO MEASURE AIR VELOCITY (FPM)

Position the Probe tip in air stream to be measured. Set the Function Switch to flow range desired i.e LOW VELOCITY or HIGH VELOCITY.

If LOW VELOCITY is selected----Read the lower scale i.e. 0 to 600 FPM.

If HIGH VELOCITY is selected---Read the Upper Scale i.e. 600 to 6000FPM.

Repeat the procedure for different readings.

King Fahd University of Petroleum & Minerals
College of Environmental design
Architectural Engineering Department

Building Mechanical Systems
ARE 322

LAB EXERCISE # 8

PSYCHROMETRICS

PSYCHROMETRICS

1. a). Using the provided ASHRAE psychrometric charts, determine the psychrometric properties of moist air existing at the given two conditions and fill in the attached table:

i). at sea level pressure of 101.325 kPa, and
ii). at an elevation of 1500 m. above sea level with a pressure of 84.556 kPa.

b). What impact do you observe on the psychrometric properties of air as elevation above sea level changes.

2. Air at *standard sea level* pressure is *sensibly cooled* from state 1 @ 35 ^{o}C DB temperature and 40% relative humidity to state 2 @ 24 ^{o}C DB temperature. ***Determine*** the properties of the air at the two conditions and ***show*** the cooling process on the psychrometric chart. Is the final state of the air within the comfort zone? and why?
What is the amount of energy (kJ/kg) required to sensibly cool the air to its final state?

3. The condition within a room *at sea level* is 24 ^{o}C, 50% relative humidity.

i). At what temperature will condensation start to occur on surfaces of the room?

Will moisture condense on the window glass and why? If:
ii). The inside surface temperature of the window is 12.5 ^{o}C, and
iii). The inside surface temperature of the window is 15 ^{o}C.

4. For each of the three spaces you took measurements in lab exercise #1, use the measurements of <u>dry-bulb temperature</u> and <u>relative humidity</u> to find other environmental parameters with the help of the psychrometrics chart. **Tabulate** your <u>*measured*</u> data along with the <u>*calculated*</u> values and **comment on the differences** between them and the possible sources of errors, if any.

Psychrometric properties of moist air at:

Elevation: …………………….……. m **Elevation:** …….…………………… m
Pressure : ………………………... kPa **Pressure :** …………………….. kPa

NO	Dry bulb Temp (C)	Wet bulb temp(C)	Dew point temp ©	Relative humidity (%)	Humidity Ratio(gm/kg)	Specific Volume(m^3/kg)	Enthalpy (kj/kg)
1	25	20					
	25	20					
2	32		15				
	32		15				
3	30			40			
	30			40			
4	42						70
	42						70
5		26.5	24				
		26.5	24				
6		25			14		
		25			14		
7				60	16.5		
				60	16.5		

King Fahd University of Petroleum & Minerals
College of Environmental design
Architectural Engineering Department

Building Mechanical Systems
ARE 322

LAB EXERCISE # 9

HEAT TRANSFER IN BUILDINGS

HEAT TRANSFER IN BUILDING STRUCTURES

1. **Find the R-value for the following building materials (use tables in the given handouts, or other references in the library, and/or manufacturer's data):**

No	Building Material	R-value $m^2.K/W$	Comments
1	200 mm concrete block (normal mass)		
2	16 mm gypsum plaster		
3	19 mm sand aggregate cement plaster		
4	5 cm polyethylene insulation		
5	5 cm fiber glass insulation		
6	5 cm expanded polyurethane insulation		
7	5 cm expanded polystyrene insulation.		
8	asphalt roll roofing		
9	16 mm gypsum board		
10	25 mm terrazzo tile		
11	5 cm oak wood		
12	45 mm solid core flush door (no storm)		
13	45 mm fiberglass core with steel stiffeners door		
14	3 mm single glazing		
15	20 mm air space		
16	wall inside air surface film (still air)		
17	45^o sloped roof inside air surface film (summer conditions)		
18	roof inside air surface film (winter conditions)		
19	outside air surface film, 3.4 m/s wind (summer conditions)		
20	outside air surface film, 6.7 m/s wind (winter conditions)		

2. Calculate the overall thermal resistance R-value of a wall that consists of 200 mm concrete block wall with 13 mm cement plaster on the inside and 16 mm plaster on the outside. Assume still air inside and outside summer conditions.

Re-calculate the R-value of the wall with the following insulation types:

3. 5 cm Polystyrene insulation
4. 5 cm Polyurethane insulation
5. 5 cm Fiberglass insulation
6. 20 mm Air space

Compare the results and show the percentage differences.

3. Compute the overall UA product of a 500 m^2 wall made up of:

100 mm	face brick
90 mm	air gap between
200 mm	common brick
16 mm	gypsum plaster on the inside.

Assume still air inside and 6.7 m/s (12 km/h) outside wind speed.

4. Compute the steady-state heat transfer rate per square meter (W/m^2) through a flat built-up roof-ceiling combination as follows:

	asphalt roll roofing
10 mm	built-up roofing
50 mm	preformed deck insulation
20 cm	lightweight concrete slab
20 mm	non reflective air space
20 mm	lightweight aggregate on metal lath.

Assume still air inside and outside summer conditions. Indoor and outdoor temperatures are 25 and 43 ^oC, respectively.

5. What is the percentage change in the R-value of the window if double glazed window is used with 6.4 mm and 13 mm ***air*** in between as compared to single glazed window? Does the resistance increase linearly with the thickness of the space?

TABULATE ALL DATA IN A NEAT FORMAT AND PROVIDE SKETCHES FOR BUILDING COMPONENTS SECTIONS.

King Fahd University of Petroleum & Minerals
College of Environmental design
Architectural Engineering Department

Building Mechanical Systems
ARE 322

LAB EXERCISE # 10

DESIGN HEATING LOAD CALCULATIONS

DESIGN HEATING LOAD CALCULATIONS

The office building shown in the attached **Figure** is located in downtown **Al-Khobar** and has the following characteristics:

- First floor: Retail (small shops)
- Floors 2 through 9 (typical): open office space to be rented to different interested organizations;
- Suspended ceiling.
- Floor-to-floor height = 3.5 m.
- Ceiling height = 2.8 m.

Building Shape:

As shown in the attached Figure.

Building Construction:

Walls:

100 mm	light-colored face brick
200 mm	concrete block (normal mass)
10 mm	cement plaster
20 mm	gypsum plaster (l.w. aggregate on metal lath)

Roof:

	Asphalt roll roofing
50 mm	preformed roof insulation
120 mm	lightweight concrete slab (1600 kg/m^3)
13 mm	gypsum plaster

Floor:

100 mm concrete on ground

Assume Al-Khobar to have annual heating degree-days of 5350 F-days

Fenestration:

6 mm clear single glass non-operable windows
light-colored venetian blinds interior shade.

Doors:

Exterior doors:

One entrance door with an area of 7.5 m^2 with the following characteristics:

45 mm light-colored steel door with
solid urethane foam core and
thermal break (metal storm)

Infiltration:

Assume 0.2 ach (air changes per hour)

Winter Indoor Conditions:

22 ^{o}C DB temperature and 50% RH

Winter Outdoor Conditions:

Winter DB for the region @ 99% design condition.

Assume WB = 5 ^{o}C

Perform the following for the Top Floor of the Building:

1. *Areas and U-values for all building components;*
2. *Building heat loss coefficient (BLC), UA_o-value;*
3. *Design heating load for the building;*
4. *Design heating load with 5 cm. expanded polystyrene insulation added to all walls of the building. Compare the results with that obtained in item 3 above;*
5. *Design heating load with 0.5 ach infiltration rate instead of 0.1 ach. Compare the results with that obtained in item 3 above;*
6. *Plot a breakdown of the heating load components on a pie chart for both items 3, 4 and 5 above and compare between them. <u>use the computer to produce your charts.</u>*

Show all detailed calculations and summarize your results in a <u>neat tabulated format</u>. Use the computer in your calculations and presentation of the results.

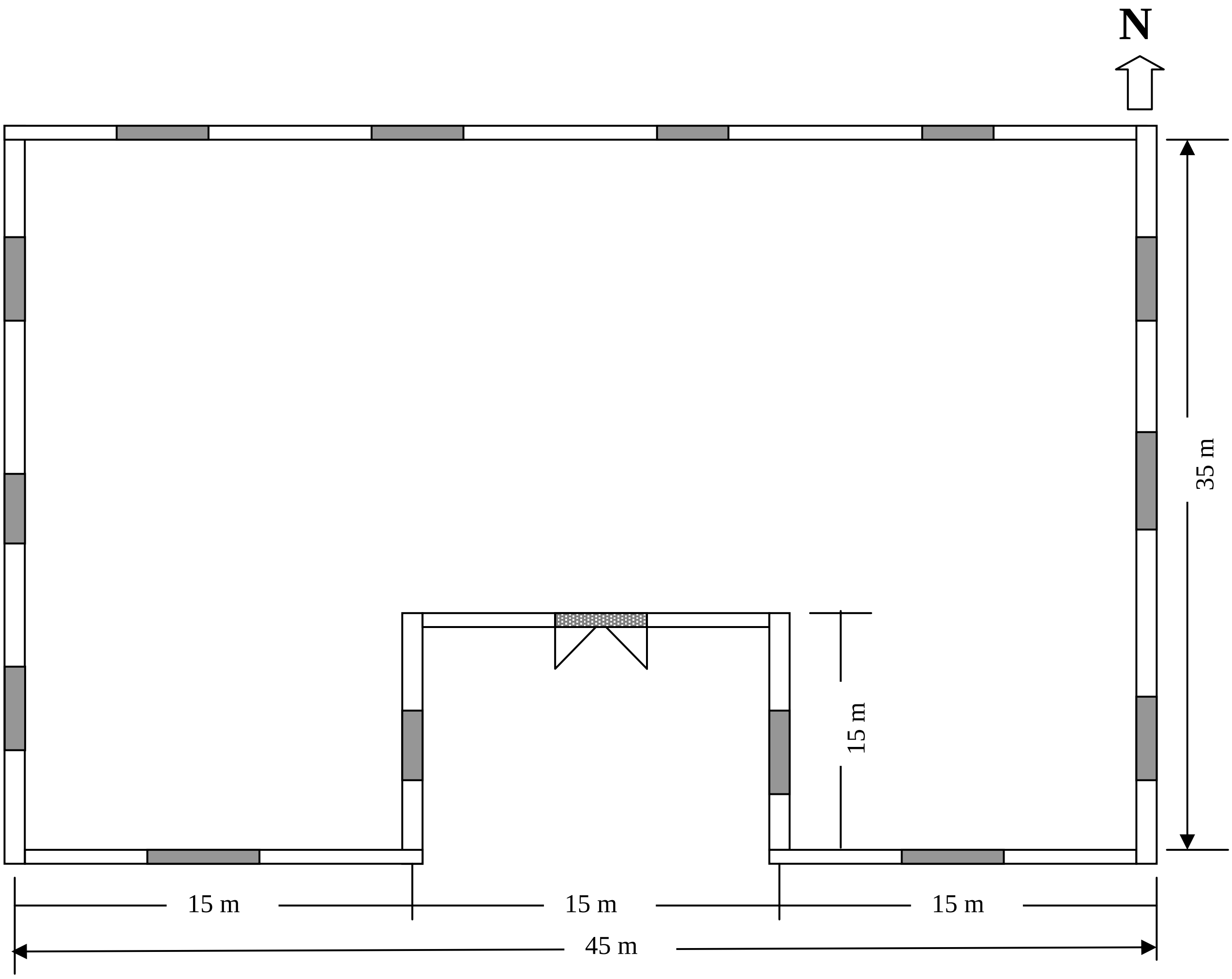

Figure 1. Office Building Plan

Building Physical Characteristics:

- First floor: Retail (small shops)
- Floors 2 through 9 (typical): open office space
- Combustible construction sheathed with plaster.
- Suspended ceiling.
- Floor-to-floor height = **3.5 m**.
- Ceiling height = **2.8 m**.
- Main door is **3m** wide by **2.5m** high (**7.5 m^2**)
- Windows are **15m^2** each

King Fahd University of Petroleum & Minerals
College of Environmental design
Architectural Engineering Department

Building Mechanical Systems
ARE 322

LAB EXERCISE # 11

MANUAL DESIGN
COOLING LOAD CALCULATIONS

DESIGN COOLING LOAD CALCULATIONS

The office building shown in the attached **Figure** is located in downtown **Al-Khobar** and has the following characteristics:

- First floor: Retail (small shops)
- Floors 2 through 9 (typical): open office space to be rented to different interested organizations;
- Suspended ceiling.
- Floor-to-floor height = 3.5 m.
- Ceiling height = 2.8 m.

Building Shape:

As shown in the attached Figure.

Building Construction:

Walls:

100 mm	light-colored face brick
200 mm	concrete block (normal mass)
10 mm	cement plaster
20 mm	gypsum plaster (l.w. aggregate on metal lath)

Roof:

	Asphalt roll roofing
50 mm	preformed roof insulation
120 mm	lightweight concrete slab (1600 kg/m^3)
13 mm	gypsum plaster

Fenestration:

6 mm clear single glass non-operable windows
light-colored venetian blinds interior shade.

Doors:

Exterior doors:

One entrance with an area of 7.5 m^2

45 mm	light-colored steel door with solid urethane foam core and thermal break (metal storm)

Operating Characteristics

Ventilation:

7.5 L/s per person (ASHRAE Standard 62-1989 requirements).
ignore infiltration.

Schedule of Operation:

The building operates from 8: a.m. to 4:00 p.m.

Occupancy:

1 person/10 m^2 .

Equipment:

1 microcomputer with 1 printer/person.
3 large copiers.

Lights:

27 W/m^2, fluorescent lights (non-ventilated type light fixtures)

Summer Indoor Conditions:

dry-bulb temperature	24 °C
Relative humidity	50%

Summer Outdoor Conditions:

Design values @ 1% cooling DB/MWB outdoor design conditions

Assume "medium" mass construction and contents, and carpeted floor covering with gypsum partitioning

<u>Perform the following for the Top Floor of the Building</u>:

Use the CLTD/SCL/CLF Design Cooling Load Calculation Method and the **MS Excel Spreadsheet Software** available in the CED Computer-Aided Design Lab. **or any other spreadsheet program** you might be familiar with **to find the following at <u>*3:00 p.m.*</u>:**

1. *Sensible cooling load;*
2. *Latent cooling load;*
3. *Total cooling load;*
4. *Air volume flow rate (L/s) required to satisfy sensible cooling load the space;*
5. *Total system refrigeration capacity (tonnage) required for the building;*
6. *Total system refrigeration capacity (tonnage) required for the building without roof insulation. Compare the results with that from item 5 above;*
7. *Plot cooling load components breakdown for items 5 & 6 above and compare.*

Show all detailed calculations and summarize your results in a neat tabulated and graphical format..

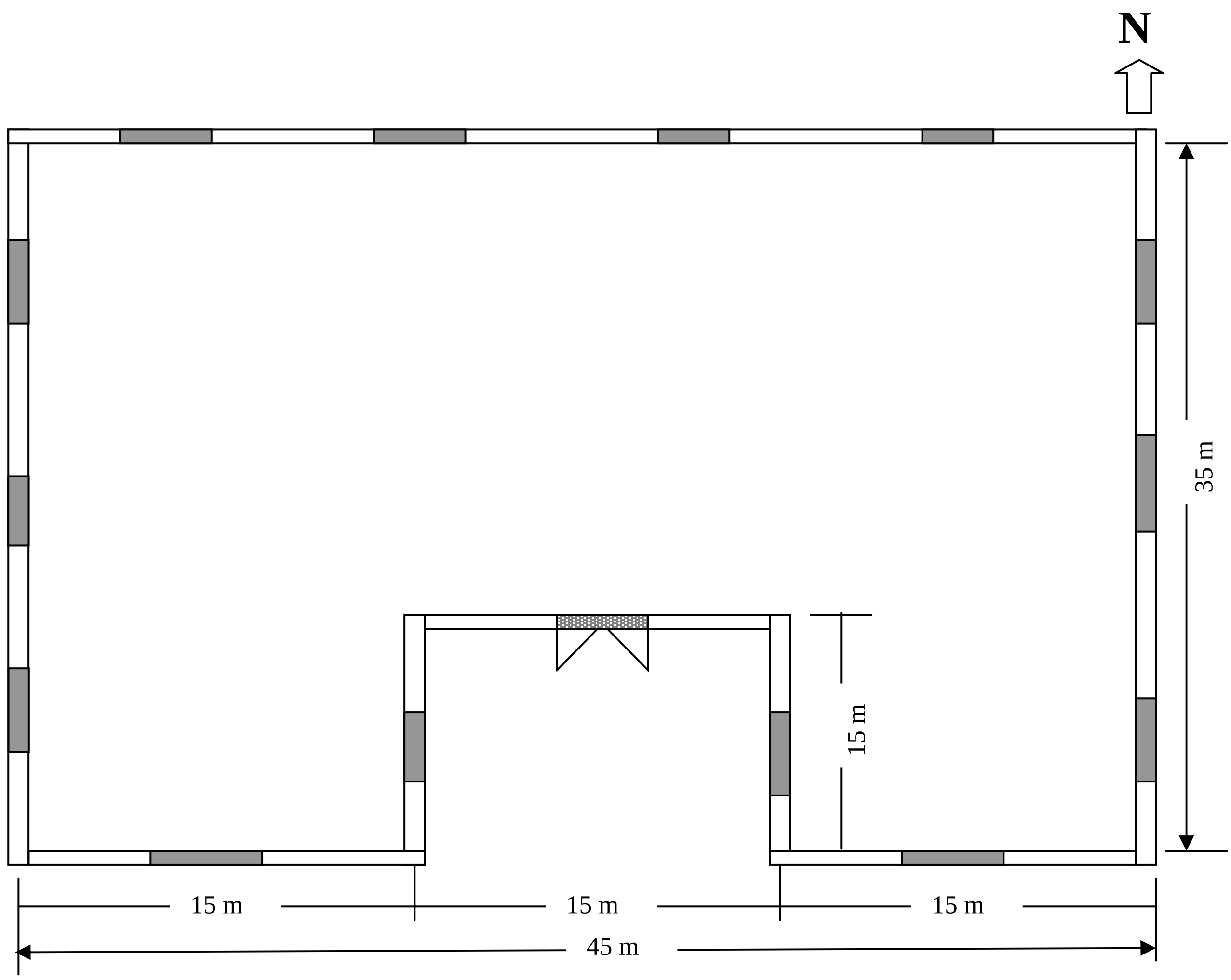

Figure 1. Office Building Plan

Building Physical Characteristics:

- First floor: Retail (small shops)
- Floors 2 through 9 (typical): open office space
- Combustible construction sheathed with plaster.
- Suspended ceiling.
- Floor-to-floor height = **3.5 m**.
- Ceiling height = **2.8 m**.
- Main door is **3m** wide by **2.5m** high (**7.5 m^2**)
- Windows are **15m^2** each

King Fahd University of Petroleum & Minerals
College of Environmental design
Architectural Engineering Department

Building Mechanical Systems

ARE 322

LAB EXERCISE # 12

COMPUTERIZED DESIGN COOLING LOAD CALCULATIONS

COMPUTERIZED DESIGN
COOLING LOAD CALCULATIONS

The office building shown in the attached **Figure**, is located in downtown **Al-Khobar** and has the following characteristics:

- First floor: Retail (small shops)
- Floors 2 through 9 (typical): open office space to be rented to different interested organizations;
- Suspended ceiling.
- Floor-to-floor height = 3.5 m.
- Ceiling height = 2.8 m.

Perform the following for the Top Floor of the Building:

Use **Carrier E20-II Block Load Calculations Software** available in the CED Computer-Aided Design Lab. to calculate the design cooling load for the office building you performed calculations for in the last lab. assignment. The flexibility of the program should allow you to find the **hour** with the **maximum** cooling load.

Also **plot** the cooling load components on a **pie chart** showing the percentage for each component of the building. Utilize the graphical capabilities of Excel or any other graphics program you are familiar with.

Summarize your design **results** and present your report in a labeled, clear, and understandable format. Include any **comments** or **assumptions** you have made in performing the calculations.

King Fahd University of Petroleum & Minerals
College of Environmental design
Architectural Engineering Department

Building Mechanical Systems
ARE 322

LAB EXERCISE # 13

BUILDING HVAC SYSTEMS TOUR

BUILDING MECHANICAL SYSTEMS TOUR

You will be taken on a tour to visit some of **the HVAC & Mechanical Plants**. The tour will be guided by a professional from the department concerned who will explain things and answer your questions.

Prepare yourself for the tour and be ready to take notes as well as sketches of the facilities and equipment to be visited. Do not hesitate to ask any questions about things you don't understand.

Prepare a **report** about your **observations** of the tour, the equipment you visited and how do they function along with the necessary sketches. Include any additional comments or ideas to the current systems. **Submit your report in a neat and understandable format.**

King Fahd University of Petroleum & Minerals
College of Environmental design
Architectural Engineering Department

Building Mechanical Systems
ARE 322

LAB EXERCISE # 14

HOT WATER SYSTEMS

HOT WATER SYSTEMS

Use the provided tables and charts to perform the following:

1. a). Specify a natural gas water heater for a **five-bedroom** house with **three baths**.

b). Determine heater and storage tank size for an apartment building having the following plumbing fixtures:

50	lavatories
20	bathtubs
20	showers
20	kitchen sinks
10	dishwashers

2. A motel with **150 units**, with a cafeteria serving **300 meals in 1 hour**, is to be built. Find the required hot water storage size assuming the following:

a). Minimum recovery rate for both motel and cafeteria.

b). Motel recovery rate of **2.2 mL/s** per unit.

Assume a "Usable" capacity of **80%** of the total size of the storage tank.

3. Find the required hot water **storage size** and the **monthly hot water consumption** for an office building with **100 persons** for:

a). Storage system with **minimum** recovery rate.

b). Additional minimum recovery rate requirement for a sandwich and snack shop open 5 days a week, serving a maximum of 100 meals per hour, and an average of 200 meals per day.

Assume a usable storage capacity of **70%** of the total storage size.