

Vacuum Equipment Simulation Lab

EquipSim - Vacuum Equipment Simulation

Vacuum Technology Module

Gas Flow Module

Heat Transfer Module

Background:

The EquipSim Vacuum Simulator was written by G. W. Rubloff's group at the University of Maryland as a National Science Foundation sponsored project. This software allows users to gain a conceptual understanding of vacuum technology in general as well as the operations of vacuum systems that are implemented in the micro-nano research areas and manufacturing. Because this is a computer simulation you can make an error without incurring the cost of replacing broken vacuum part that would result from your mistake in the real world. Completing this simulator lab before working on actual vacuum systems will help you be more efficient and safer when you are working in industry or research.

As you are learning from lecture, vacuum systems are used for a variety of processes: metal deposition, etching, implanting, Scanning Electron Microscopy (SEM), etc. The vacuum simulator utilizes a block diagram schematic of a vacuum system that resembles actual systems used on process equipment. This enables the students to visualize components of a vacuum system while at the same time monitoring (simulated) pressure gauges representative of those employed on real vacuum systems.

Vacuum Technology Module Activity #1

- A. Log into Nano4me.org with the user name and password.
 - a. If you have not registered with our site yet please do so now
<https://nano4me.ssl.subhub.com/subscribe>
- B. Go to http://nano4me.live.subhub.com/downloads/20090528_32
- C. Download EquipSim3' software under this webpage titled "ESC 211 - Vacuum Equipment Simulation Lab with EquipSim"
 - a. (Note we are not following the lab that downloads with this program, though the labs are similar.)
- D. Extract the zipped files from this download to your Programs/Applications folder on your hard drive.
- E. Open the equipsim (v32) folder and double click on the EquipSim3 icon, see Figure 1.
 - a. After selecting the "**EquipSim3**" icon, the window on the next page should open, Figure 2.

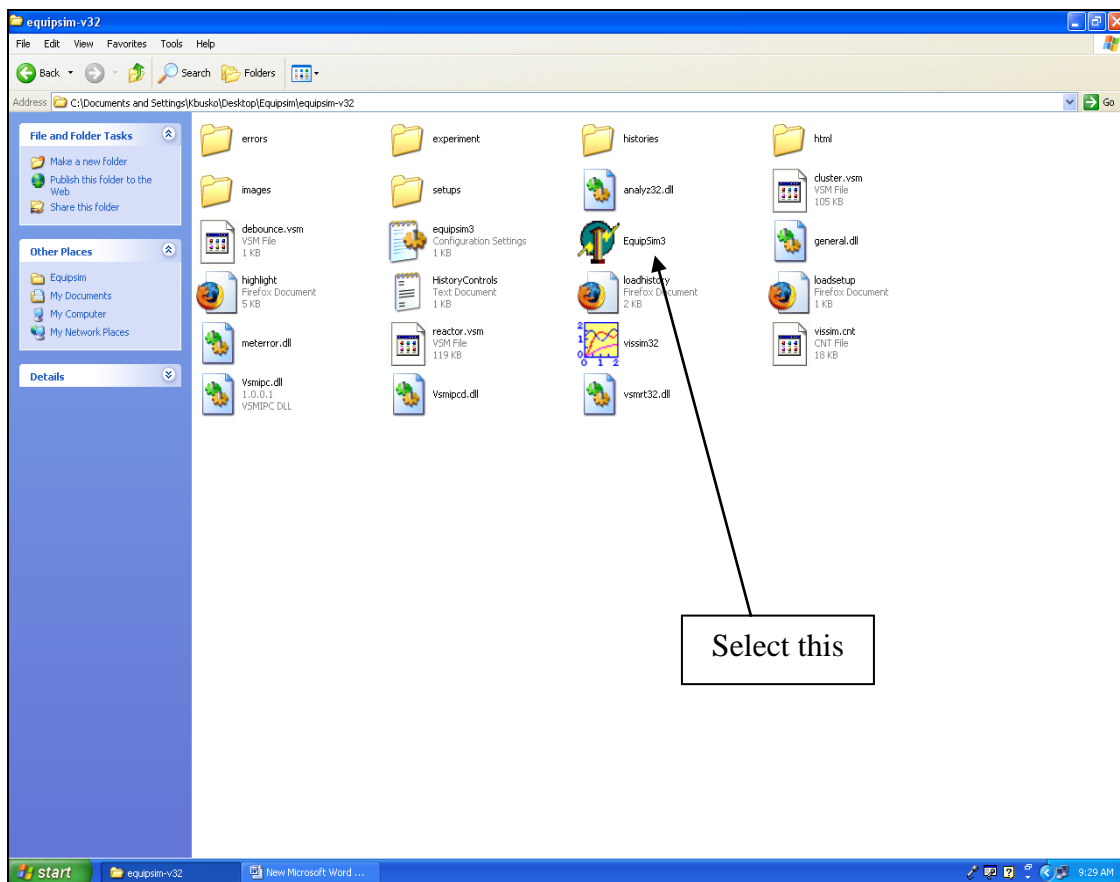


Figure 1 EquipSim (v32) folder content after downloading

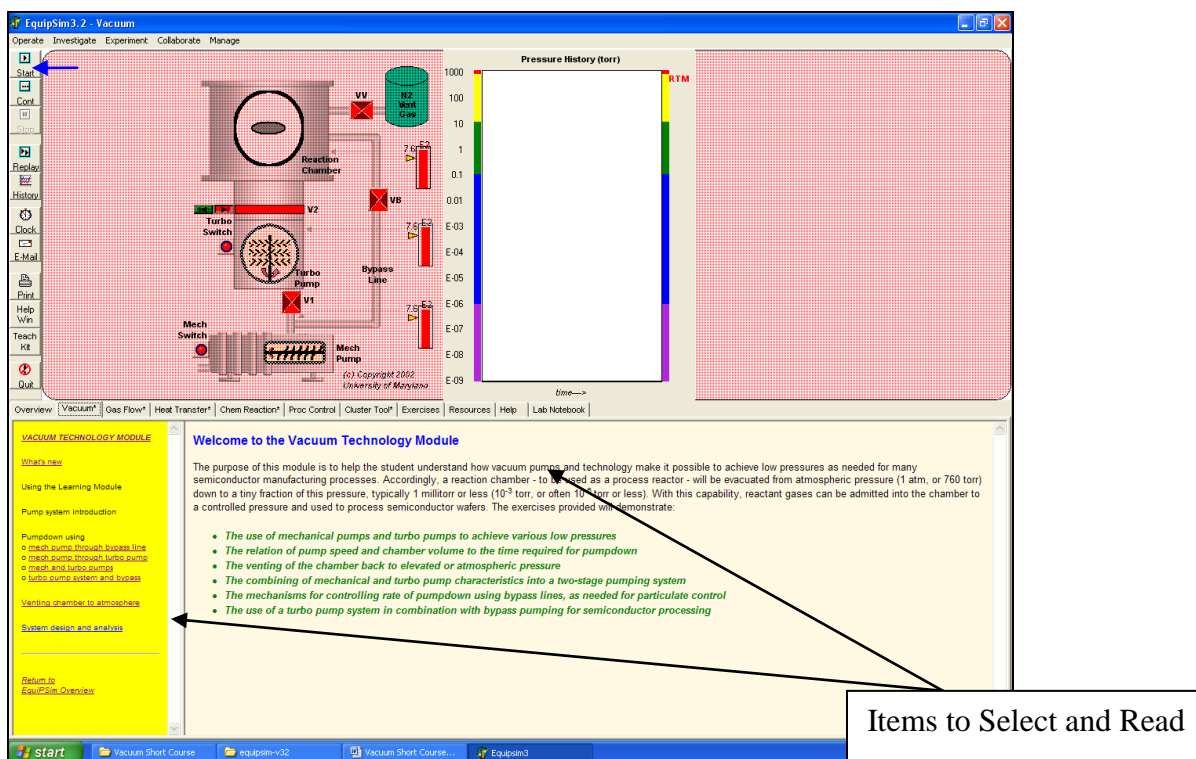


Figure 2 Main screen of the vacuum simulator.

- F. Read “**Welcome to the Vacuum Technology Module**” on the main page of the EquipSim program.
- G. Familiarizes yourself with the program by clicking the “**Start**” button (shortcut key F9) at the top left of the window directly below the “Operate” tab, see blue arrow in Figure 2.
 - a. Click the “**Stop**” button to end your trial run.
 - i. (Note: the “**Cont**” and “**Replay**” are now available)
 - ii. Note the program’s “**History**” and “**Clock**” functions also
- H. Click on the bulleted item “**Mech pump through bypass line**” within the yellow column next.
- I. Read the description and complete exercises #1 and #2. Try to answer the program’s questions in the text before looking up the Answers.

You will be completing all following lab questions on Angel. Your questions from this lab are similar to those of the EquipSim program but are NOT the SAME. Read over the below question CAREFULLY and answer them as you work through the lab.
1 pt. each.

1. *From exercise #1 with “Pumpdown using mech pump through bypass,” what was the base pressure reached by the pump?*
 2. *From exercise #1 with “Pumpdown using mech pump through bypass,” how long did the pump take to reach its base pressure according to the “Pressure History” chart on the right of the EquipSim window?*
 3. *From exercise #2 with “Pumpdown using mech pump through bypass,” how long did the chamber take to reach its base pressure (same as the mech. pump) according to the “Pressure History” chart on the right of the EquipSim window?*
 4. *From exercise #2 with “Pumpdown using mech pump through bypass,” why does the chamber take longer to pump down to base pressure than the mech. pump (disregard the piling)*
 5. *Why are faster pump down times desirable?*
 6. *If contamination by condensable gases like water vapor occurs, what is a reasonable corrective action to take in a manufacturing setting?*
- J. Select **“Mech pump through turbo pump.”**
- K. Read the description, complete exercise #1, and answer the questions below.
(Note: be sure **VB-cutoff** valve is **closed** before beginning)
7. *From exercise #1 with “Pumpdown using mech pump through turbo,” what was the time to reach base pressure?*
- L. Select **“Mech and turbo pumps.”**
- M. Read the description, complete exercises #1 and #2, and answer the questions below.
8. *From exercise 2 with “Mech and turbo pumps,” what was the affect on the mech. pump when you switched on the turbo pump?*
 9. *From exercise 2 with “Mech and turbo pumps,” at what pressure level could the impact of the turbo pump be clearly observed?*
 10. *From exercise 2 with “Mech and turbo pumps,” at how long after the pressure level in the previous was reached did it take for the chamber to reach base pressure?*
- N. Select **“Turbo pump system and bypass”**

O. Read the description, complete exercise #1, and answer the question below.

11. From exercise 1 with “Turbo pump system and bypass,”
employing the procedure from this section how long would it take
to pump down one full cycle (starting from N_2 purge to chamber
pressure below 0.001 mTorr)?

P. Select “**Venting chamber to atmospheric pressure.**”

Q. Read the description, complete exercise #1, and answer the question below.

12. From exercise 1 with “Venting chamber to atmosphere,” What
factor(s) does the chamber venting rate depend on?

13. From exercise 1 with “Venting chamber to atmosphere,” why is
high venting rates desirable?

14. From exercise 1 with “Venting chamber to atmosphere,” What is
one issue that could occur if the venting rate is too high?

Gas Flow Activity #2

A. Click on the “**Gas Flow***” tab and click “**Yes**” in the window that appears.

a. The window below in Figure 3 should appear next.

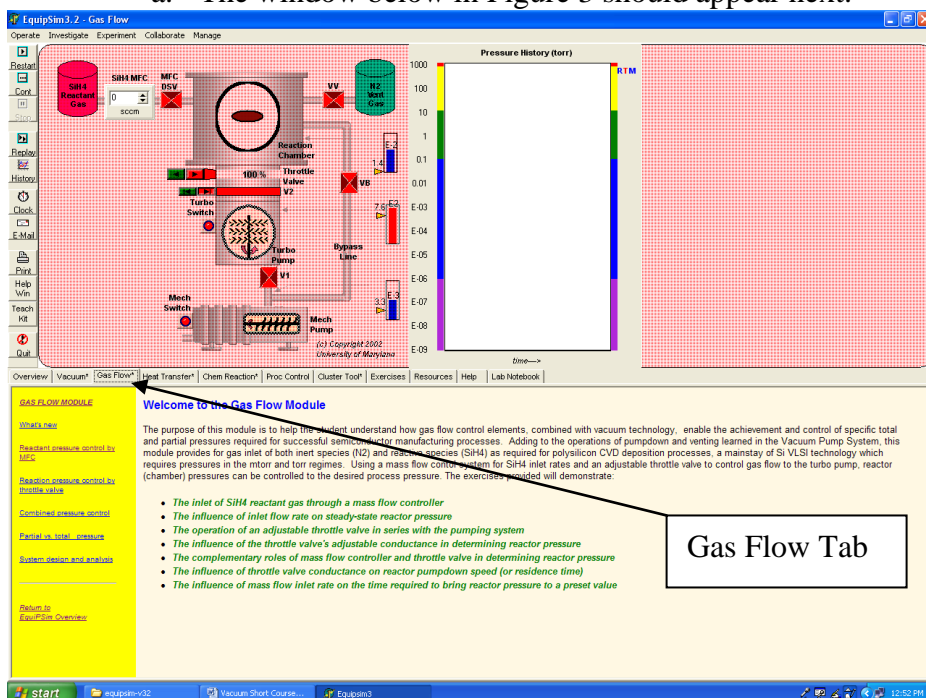


Figure 3 Main screen of the Gas Flow exercise screen

B. Read “**Welcome to the Gas Flow Module.**”

- a. **NOTE:** the “Observations,” part of the exercise text, are often incorrect in this section. Use the setting from the below questions and record your information from the gauges and “Pressure History” for your answers.
- C. Click on the bulleted item “**Reactant pressure control by MFC**” within the yellow column next.
- D. Read through this entire section and then click on the hyperlinked text in the blue frame which reads “**Exercise: control SiH₄ pressure in reactor by MFC adjustment.**”
- E. Read through this exercise and answer the questions below.
- a. Note: the first step should read “valves V1 and **V2** are open.”)
1. *From the exercise with “Control SiH₄ pressure in the reactor by MFC adjustment,” with 10 sccm flow of SiH₄ and 100% throttle valve what chamber pressure was reached?*
 2. *From the exercise with “Control SiH₄ pressure in the reactor by MFC adjustment,” with 100 sccm flow of SiH₄ and 100% throttle valve what chamber pressure was reached?*
 3. *From the exercise with “Control SiH₄ pressure in the reactor by MFC adjustment,” what flow rate in sccm’s is needed to reach a chamber pressure of 3.7 mTorr*
- F. Select “**Reactant pressure control by throttle valve.**”
- G. Read through this entire section and then click on the hyperlinked text in the blue frame which reads “**Exercise: control SiH₄ pressure in reactor by throttle valve adjustment.**”
- H. Read through this exercise and answer the questions below.
- a. Note: the first step should read “valves V1 and **V2** are open.”)
4. *From the exercise with “Control SiH₄ pressure in the reactor by throttle valve adjustment,” with 100 sccm flow of SiH₄ and 50% throttle valve what chamber pressure was reached?*
 5. *From the exercise with “Control SiH₄ pressure in the reactor by throttle valve adjustment,” with 100 sccm flow of SiH₄ and 20% throttle valve what chamber pressure was reached?*
 6. *From the exercise with “Control SiH₄ pressure in the reactor by throttle valve adjustment,” with 100 sccm flow of SiH₄ and 10% throttle valve what chamber pressure was reached?*
 7. *From the exercise with “Control SiH₄ pressure in the reactor by throttle valve adjustment,” given a SiH₄ MFC flow rate of 100 sccm what percent of throttle valve opening would result in a chamber pressure of 87 mTorr?*

- I. Select “**Combined pressure control.**”
- J. Read through this entire section and then click on the hyperlinked text in the blue frame which reads “**Exercise: combined pressure control.**”
- K. Read through this exercise and answer the questions below.
 - a. Note: the first step should read “valves V1 and **V2** are open.”)
- 8. *From the exercise with “[sic] Control SiH₄ pressure in the reactor by throttle valve adjustment,” with 100 sccm flow of SiH₄ and 50% throttle valve what chamber pressure was reached?*
- 9. *From the exercise with “[sic] Control SiH₄ pressure in the reactor by throttle valve adjustment,” with 50 sccm flow of SiH₄ and 100% throttle valve what chamber pressure was reached?*
- 10. *From the exercise with “[sic] Control SiH₄ pressure in the reactor by throttle valve adjustment,” with 50 sccm flow of SiH₄ and 50% throttle valve what chamber pressure was reached?*
- 11. *From the exercise with “[sic] Control SiH₄ pressure in the reactor by throttle valve adjustment,” what are TWO combinations of flow rate and percent of throttle valve opening that yield an 84 mTorr chamber pressure?*
- L. Select “**Pressure vs. total pressure.**”
- M. Read through this entire section for background on partial pressure.
 - a. No questions

Heat Transfer Activity #3.

- A. Click on the “**Heat Transfer***” tab and click “**Yes**” in the window that appears.
 - a. The window below in Figure 4 should appear next.

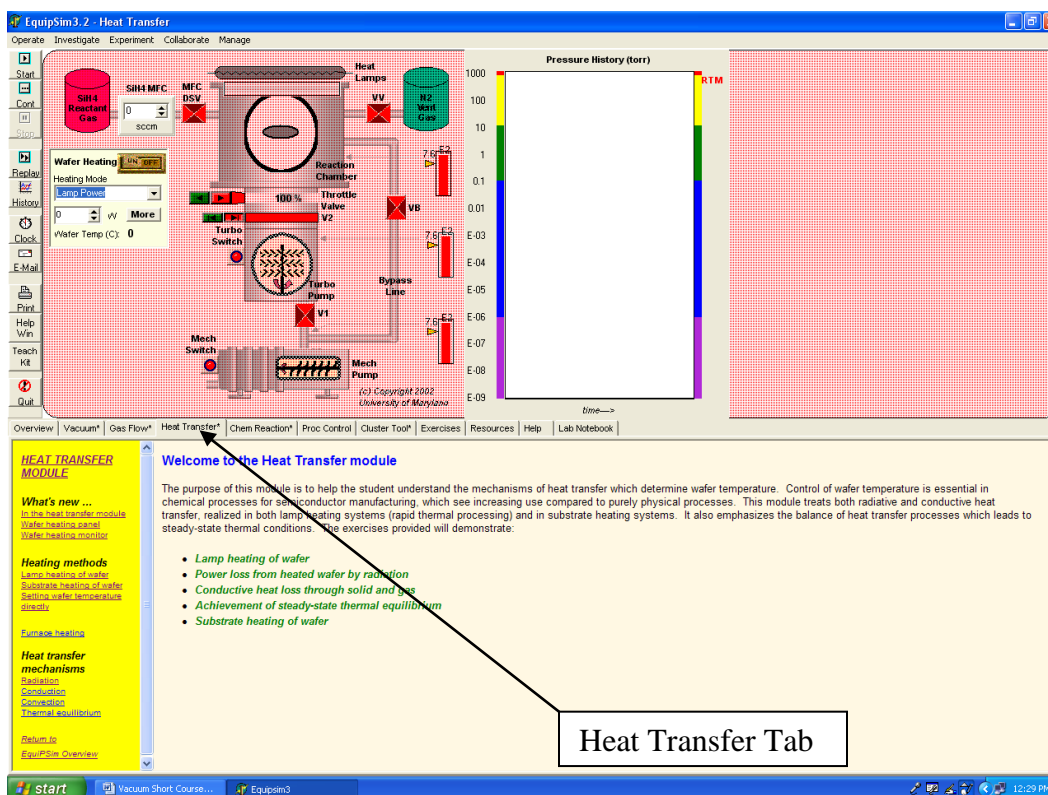


Figure 4 Main screen of the Heat Transfer exercise.

- B. Read “Welcome to the Heat Transfer Module.”
- C. Click on the bulleted item “Lamp heating wafer” within the yellow column next.
- D. Read through this entire section and then click on the hyperlinked text in the blue frame which reads “Exercise: lamp heating of wafer.”
- E. Read through this exercise and answer the questions below.
 - a. Select “Lamp Power” from the drag-down menu in the “Wafer Heating” frame of the vacuum system schematic.
 - i. Note: to activate the heating lamp you must click on the brown toggle switch just right of the text “Wafer Heating.” The left half should turn yellow when ON.
 - b. Click the “More” button, within the “Wafer Heating” frame.
 - i. Move the “Wafer Heating Details” window that appeared in the last step so you can still see the vacuum system operation.
1. From the exercise with “Lamp Heating of Wafer,” after turning on the lamp to 2500 W what net power to the wafer was reach upon stabilizing?
2. From the exercise with “Lamp Heating of Wafer,” after turning on the lamp to 2500 W what wafer temp was reach upon stabilizing?
3. From the exercise with “Lamp Heating of Wafer,” after turning on the lamp to 5000 W what wafer temp was reach upon stabilizing?

- F. Select “**Substrate heating of water.**”
- G. Read through this entire section and then click on the hyperlinked text in the blue frame which reads “**Exercise: Substrate heating of wafer.**”
- a. Change the wafer heating mode to “Substrate Heater” from the drop-down menu after restating.
-
4. *From the exercise with “Substrate Heating of Wafer,” after turning on the substrate heater to 600 °C what wafer temp was reach upon stabilizing?*
 5. *From the exercise with “Substrate Heating of Wafer,” after this test stabilized how much power did the wafer adsorbed by radiation?*
 6. *From the exercise with “Substrate Heating of Wafer,” after this test stabilized how much power did the wafer adsorbed by conduction (solid)?*
 7. *From the exercise with “Substrate Heating of Wafer,” after this test stabilized how much power did the wafer loose and by what means)?*
- H. Select and read through “**Furnace heating,**” “**Radiation,**” and “**Conduction.**” Answer the below question about the text.
8. *From the section “Furnace heating,” where does deposition occur in a tube furnace system?*
 9. *From the section “Radiation,” What law demonstrates that bodies at high temperature radiate large amounts of power?*
 10. *From the section “Conduction,” Why is the thermal conductivity of gases less than that of solids or liquids?*

(ALL LAB QUESTIONS TO BE ANSWERED ON ANGEL, NO HARD COPY)

Generic Pump Down Procedure (for vacuum system operation)

0. Start off in idle/isolation: all valves closed, all pumps and gauges off
1. Turn on the Rough Pump and Low-Vac gauges
2. Open the isolation valve, if equipped
3. Open the roughing valve
4. Wait for the chamber to reach base roughing pressure
5. Close the roughing valve
6. Open the foreline valve
7. Wait for the foreline to reach base roughing pressure
8. Turn on the Turbo Pump
9. Wait for the Turbo Pump to reach its operating speed
10. Open the High-Vac valve
11. After about 1 minute, turn on the High-Vac gauge