TEST: The Expert System for Thermodynamics: A web-portal to Make Thermodynamics Fun to Learn and Practice

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Acknowledgement

- Pearson
- Support from NASA and NSF
- Support from Govt. of Japan
- Prof. Swapan Bhaumik, FIE

Overview of the Talk

- Accessing TEST.
- The scope of the TEST portal.
- Different modules of TEST.
  - Table Module: Traditional Charts and Tables.
  - Animations: Visualization of Thermal Systems
  - Interactives: Numerical Laboratory.
  - Problems: Multi-media Problems and Examples
  - TESTapps: The Thermodynamic Calculators

Accessing TEST

- Academic version of TEST is accessible from www.pearson.com/Bhattacharjee
- The Professional version of TEST is accessible from www.thermofluids.net.
- Currently 3895 educators, (939 from US), 4094 professionals; and 38,444 students are registered in the TEST portal.
- Making an account takes 5 minutes.

The Scope of the TEST Portal

- Designed for life-long learning, TEST connects thermodynamic applications to their fundamentals.
- Hundreds of Animations and Interactives are used throughout the site.
- Replacing interpolations using property tables with intuitive state calculators. The concept of a thermodynamic state as a mathematical object replaces properties; just as a vector or tensor replace a set of numbers conceptually.
- The online calculators are called TESTapps.

The Scope of the TEST Portal

- Using the states as a building block, device or process objects are built which solve the governing mass, energy, entropy, and exergy equations.
- The device and process objects are used to simulate complex cycles and other thermodynamic applications.
- The client-server architecture (web services) of the calculators allow powerful applications such as chemical equilibrium analysis possible over the browser interface.
- Along with graphical interface, TESTapps also allow simple programming interface, creating a powerful tool for what-if studies.

The Scope of the TEST Portal

- Educators can create a group and ask students to associate their accounts with that group.

- At any time a progress report can be generated where activities by the group members are tabulated. This makes it very easy to assign homework or even conduct an online test where ‘cheating’ becomes more difficult.

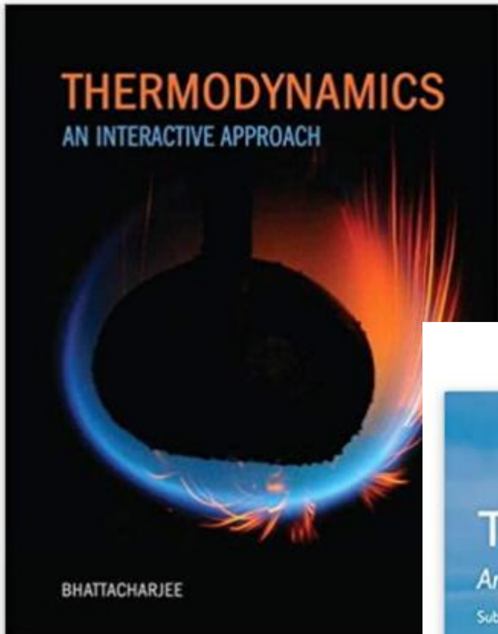
Publications

Textbook – US and Global version

Thermodynamics: An Interactive Approac

by Subrata Bhattacharjee (Author)

25 ratings



Hardcover $47.28 - $193.47 | Paperb $146.93

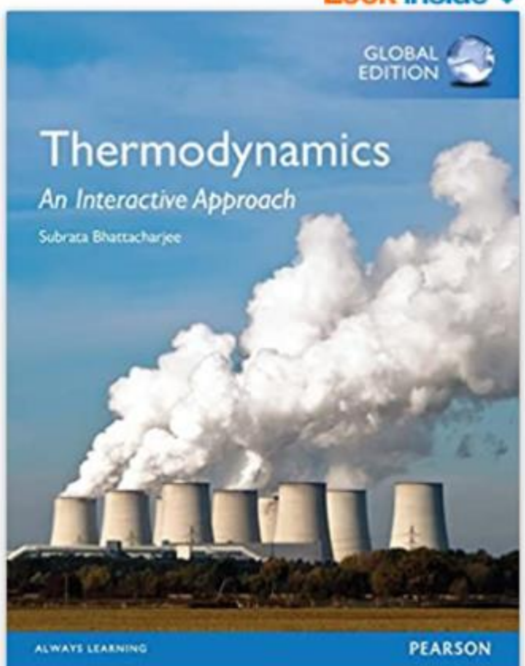
Rent

Due Date: May 23, 2022 F

- **FREE** return shipping a

ISBN-13: 978-0130351173
ISBN-10: 0130351172

Why is ISBN important?



Therm
Global

by Bhattacha

See all forma

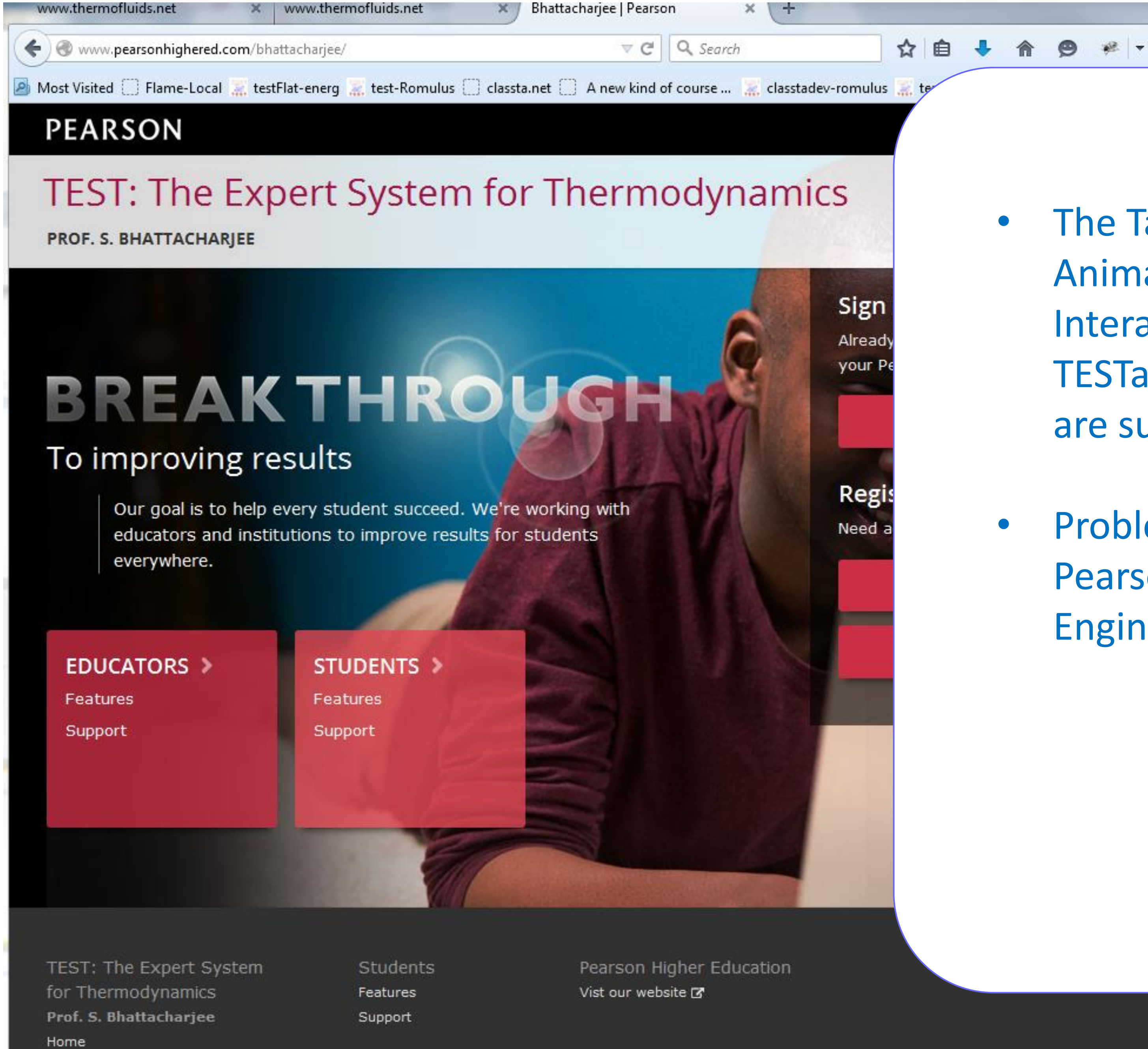
Paperback $65.90

2 Used from $4
9 New from $6

For the therm
department
that introduc
progressively
for todays the
based resourc

- The textbook takes a layered approach (as opposed to the traditional spiral approach).
- It integrates TEST as a learning tool in every chapter.
- Adopted by many universities in US and other countries.

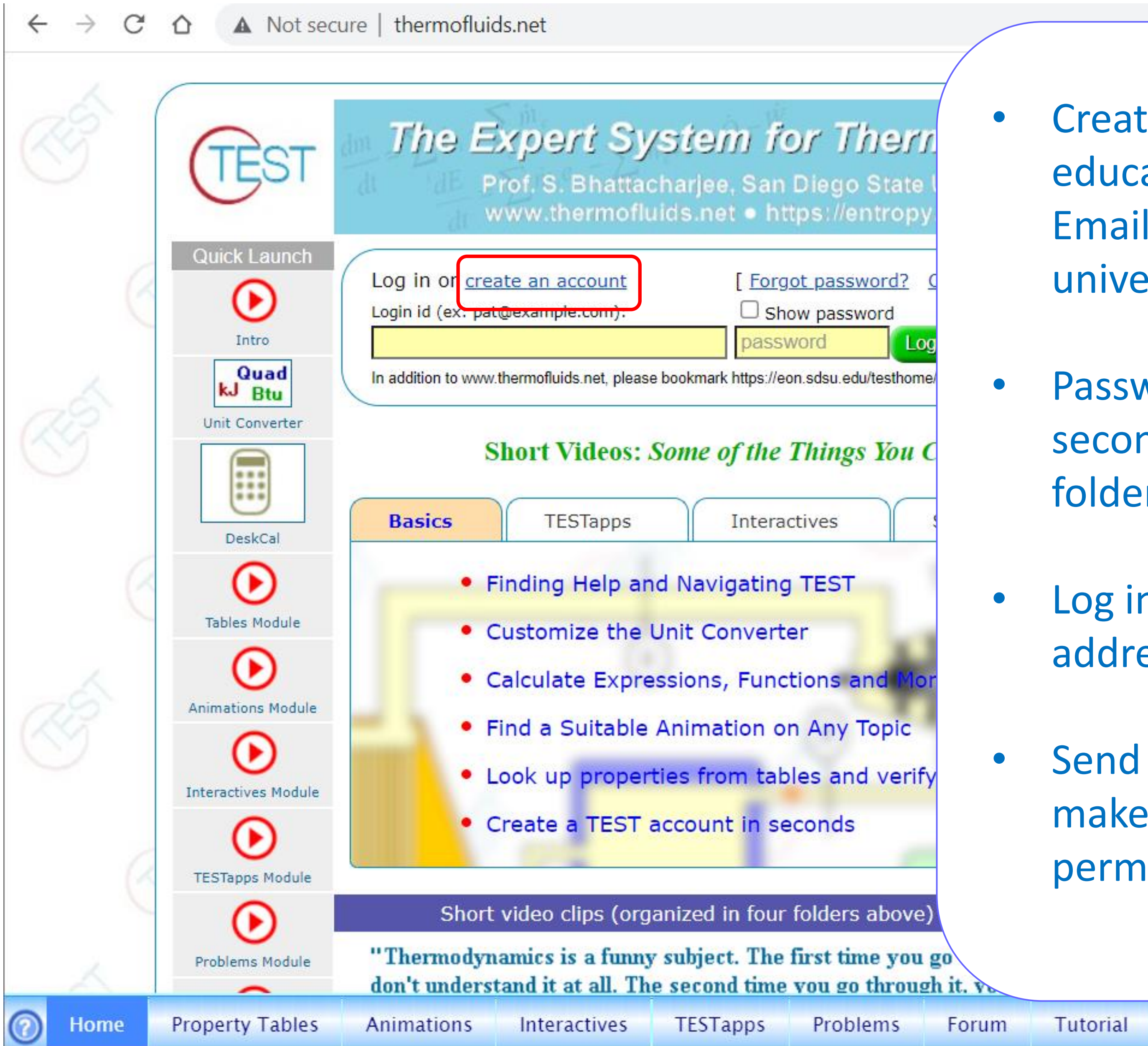
pearsonHigherEd.com/Bhattacharjee – PEARSON version of TEST for Students



- The Tables, Animations, Interactives, and TESTapps modules are supported.
- Problems are part of Pearson's Mastering Engineering site.

Creating An Account and Help Pages

thermofluids.net– Home Page: Creating an Account Takes Seconds



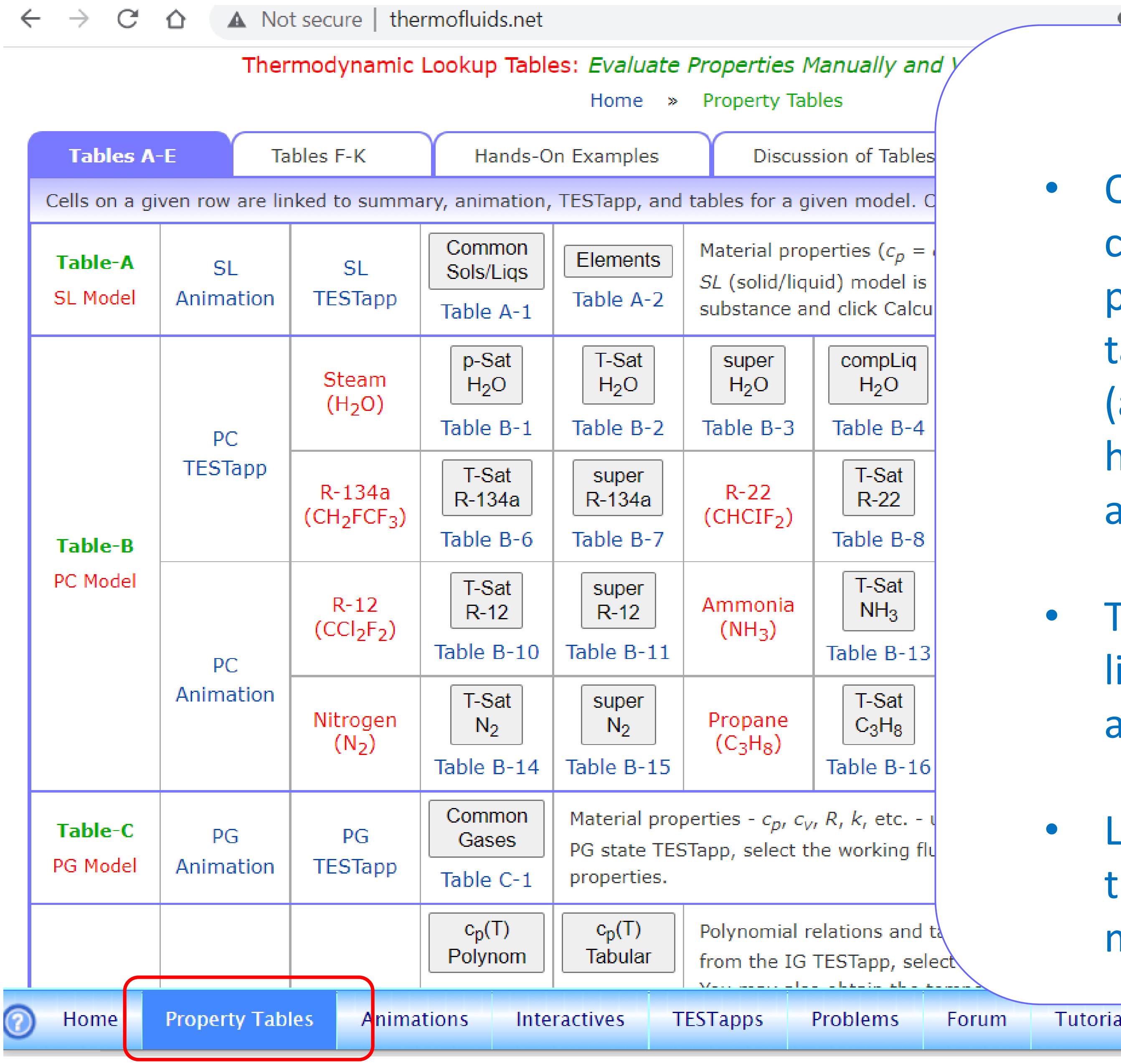
- Create professional or educator's account (an Email, your name, and university name).
- Password arrives in seconds (check spam folder).
- Log in with your email address as the login id.
- Send an email to me to make the account permanent.

Help – The Ubiquitous Help Icon

- Simply move the pointer over the help icon on any page for context sensitive help.

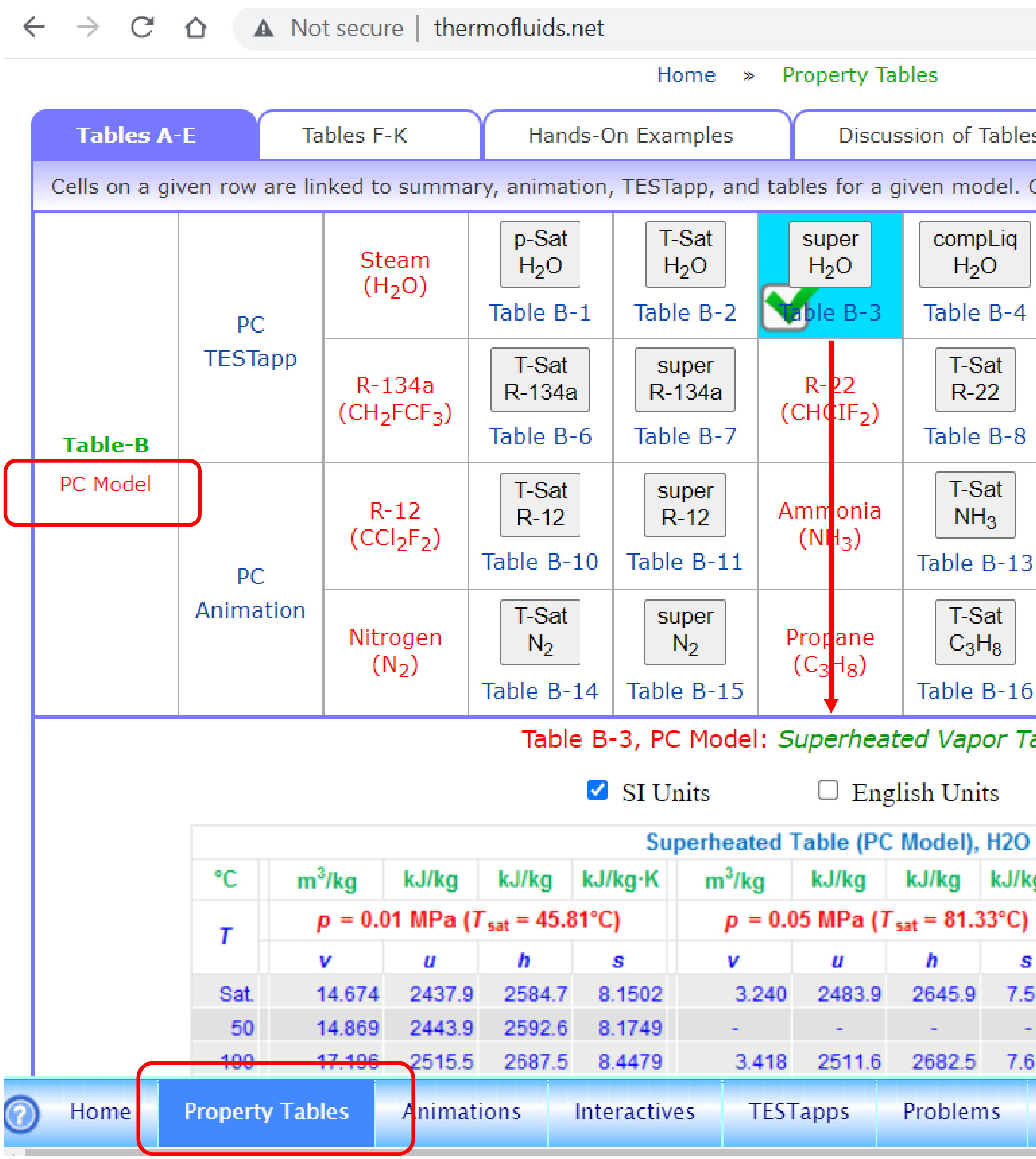
The Table Modules

TEST Modules– Different Modules in Different Tabs



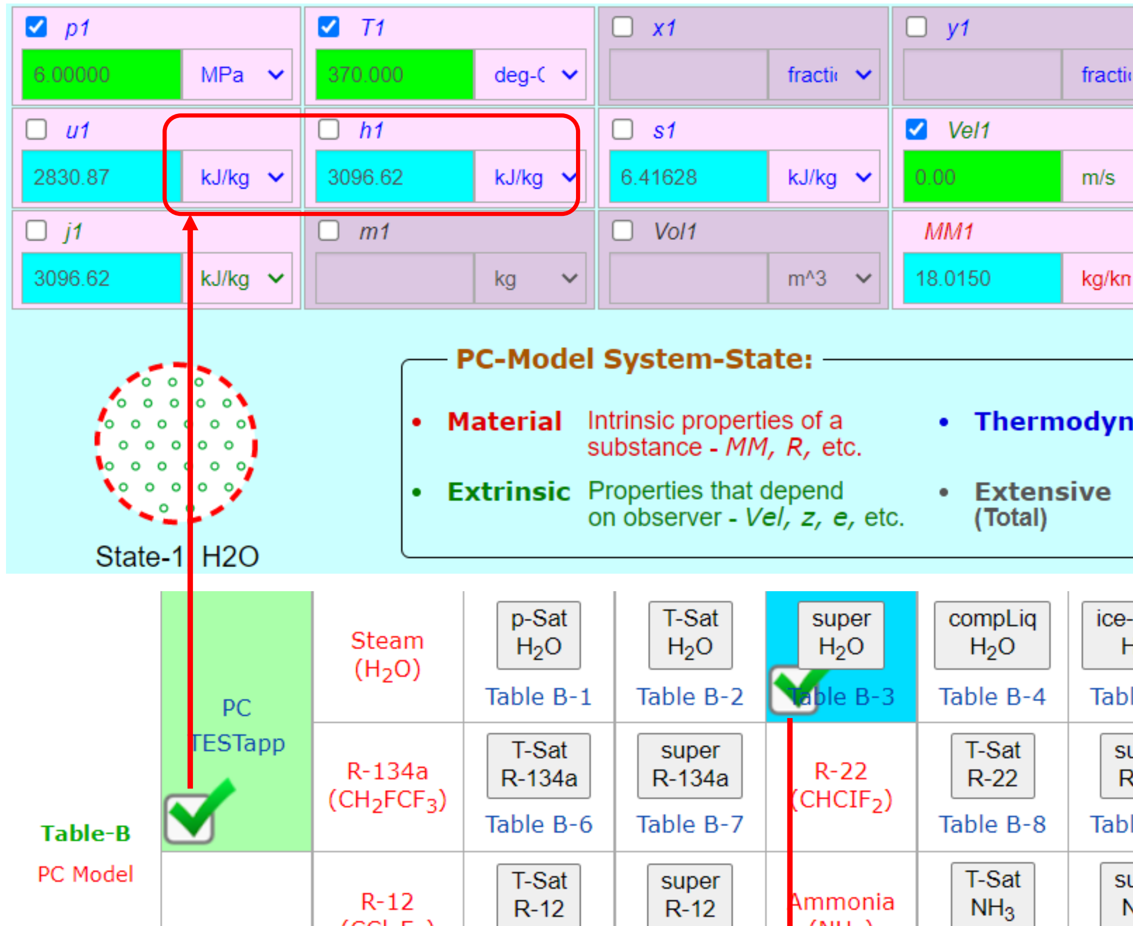
- Once you log in, you can open a TEST page on multiple tabs of the browser (at top) without having to log in again.
- TEST modules are linked from the tabs at the bottom.
- Let us begin with the Property Tables module.

Property Table Module– Traditional Tables with a Verification Calculator



- Property Tables are organized according to thermodynamic models.
- Clicking on a Table cell bring the table in a new row underneath.
- Easy to switch between SI or English mode.
- Instant interpolation using TESTapp.

Property Table Module–Interpolation is no Longer Necessary

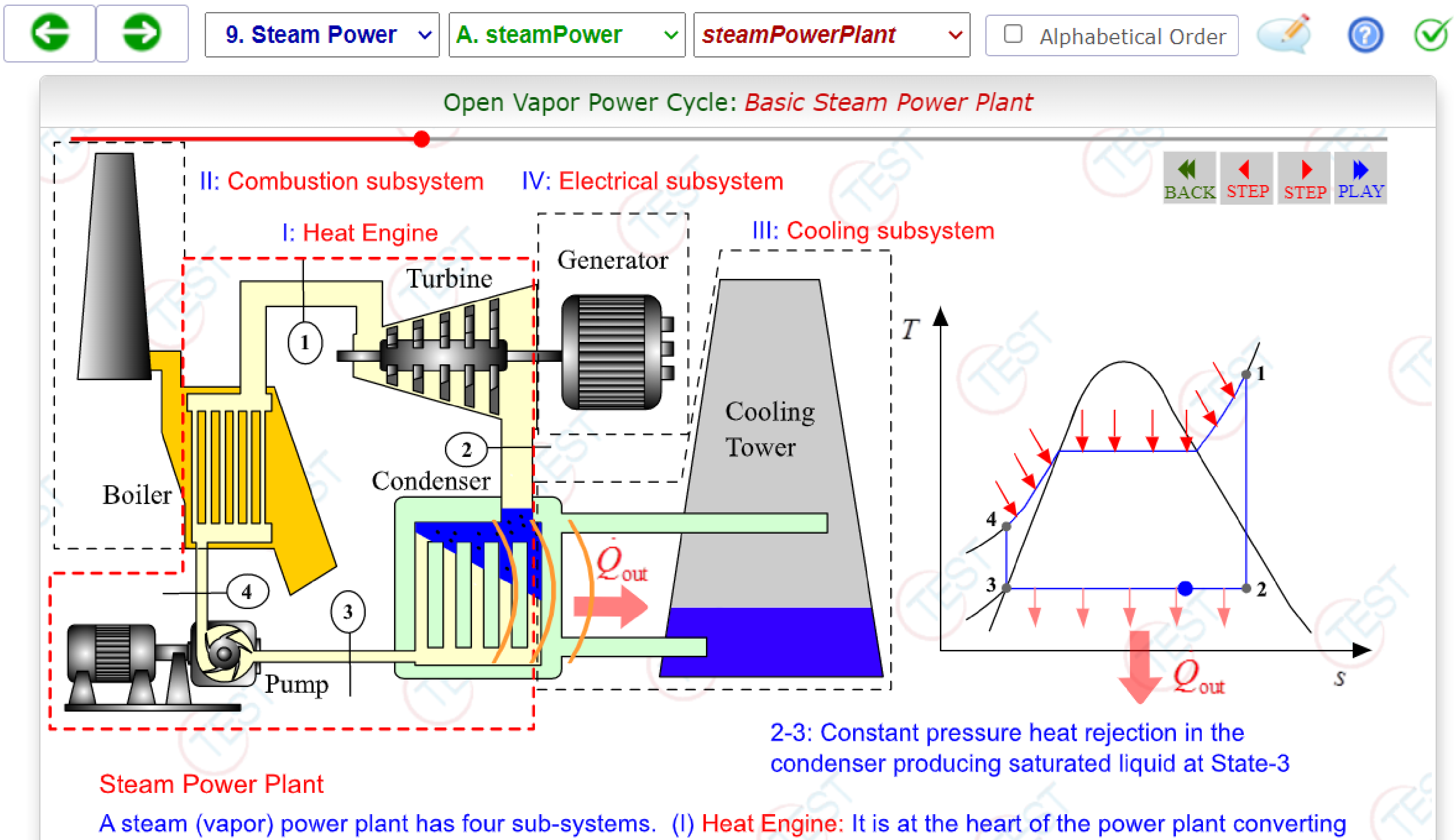


T	p = 6.0 MPa (T_{sat} = 275.64°C)			
	v	*u*	*h*	*s*
Sat.	0.03244	2589.7	2784.3	5.8892
300	0.03616	2667.2	2884.2	6.0674
350	0.04223	2789.6	3043.0	6.3335
400	0.04739	2892.9	3177.2	6.5408
450	0.05214	2988.9	3301.8	6.7193

- Suppose we would like to find enthalpy of steam at 6 Mpa and 370 deg-C.
- Instead of interpolating from the table, we can use the TESTapp linked above the table.
- Simply enter values of p1 and T1 and Calculate h1 as 3096.62 kJ/kg.

Animations Module

Animation Module– 16 Chapters of Animations



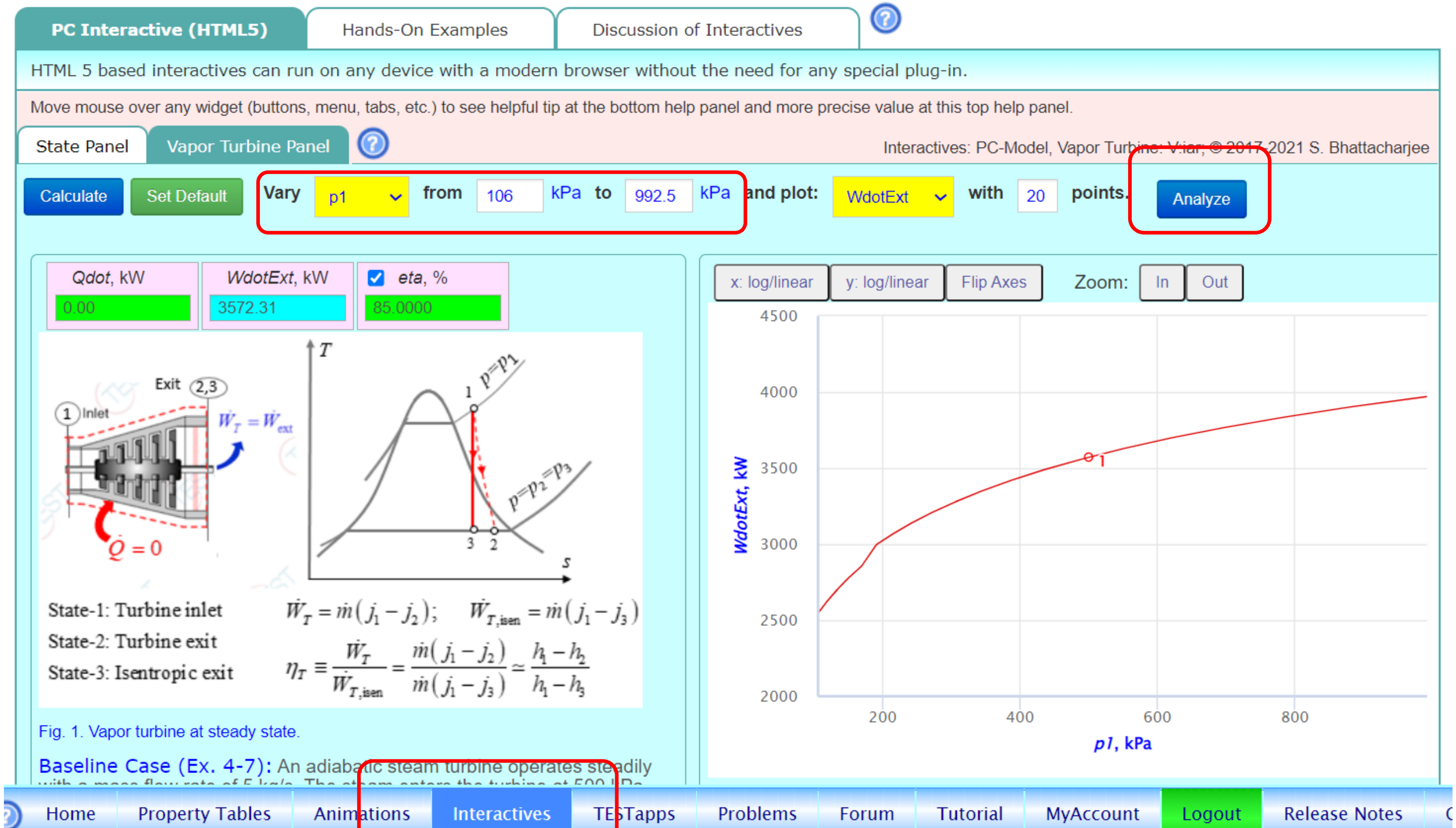
- Anim. 9.A.*steamPowerPlant* is being displayed.
- Use the slide bar and buttons to control.
- TEST will keep track of animations you have visited.
- Some animations have multiple screens.

Interactives Module

Interactive Module– Parametric Study Even Before Understanding a Concept or Device

Open-Steady Vapor Turbine Interactive: *PC (Phase-Change) Model*

Home » Interactives » Open-Steady Devices » Current Interactive Page



- Interactives to explore thermodynamic properties, devices, and processes.
- Typical conditions are default values (which can be changed of course).
- Graphical parametric studies can be done instantly.
- Simple pick a parameter and click Analyze.

Problems Module

Problems Module – Problems Organized in 16 Chapters

Problems Module: Interactive Problem Solving

Create a Custom Chapter

From a list of problem ids:

0-1-1 1-2-7 3-1-2

GO

Using conditional search:

Any Chapter | Any ILO (Ideal Learning Outcome)

Any Type of Problems | containing | Turbi

Sixteen Chapters of Multi-Media Problems

Interactions **Chapter-0**	Mass and heat and work interactions.	Gas Turbines **Chapter-8**	Gas turbi its variat
States **Chapter-1**	Understanding states and properties.	Steam Power **Chapter-9**	Vapor po
Gov. Equations **Chapter-2**	Balance equations for mass, energy, and entropy; Analysis of closed steady systems and cycles.	Refrigeration **Chapter-10**	Vapor co
Properties **Chapter-3**	Material models (SL, PC, IG, PG, and RG model) to evaluate properties of working substances.	Advanced States **Chapter-11**	Advance relations
Steady Systems **Chapter-4**	Mass, energy, and entropy analysis of open-steady systems (nozzles, pumps, turbines, etc.)	Psychrometry **Chapter-12**	Psychron
Unsteady Systems **Chapter-5**	Mass, energy, and entropy analysis of unsteady processes.	Combustion **Chapter-13**	Chemical reaction and combustion.

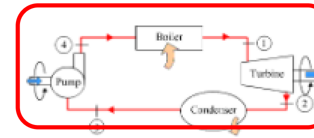
- You can search for problems using keyword, learning outcome, chapter name, or problem id.
- Click on a chapter to browse problems, see manual or TEST solution, or seek assistance to solve a problem.

Home | Property Tables | Animations | Interactives | TESTapps | Problems | Forum | Tutorial | MyAccount

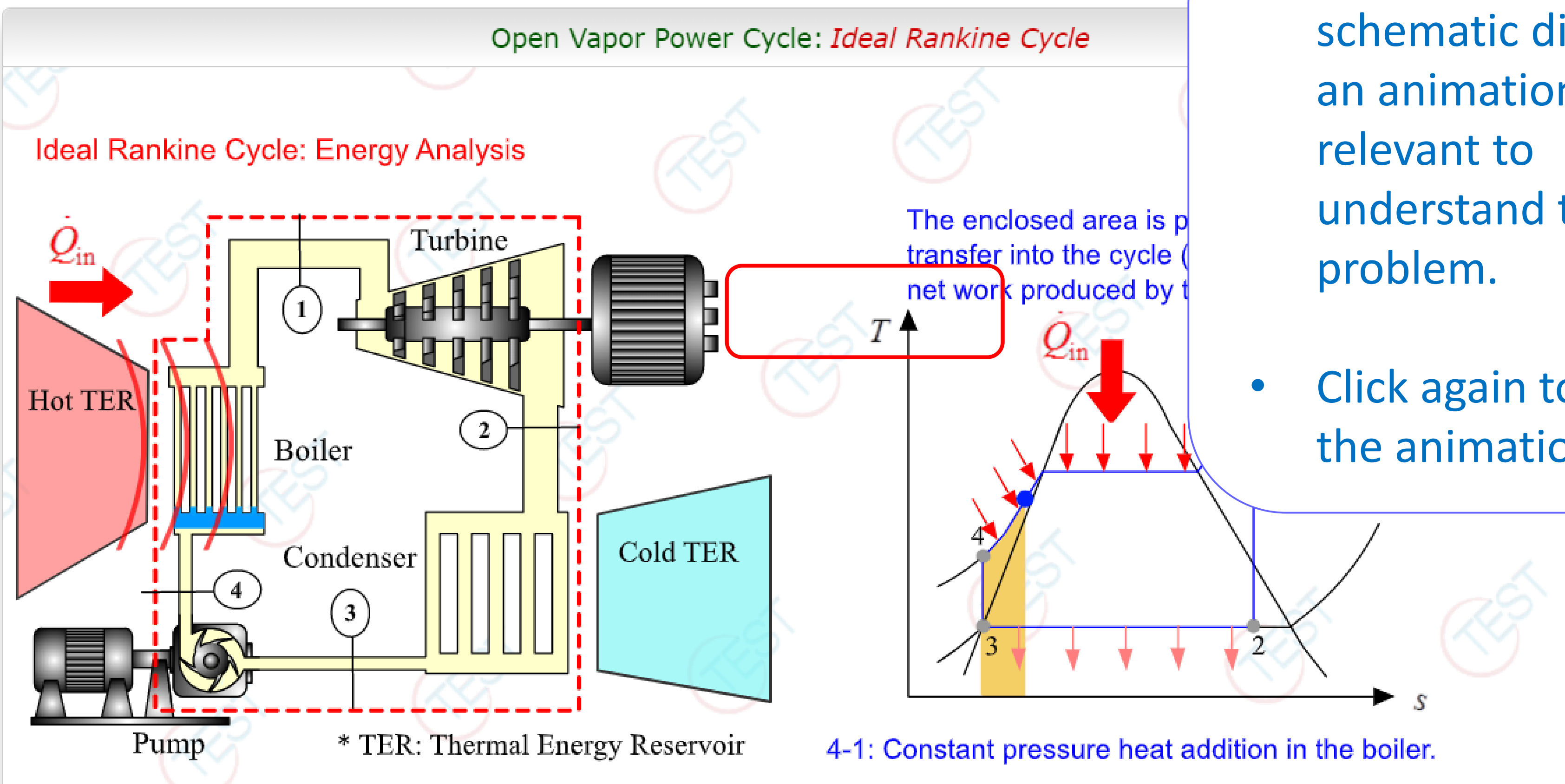
Problems Module – Problems Linked to Animations

9-1-5 [OPZ] A steam power plant operates on the simple ideal Rankine cycle. Steam enters the turbine at 4 MPa, 500°C and is condensed in the condenser at a temperature of 40°C. (a) Show the cycle on a T-s diagram. If the mass flow rate ($\dot{m}$) is 10 kg/s, determine (b) the thermal efficiency (η_{th}) of the cycle and (c) the net power output ($\dot{W}_{net}$) in MW.

[Solution] [Discuss]



Anim. 9-1-5



- Clicking on the schematic displays an animation that relevant to understand the problem.
- Click again to close the animation.

Problems Module – Check Your Answers and Monitor Outcome Based Progress

9-1-5 [OPZ] A steam power plant operates on the simple ideal Rankine cycle. Steam enters the turbine at 4 MPa, 500^{o}C and is condensed in the condenser at a temperature of 40^{o}C. (a) Show the cycle on a T-s diagram. If the mass flow rate ($\dot{m}$) is 10 kg/s, determine (b) the thermal efficiency

and (c) the net power output ($\dot{W}_{net}$) in MW.

Answ

My Solution | **Outcome Based Learning** | **Progress Report**

Problem Type: **Extra-Credit Problem:** Once you solve the preceding key this section, solve extra-credit problems to gain mastery o learning outcome) and improve your TEST rank.

Status: **Not yet attempted!** Number of Attempts: **0**;

My Answers: Difficulty rating [1], # of attempts, and hints [eqv. to 3 att your score.

Part	Answer Value	Unit	Weight (%)
(a)		%	50
(b)		MW	50

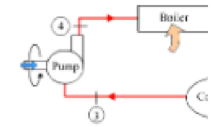
Grade My Ar

- Clicking the problem number takes a user to a grade sheet.
- An answer can be verified and recorded.
- TEST will update an outcome based bar chart.
- Also a progress report will be updated.

Problems Module – Discussing a Problem

9-1-5 [OPZ] A steam power plant operates on the simple ideal Rankine cycle. Steam enters the turbine at 4 MPa, 500^oC and is condensed in the condenser at a temperature of 40^oC. (a) Show the cycle on a T-s diagram. If the mass flow rate ($\dot{m}$) is 10 kg/s, determine (b) the thermal efficiency (η_{th}) of the cycle and (c) the net power output ($\dot{W}_{net}$) in MW.

[Solution] [Discuss]



Anim. 9-1

More Action..

Post ○ Question ● Comment From: Prof. Subrata Bhattacharjee ☐ An

Click here to post a question or comment on this problem. To respond t
click the Reply link under the comment.

703 Jul 16, 2013; Prob-OPZ, Chap-9, Problems, Steam Power ; Mr. Kush Gupta

I have solved this problem manually and using the daemon and my answers were marked correct by TEST.

(Originating page: Chapter 9) tag reply edit archive delete thread

- Use the discuss link to seek help on a particular problem

Problems Module – TEST and Manual Solutions

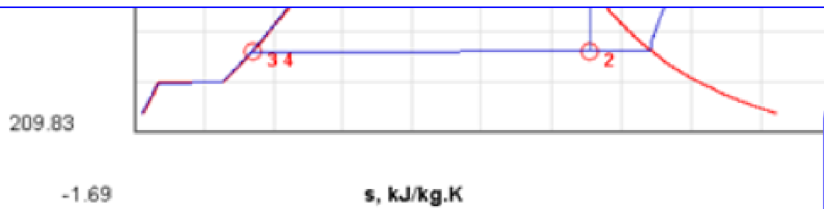
9-1-5 [OPZ] A steam power plant operates on the simple ideal Rankine cycle. Steam enters the turbine at 4 MPa, 500°C and is condensed in the condenser at a temperature of 40°C. (a) Show the cycle on a T-s diagram. If the mass flow rate ($\dot{m}$) is 10 kg/s, determine (b) the thermal efficiency (η_{th}) of the cycle and (c) the net power output ($\dot{W}_{net}$) in MW.

[Solution] [Discuss]

Answers: (b) 37.64%, (c) 12.324 MW

TEST Solution | Manual Solution

Note: If you detect any error in the solution (if it is available and displayed below), please report it to support@thermofluids.net. We appreciate your input!



State-1 (given p_1, T_1):

$h_1 = 3445.19 \frac{\text{kJ}}{\text{kg}}$; $s_1 = 7.0900 \frac{\text{kJ}}{\text{kg}\cdot\text{K}}$;

State-2 (given $T_2, s_2 = s_1$):

$h_{f@40°C} = 167.57 \frac{\text{kJ}}{\text{kg}}$; $h_{fg@40°C} = 2406.72 \frac{\text{kJ}}{\text{kg}}$;

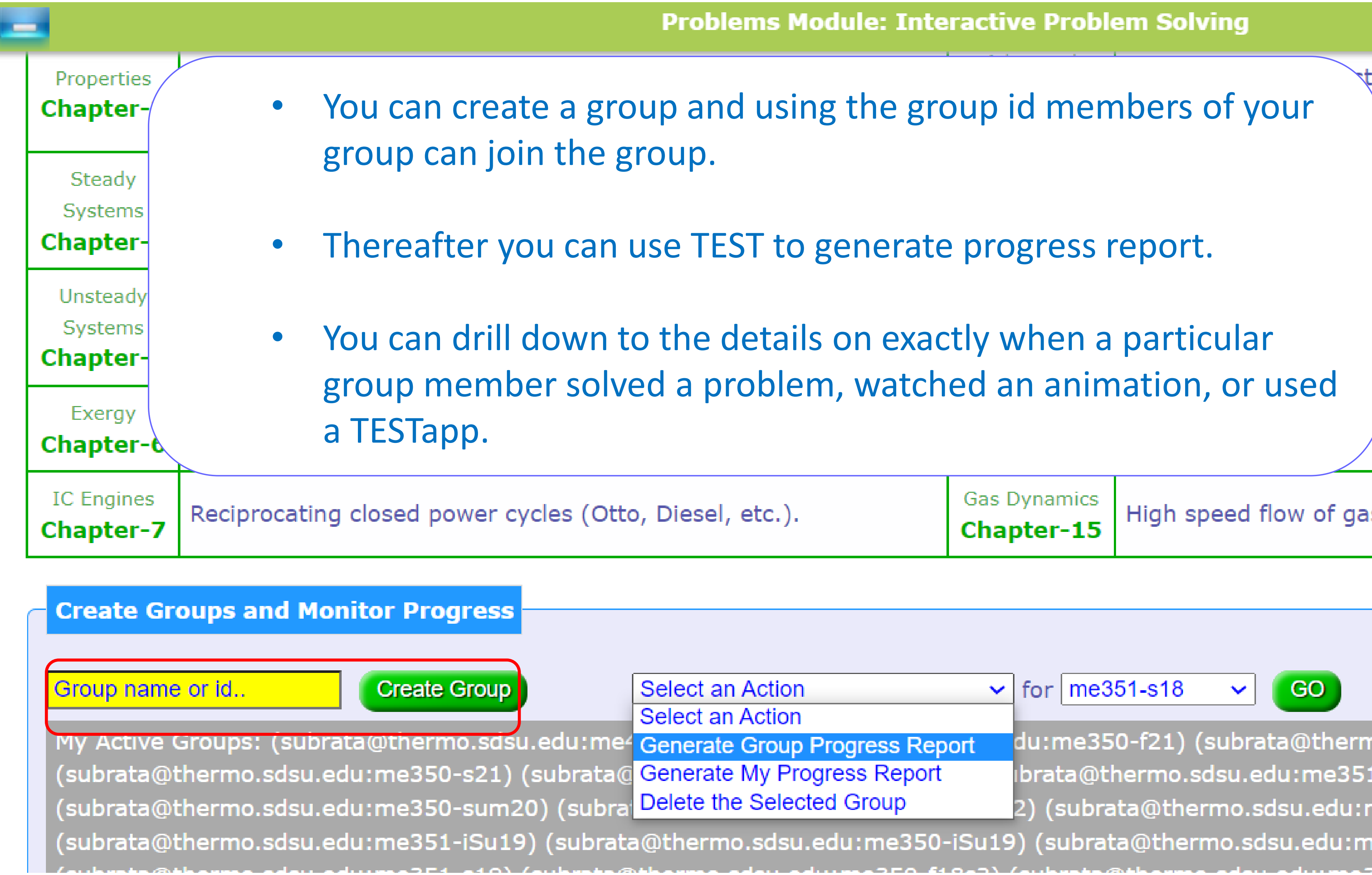
$s_{f@40°C} = 0.5725 \frac{\text{kJ}}{\text{kg}\cdot\text{K}}$; $s_{fg@40°C} = 7.6847 \frac{\text{kJ}}{\text{kg}\cdot\text{K}}$;

$x_2 = \frac{s_2 - s_{f@40°C}}{} = \frac{7.0900 - 0.5725}{7.6847} = 0.8481$;

- Users with Appropriate Privilege can access the manual and TESTapp-based solutions.
- Solutions to examples are available to all users.

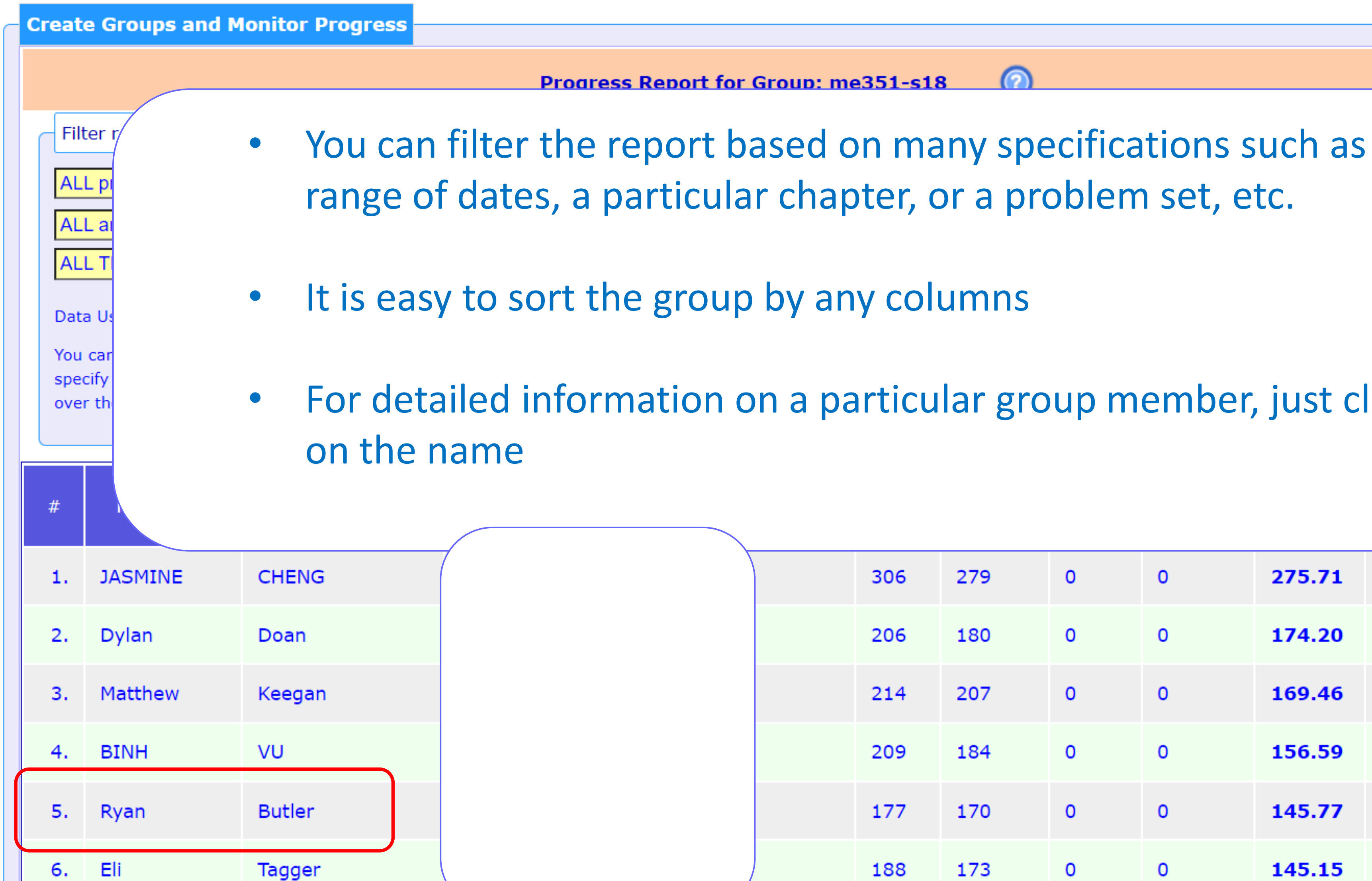
Problems Module – Creating a Group

- You can create a group and using the group id members of your group can join the group.
- Thereafter you can use TEST to generate progress report.
- You can drill down to the details on exactly when a particular group member solved a problem, watched an animation, or used a TESTapp.



Problems Module – Generating a Report

- You can filter the report based on many specifications such as a range of dates, a particular chapter, or a problem set, etc.
- It is easy to sort the group by any columns
- For detailed information on a particular group member, just click on the name



Problems Module – Generating Personalized Report

- Details are at your fingertip, making it difficult for students to use dishonest practice to solve homework.

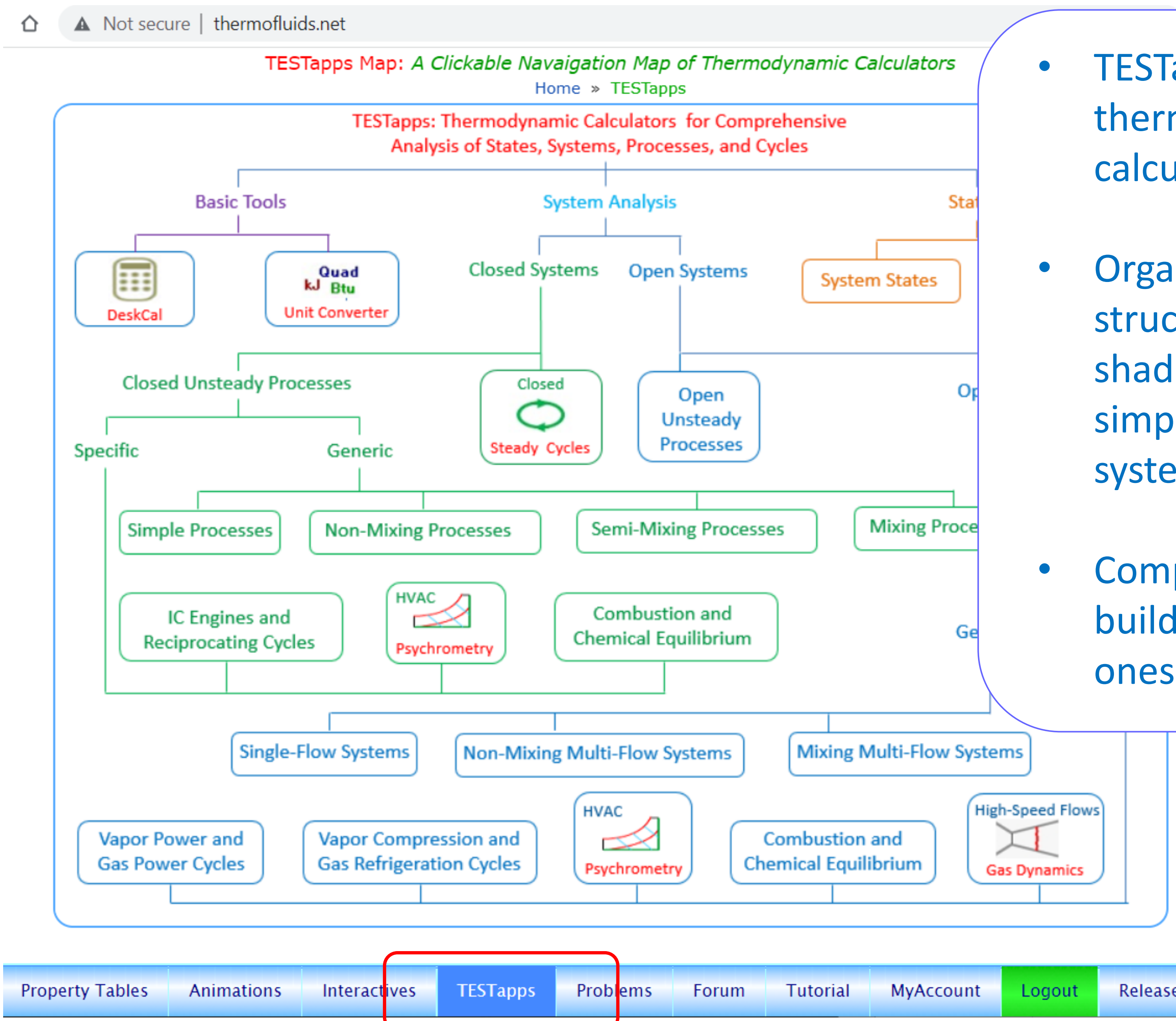
5.	Ryan	Butler	rsb1997@hotmail.com	177	170	0	0	**145.77**	**0.0**

Solution Record: Email Member Report to Me (To close this report, click on the highlighted row above.)

Problem Number	Last Attempted	No. of Attempts	Solved Correctly	Points Earned
0-1-4 [UF]	Aug 29, 2017	1	Yes	1.00
0-1-16 [XE]	Aug 29, 2017	5	Yes	0.66
0-2-8 [XQ]	Sep 1, 2017	8	Yes	0.60
0-3-2 [UG]	Sep 1, 2017	3	Yes	0.81

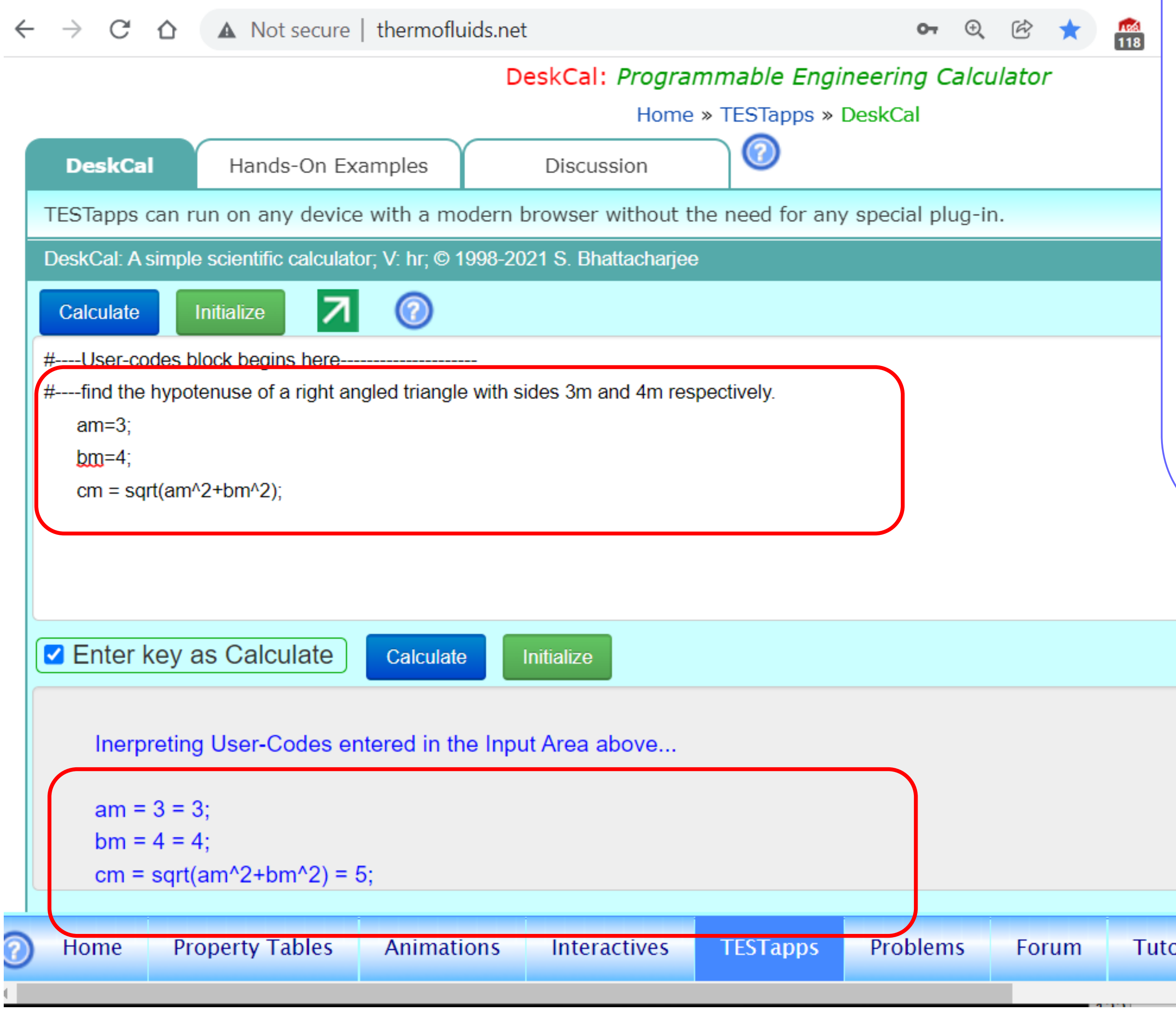
TESTapp Module – The workhorse of TEST

TESTapp Module– Calculators Organized According to Thermodynamic Assumptions



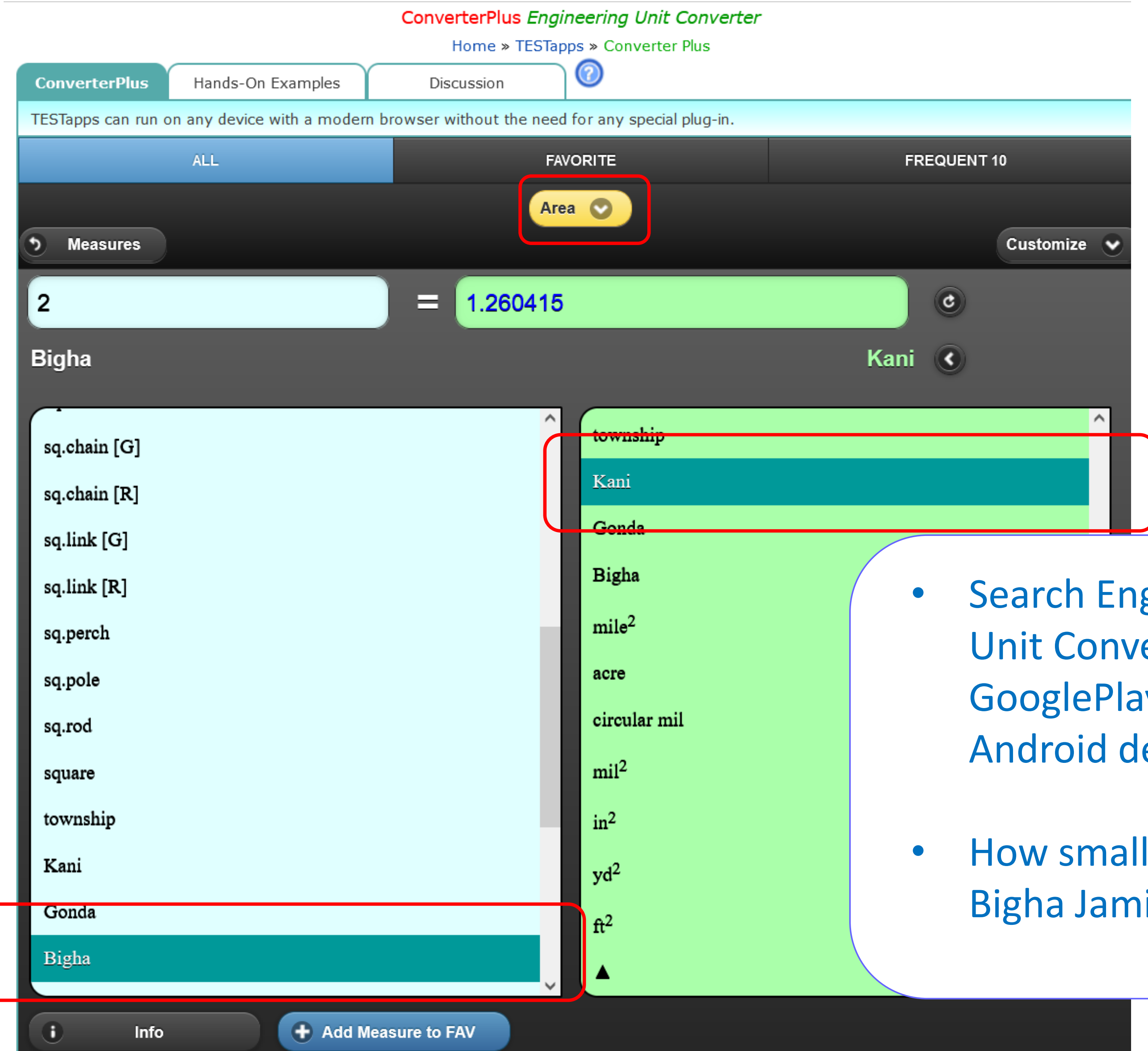
- TESTapps are thermodynamic calculators.
- Organized in a tree structure that shadows simplification of systems.
- Complex TESTapps build upon simpler ones.

A Simple TESTapp – The DeskCal



- All TESTapps have similar format with 3 tabs.
- Let us do a simple calculation: finding the hypotenuse of a right-angled triangle.

Another Rudimentary TESTapp – The Engineering Unit Converter



- Search Engineering Unit Converter in GooglePlay for your Android device
- How small is '2 Bigha Jami'

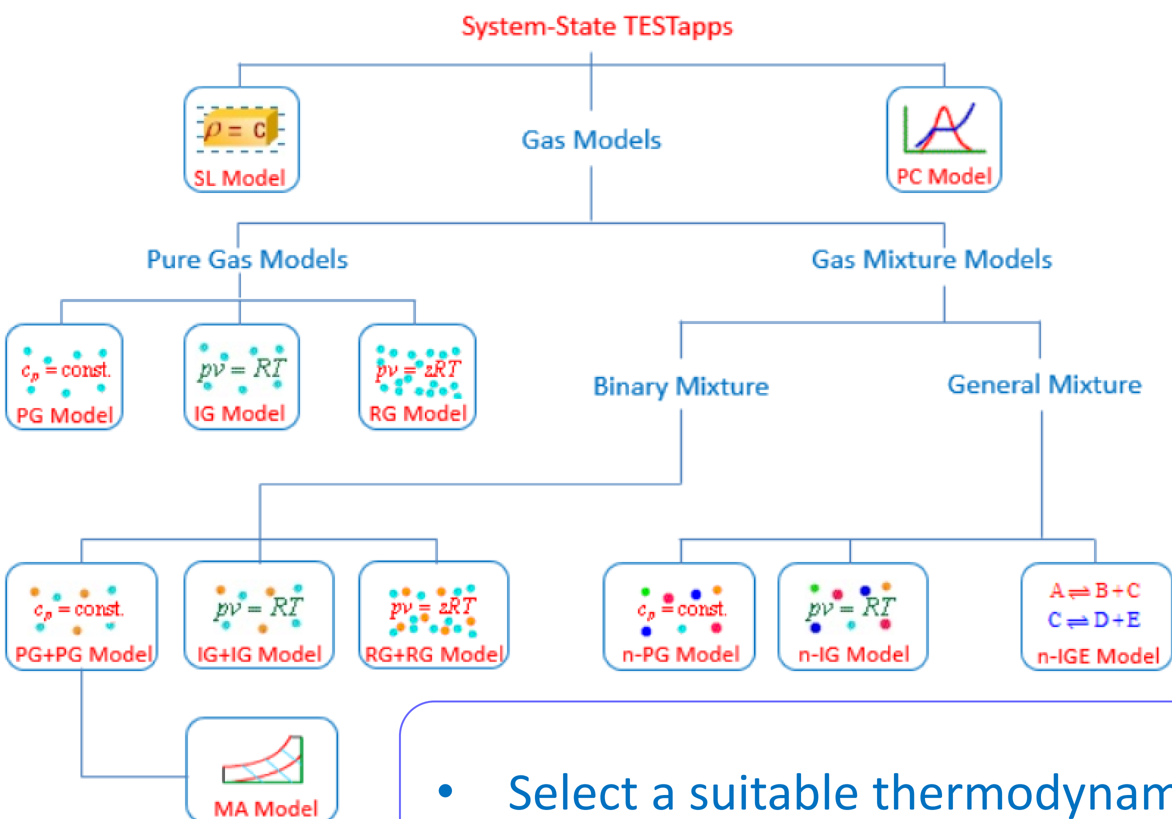
TESTapps – Launching a State TESTapp

System-State TESTapps: *Select a Material Model*

Home » TESTapps » System-State

Select a Model | Relevant Animation

You can switch among the tabs above without affecting the state of your calculations.



Using the Back button will take you to the home page

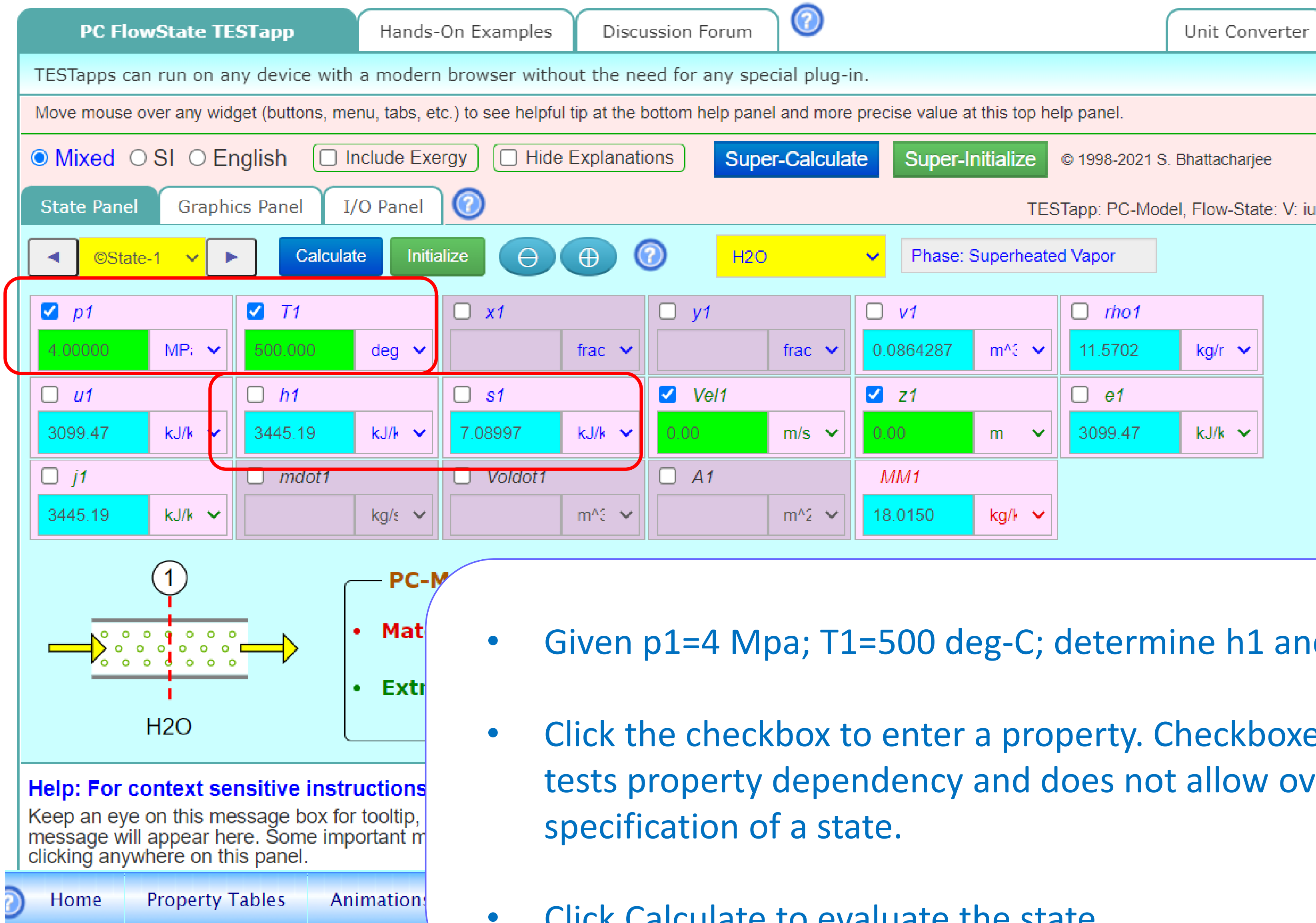
- Select a suitable thermodynamic model.

Home | Property Tables | Animations | Interactives | TESTapps | Problems | Forum | Tutorial | MyAccount | Logout

State TESTapp – Calculate a State Directly with Flow-State TESTapp

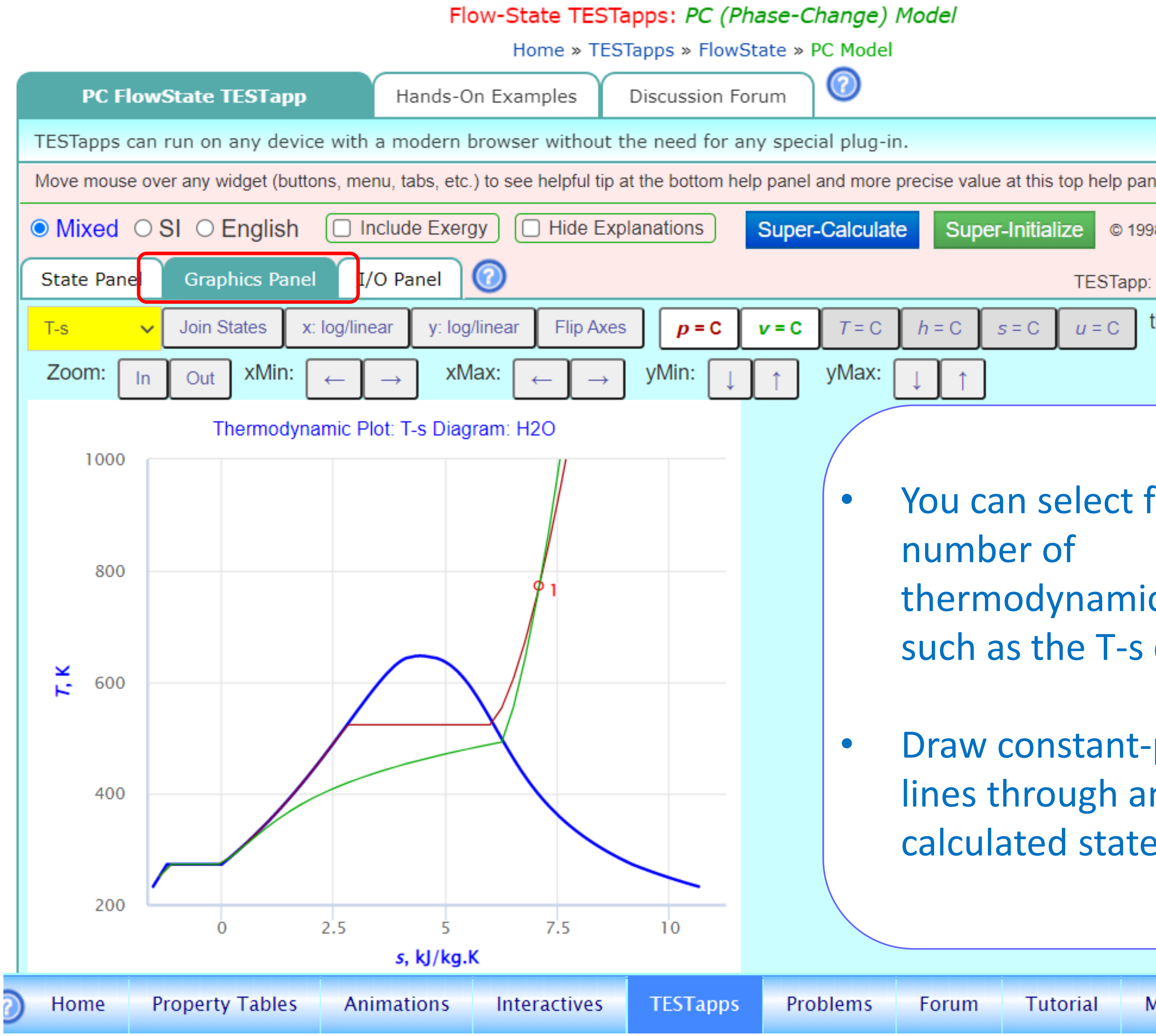
Flow-State TESTapps: *PC (Phase-Change) Model*

Home » TESTapps » FlowState » PC Model



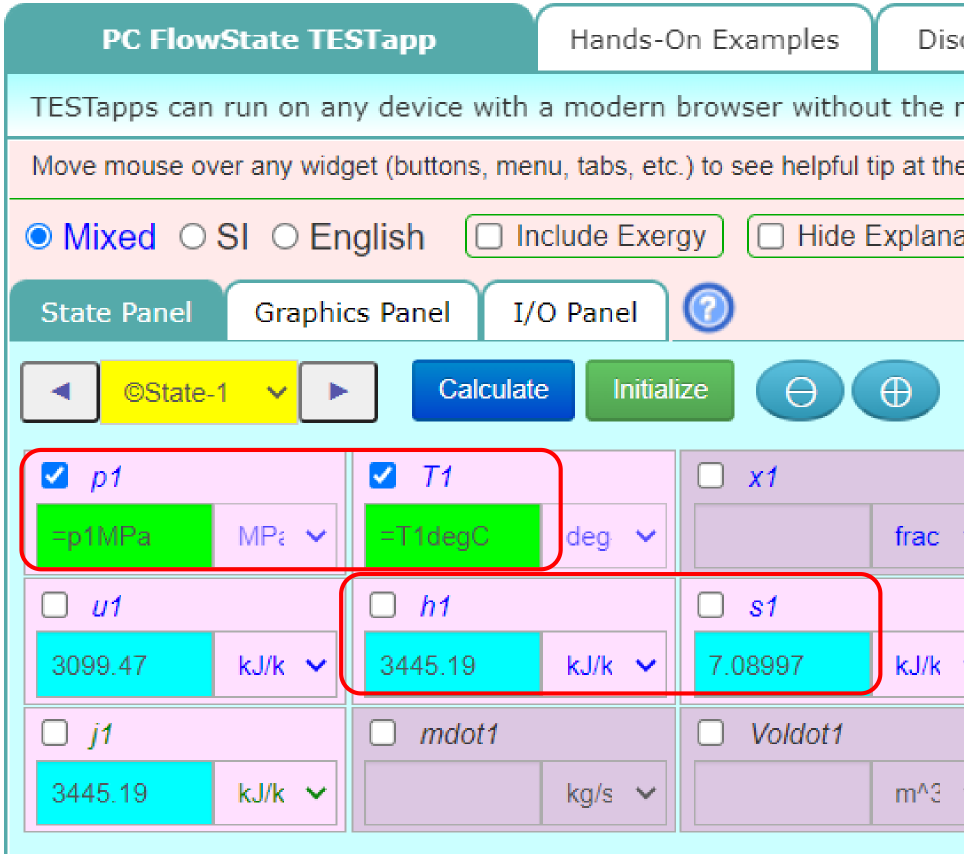
- Given p1=4 Mpa; T1=500 deg-C; determine h1 and s1.
- Click the checkbox to enter a property. Checkboxes tests property dependency and does not allow over-specification of a state.
- Click Calculate to evaluate the state.

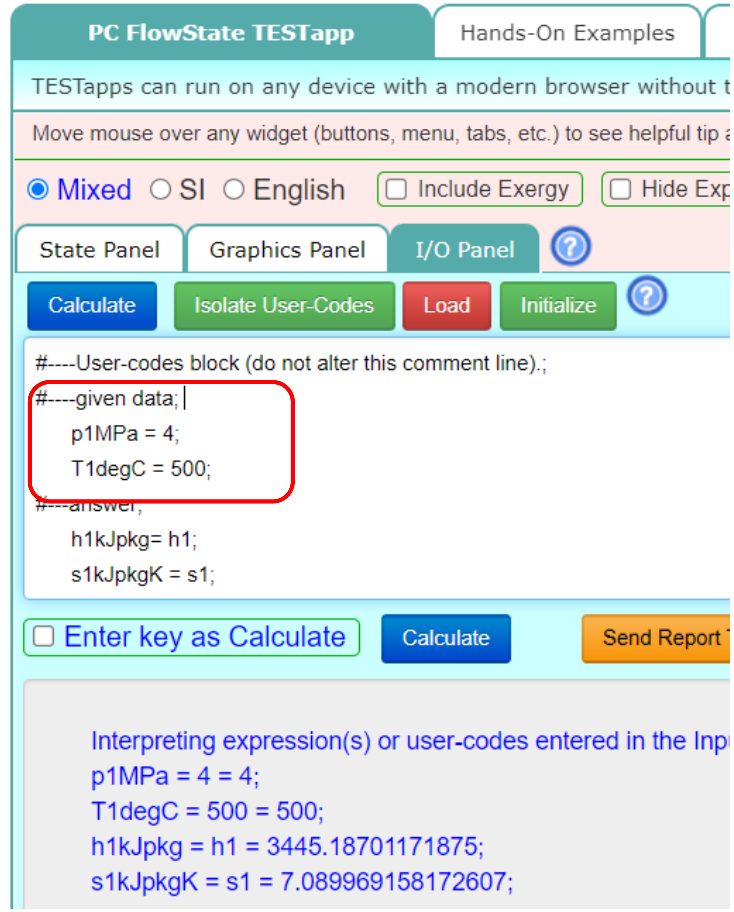
TESTapp – Visualize the Calculated States



- You can select from a number of thermodynamic plots such as the T-s diagram.
- Draw constant-property lines through any calculated state.

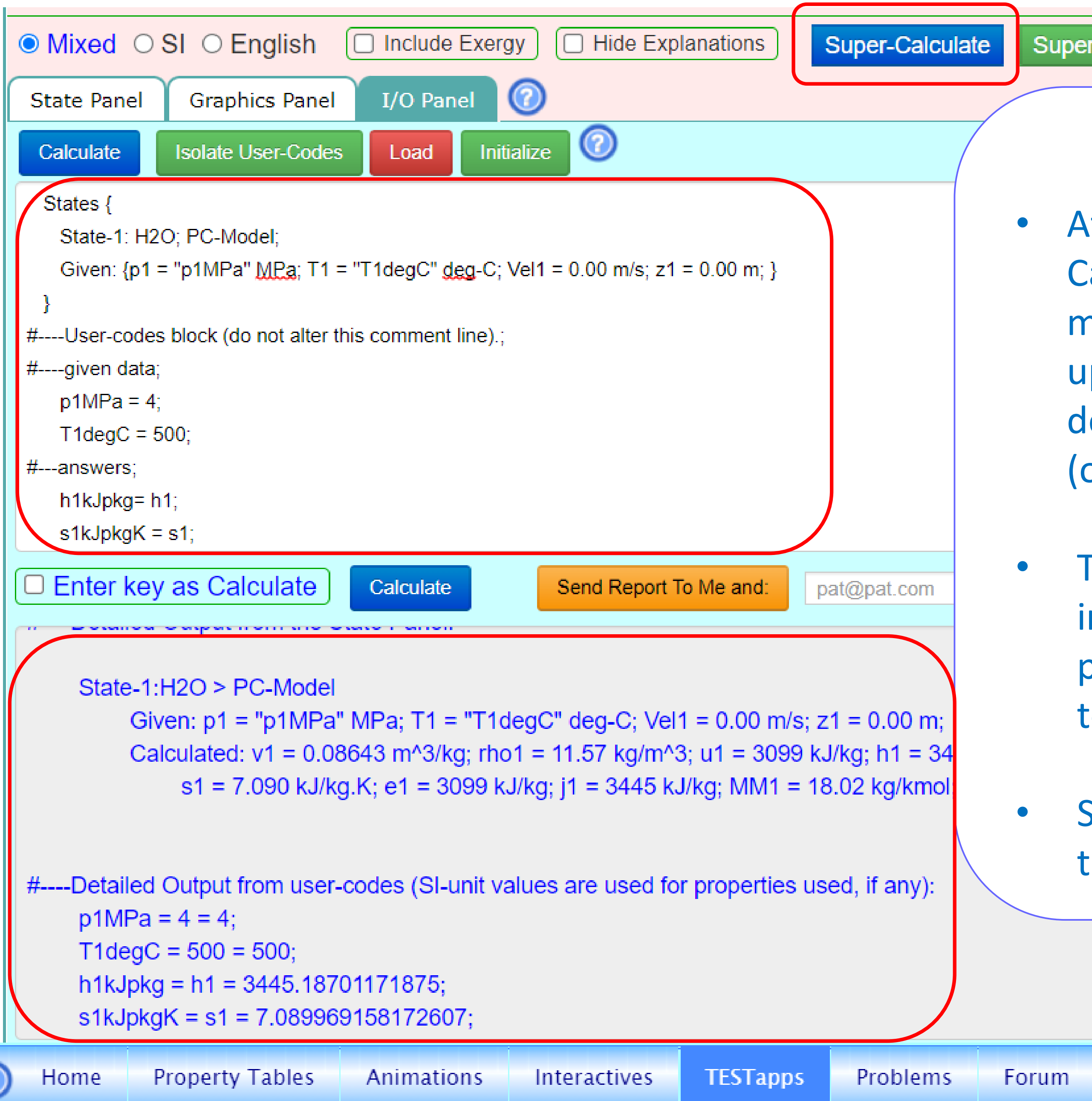
State TESTapp – Using Variables Instead of Hard Numbers





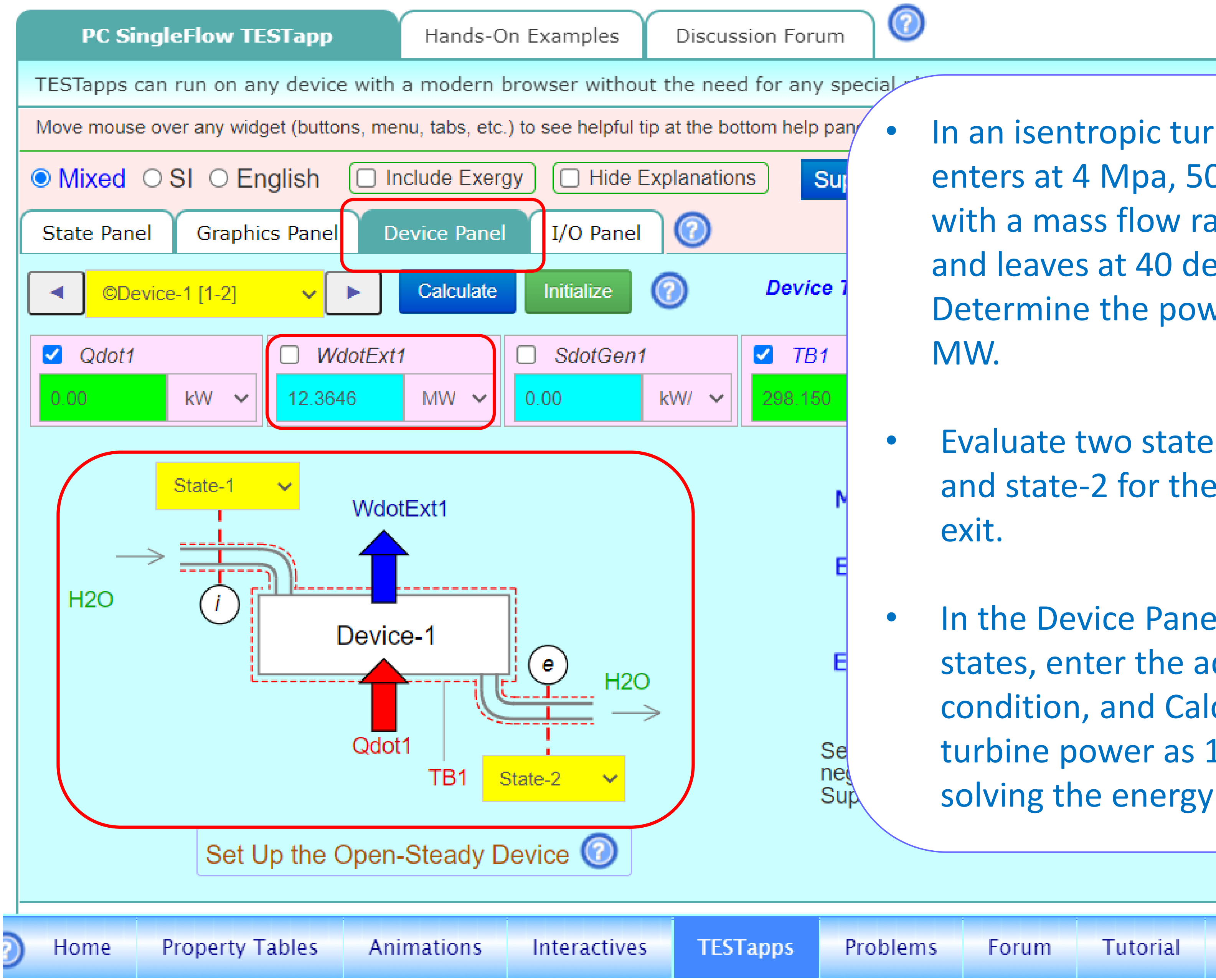
- In the I/O panel, declare p1MPa=4 ; T1degC=500 deg-C; determine h1 and s1.
- Calculate to register the values, which appear in the output panel below.
- Use those variables (in appropriate unit) in the state panel.

State TESTapp – Super-Calculate for a Solution Report and TEST-codes



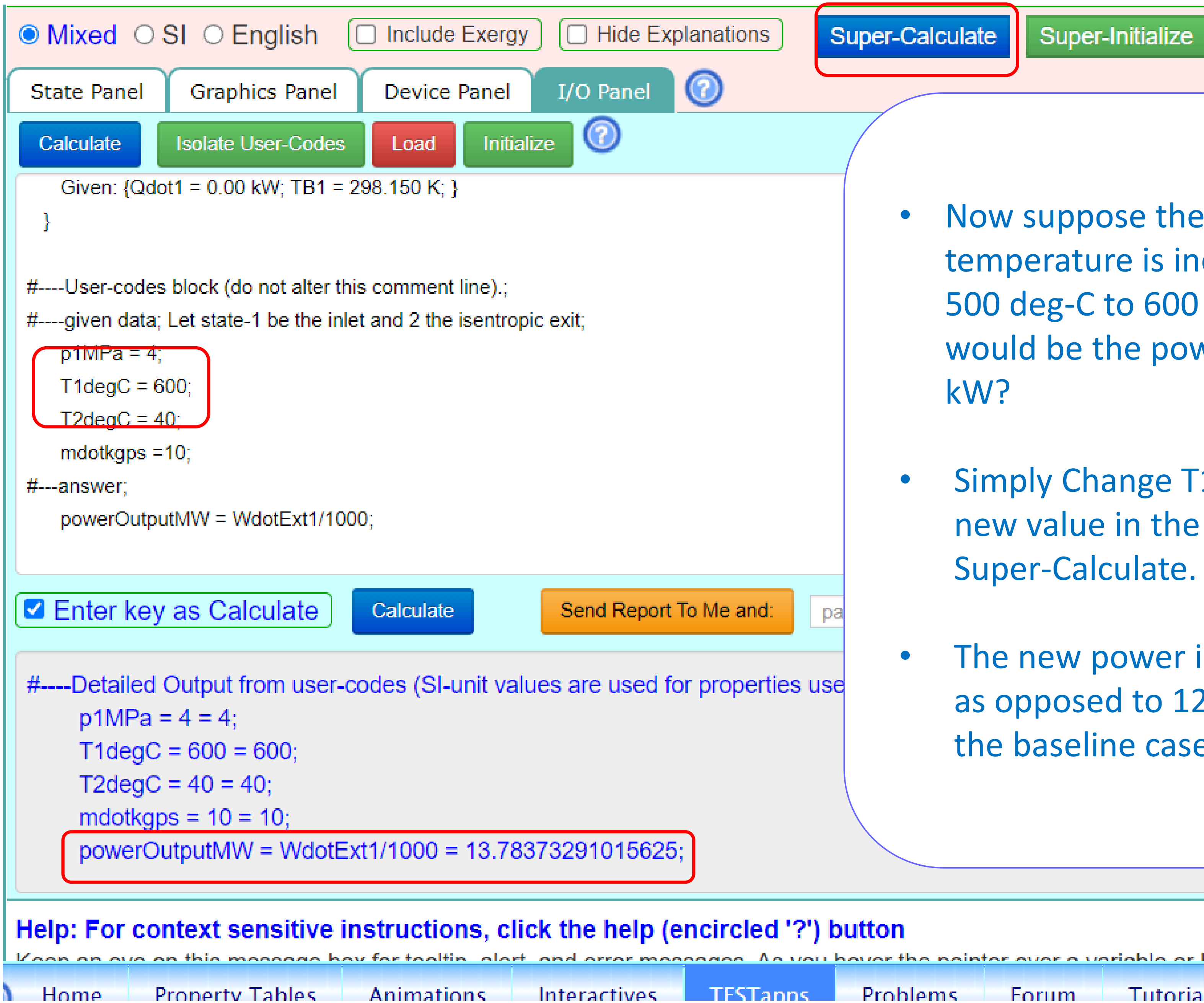
- After any solution, click Super-Calculate to generate a solution macro called TEST-codes in the upper (input) panel and a detailed report on the lower (output) panel.
- TEST-codes contain all the information used to solve the problem and can be used later to regenerate a solution.
- Simply paste the code back in the input panel and click Load.

Device TESTapp – Use States to Construct a Turbine Analysis



- In an isentropic turbine, steam enters at 4 Mpa, 500 deg-C, with a mass flow rate of 10 kg/s and leaves at 40 deg-C. Determine the power output in MW.
- Evaluate two states: state-1 and state-2 for the inlet and exit.
- In the Device Panel, load the states, enter the adiabatic condition, and Calculate the turbine power as 12.3 MW by solving the energy equation.

Device TESTapp – What-if the Turbine Inlet Temperature is Increased?

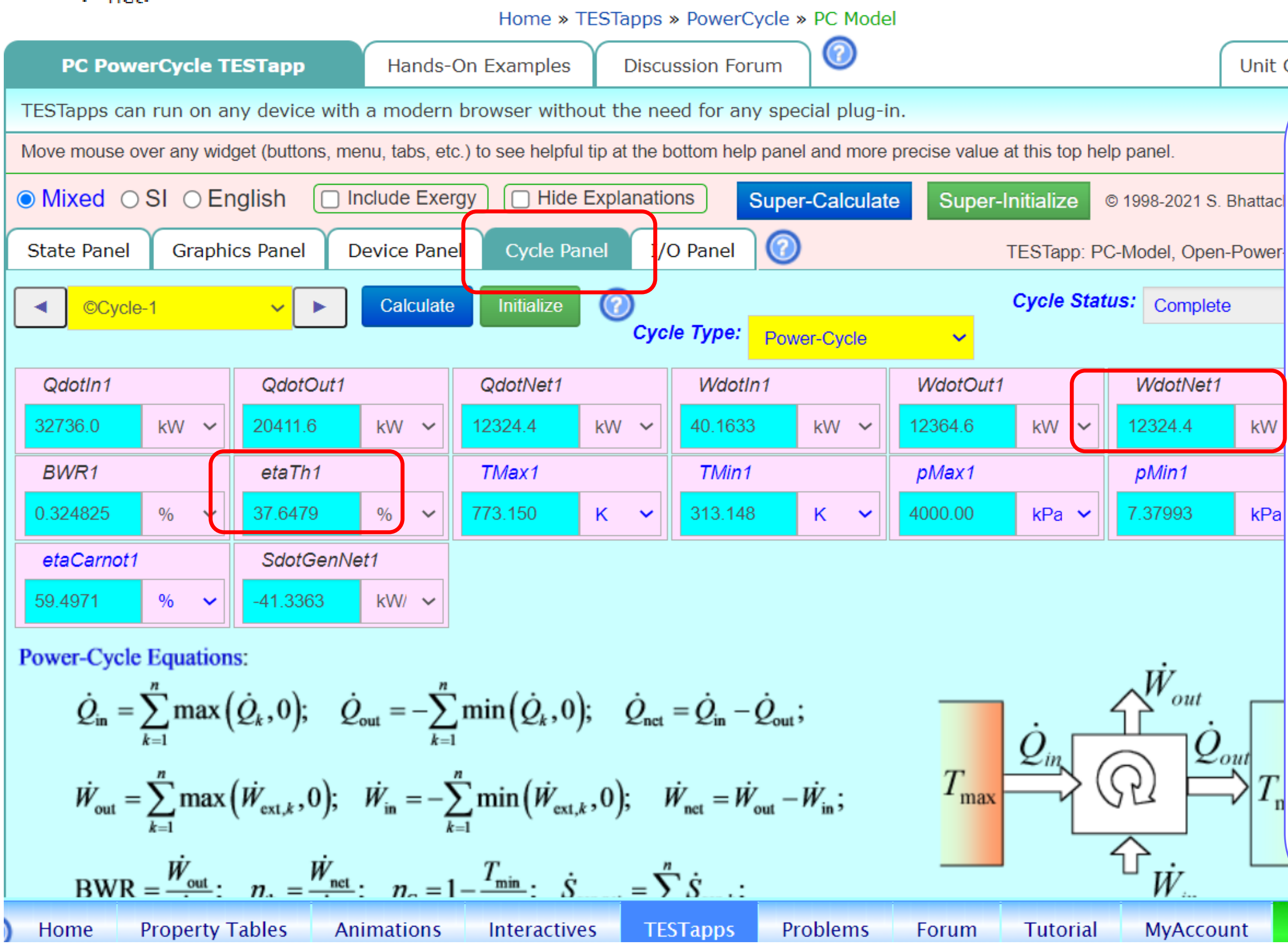


- Now suppose the turbine inlet temperature is increased from 500 deg-C to 600 deg-C. What would be the power output in kW?
- Simply Change T1degC to its new value in the I/O panel and Super-Calculate.
- The new power is 13.78 MW as opposed to 12.36 MW for the baseline case.

Vapor Power TESTapp – A Rankine Cycle Based Power Plant Simulation

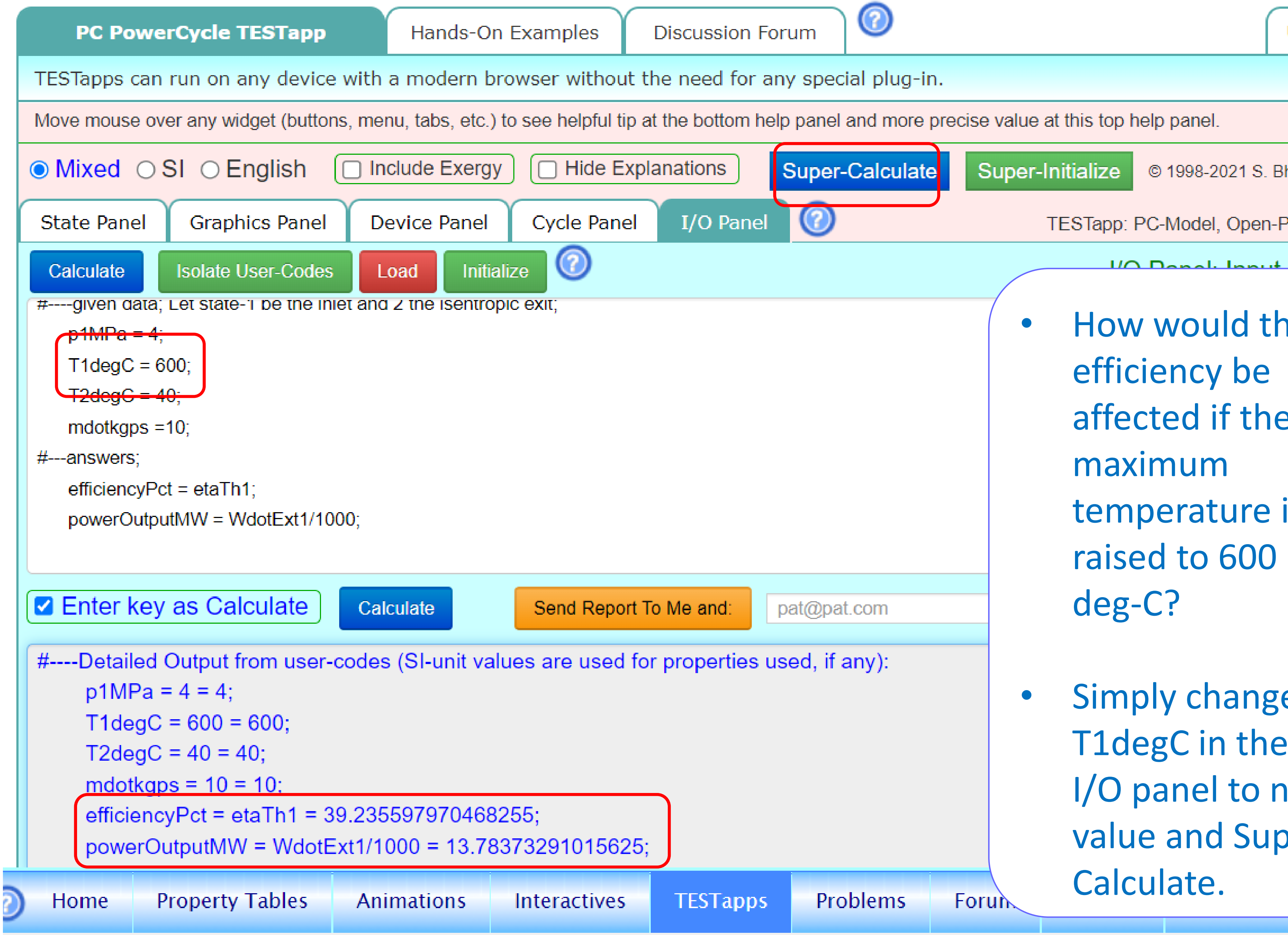
9-1-5 [OPZ] A steam power plant operates on the simple ideal Rankine cycle. Steam enters the turbine at 4 MPa, 500^{o}C and is condensed in the condenser at a temperature of 40^{o}C. (a) Show the cycle on a T-s diagram. If the mass flow rate ($\dot{m}$) is 10 kg/s, determine (b) the thermal efficiency (η_{th}) of the cycle and (c) the net power output ($\dot{W}_{net}$) in MW.

[Solution] [Discuss]



- Once all the devices – turbine, condenser, pump, and, boiler are analyzed, the cycle is completed and overall cycle results are displayed in the cycle panel.

Vapor Power TESTapp – What if the Maximum Temperature Increases to 600 deg-C?

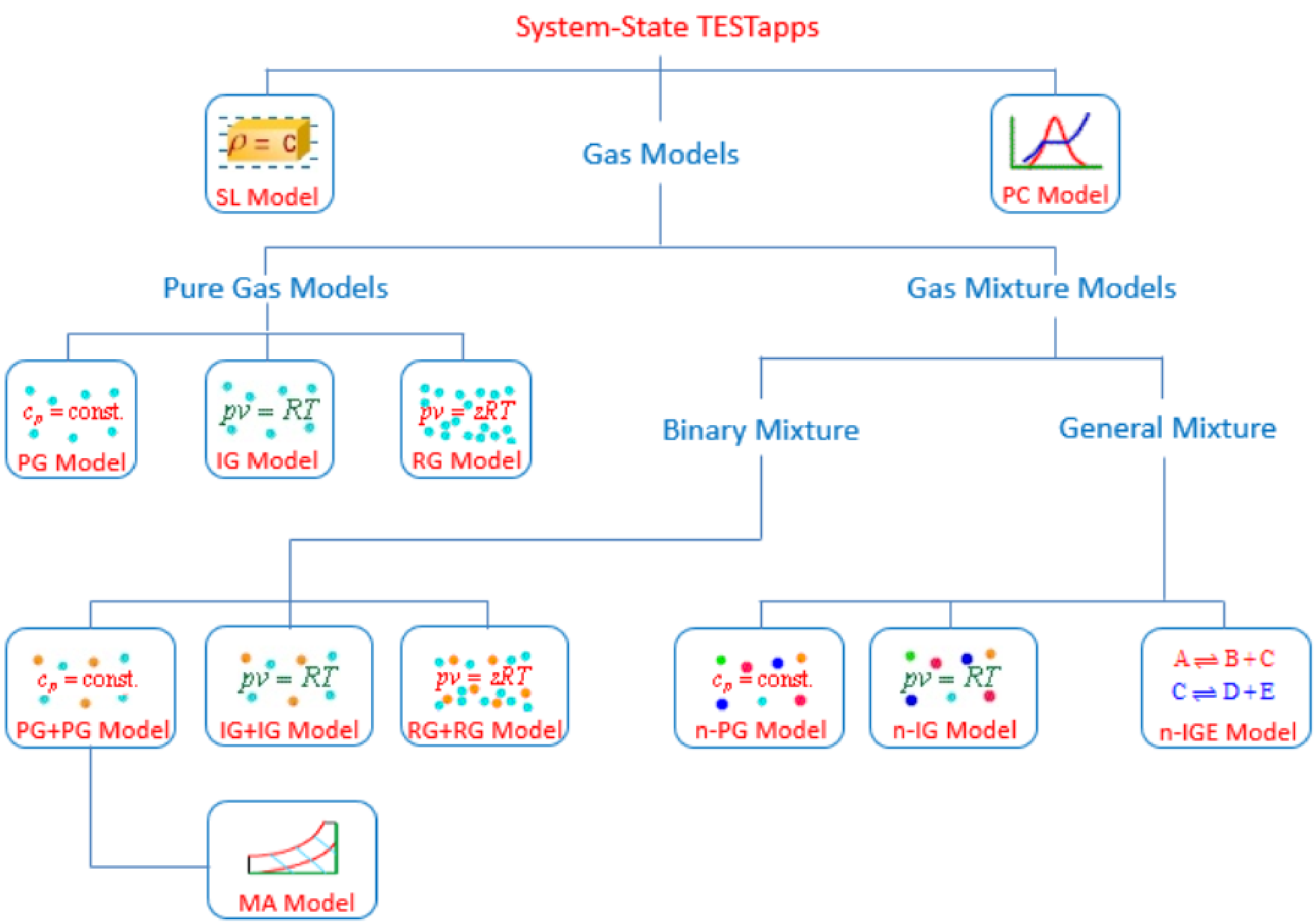


- How would the efficiency be affected if the maximum temperature is raised to 600 deg-C?
- Simply change T1degC in the I/O panel to new value and Super-Calculate.

There is an App for Every Thermodynamic Problem

System State TESTapps – Many Thermodynamic Models

- Based on the working substance, select an appropriate model to launch the system state TESTapp..

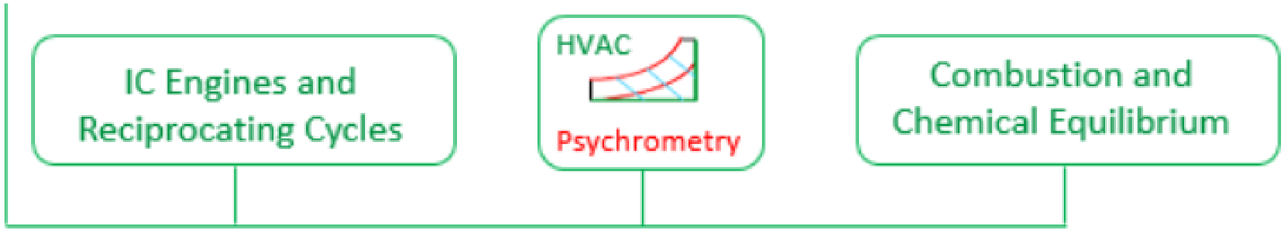


Closed-Process TESTapps – Built Upon System State TESTapps

- The Simple Process is when the beginning state and the final state can be represented by just two unique states.
- Non-Mixing Process may involve more than one beginning or final state without the subsystems mixing.
- Semi-Mixing Process may involve more than one beginning or final state without the subsystems partially mixing.
- Mixing Process may involve more than one beginning state but a single final state.

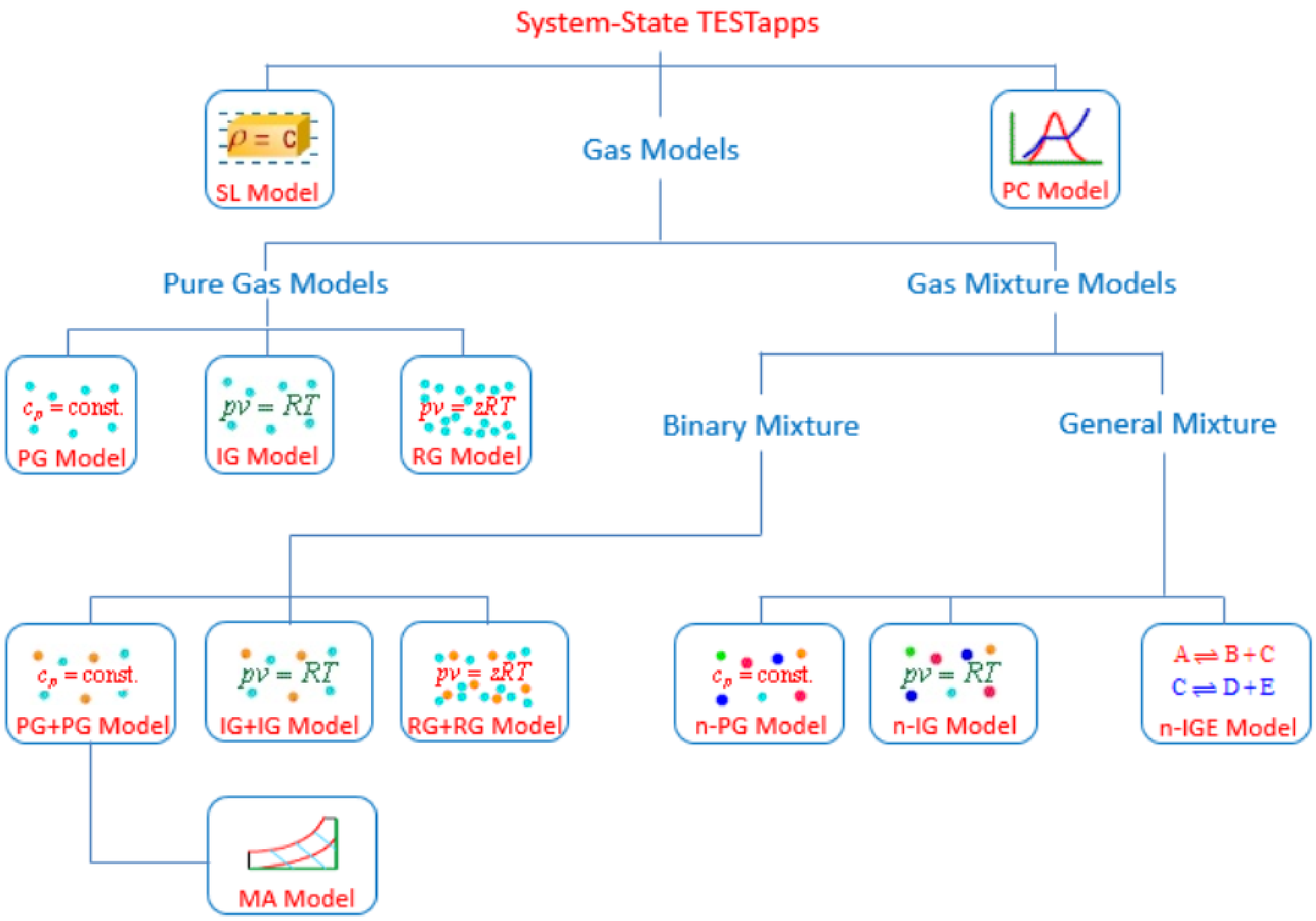
Specific Closed-Process TESTapps – Built Upon Process TESTapps

- The reciprocating engine cycles (Otto, Diesel) apps cover SI and CI engines.
- Moist air undergoing a closed process is analyzed by the closed HVAC app.
- The combustion and chemical equilibrium apps in this branch deals with combustion in a closed system.



Flow State TESTapps – Many Thermodynamic Models

- Based on the working substance, select an appropriate model to launch the flow state TESTapp..

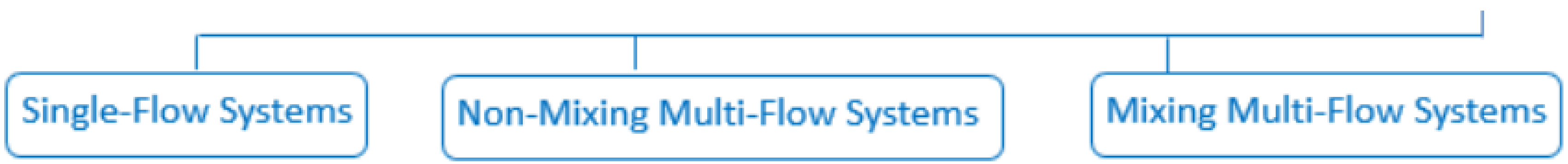


Open-Steady Device TESTapps – Built Upon Flow State TESTapps

- The Single-Flow Systems have only one flow flowing through the system at steady state. Examples: turbine, pump, nozzle, compressor, etc.

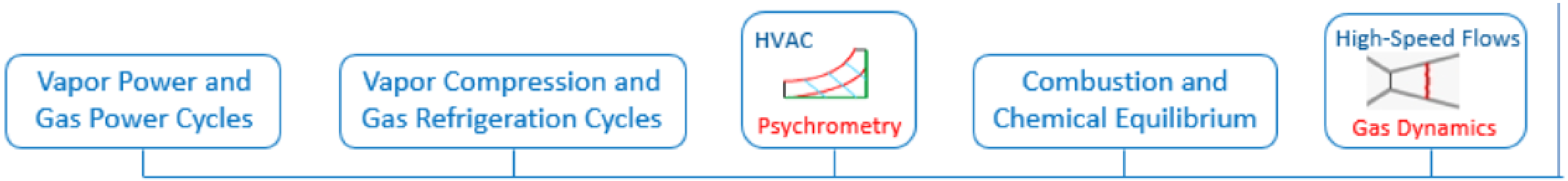
- Non-Mixing Multi-Flow Systems have at least two flows which are not mixing. Example: A closed-type heat exchanger.

- Mixing Multi-Flow Systems have at least two flows which are mixing or separating. Example: A mixing chamber.



Specific Open-Steady TESTapps – Built Upon Open-Steady Device TESTapps

- The vapor power and gas power cycle apps (Rankine and modified Rankine cycles, Brayton and modified Brayton cycles) apps builds on open-steady device apps.
- The vapor compression and gas refrigeration cycle also build on open-steady device apps.
- The HVAC app is based on the moist-air (MA) model and can be used for air-conditioning and other psychrometric applications.
- The combustion and chemical equilibrium apps are some of the most advanced apps offered by TEST.
- The gas-dynamic app is used for high speed flow (supersonic) analysis.



Thank You!
Questions?

du Châtelet is credited with the first experiment ever to distinguish momentum from kinetic energy (to the vexation of Sir Isaac Newton). The following quote is from Wikipedia:

Voltaire, one of her lovers, declared in a letter to his friend King Frederick II of Prussia that du Châtelet was "a great man whose only fault was being a woman".