

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

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Tripura, India



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- 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](http://www.pearson.com/Bhattacharjee)
- The Professional version of TEST is accessible from [www.thermofluids.net](http://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.



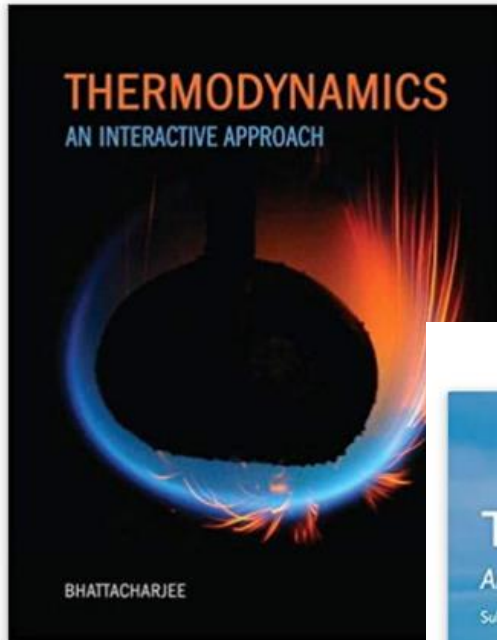
## Publications



# Thermodynamics: An Interactive Approach

by Subrata Bhattacharjee (Author)

★★★★☆ 25 ratings



ISBN-13: 978-0130351173

ISBN-10: 0130351172

[Why is ISBN important?](#)

**Hardcover**

\$47.28 - \$193.47

**Paperback**

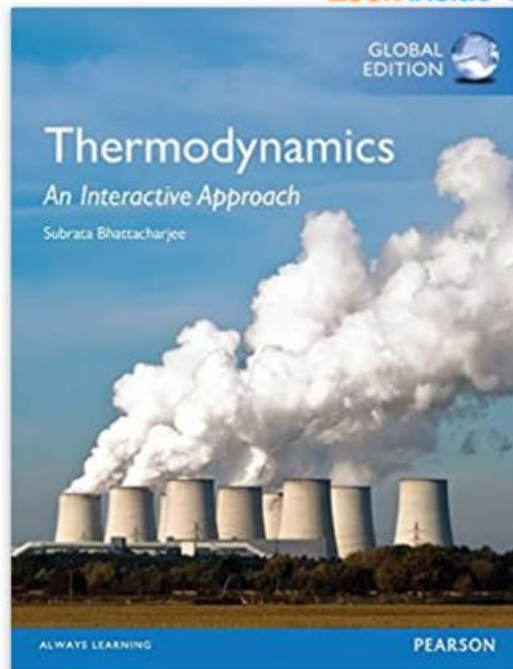
\$146.93

**Rent**

Due Date: May 23, 2022

- FREE return shipping

[Look inside](#)



## Thermodynamics: An Interactive Approach, Global Edition

by Subrata Bhattacharjee

★★★★★

[See all formats](#)

**Paperback**

**\$65.90**

2 Used from \$49.99

9 New from \$65.90

For the thermodynamics department that introduces progressively for today's the based resource

- 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.



www.thermofluids.net x www.thermofluids.net x Bhattacharjee | Pearson x +

www.pearsonhighered.com/bhattacharjee/ Search

Most Visited Flame-Local testFlat-energy test-Romulus classta.net A new kind of course ... classtadev-romulus te

**PEARSON**

# TEST: The Expert System for Thermodynamics

PROF. S. BHATTACHARJEE

## BREAKTHROUGH

To improving results

Our goal is to help every student succeed. We're working with educators and institutions to improve results for students everywhere.

**EDUCATORS** >

Features  
Support

**STUDENTS** >

Features  
Support

Sign In  
Already have an account? Sign in here.

Register  
Need an account? Register here.

TEST: The Expert System for Thermodynamics  
Prof. S. Bhattacharjee  
Home

Students  
Features  
Support

Pearson Higher Education  
Visit our website

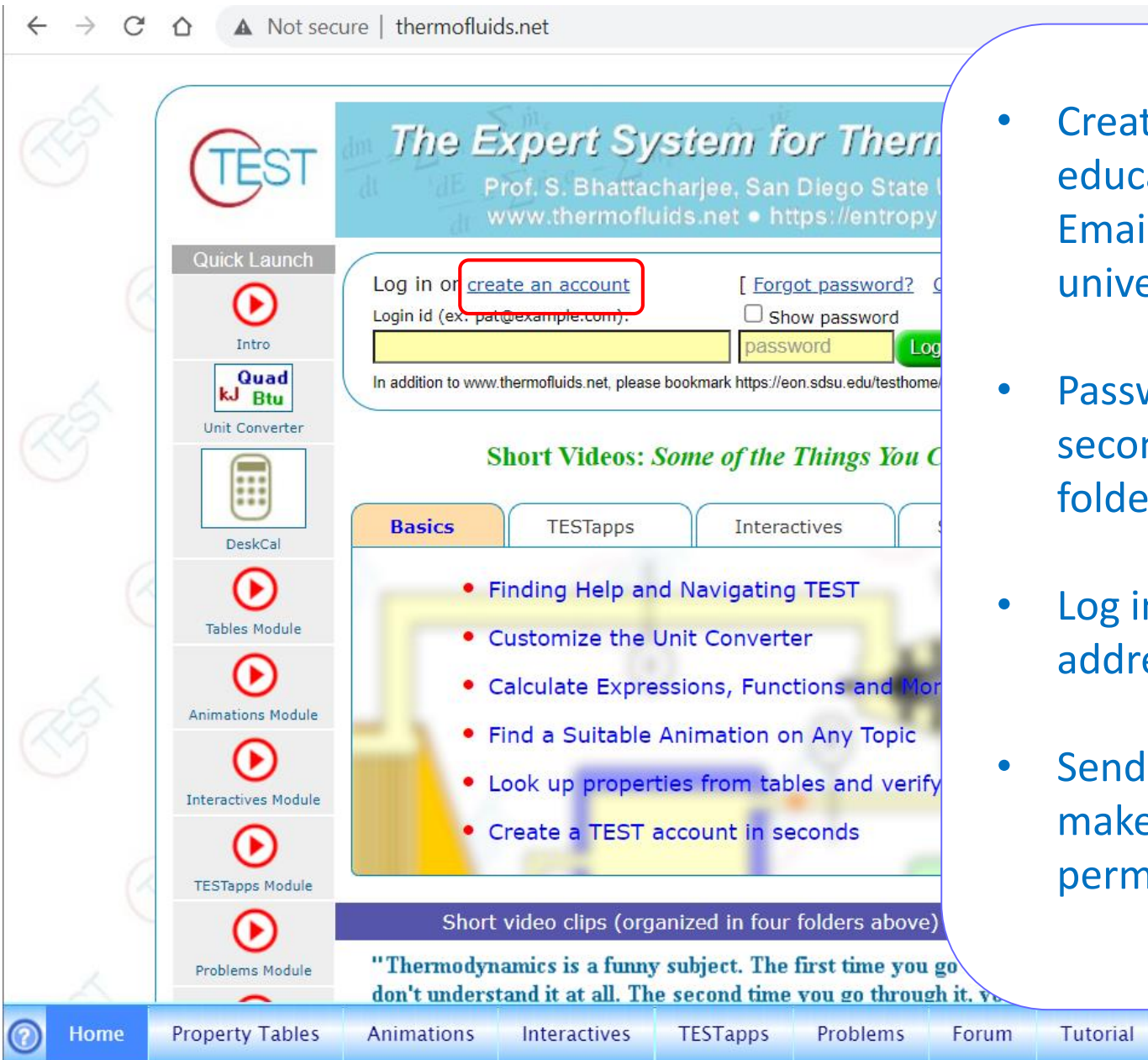
- The Tables, Animations, Interactives, and TESTapps modules are supported.
- Problems are part of Pearson's Mastering Engineering site.



## 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

The screenshot shows the TEST software interface. At the top, the title bar reads "The Expert System for Thermodynamics" with a question mark icon in the top right corner. Below the title bar, the author information is displayed: "Prof. S. Bhattacharjee, San Diego State University" and "www.thermofluids.net • https://entropy.sdsu.edu". A "Professional Mode" badge is visible in the top right. The left sidebar contains a "Quick Launch" section with icons for "Intro", "Unit Converter", "DeskCal", "Tables Module", "Animations Module", "Interactives Module", "TESTapps Module", and "Problems Module". The main content area features a "Short Videos: Some of the Things You Could Do with TEST" section with tabs for "Basics", "TESTapps", "Interactives", and "Solving Problems". A large, rounded rectangular callout box is overlaid on the main content area, containing a bulleted list item: "Simply move the pointer over the help icon on any page for context sensitive help." The bottom navigation bar includes links for "Home", "Property Tables", "Animations", "Interactives", "TESTapps", "Problems", "Forum", "Tutorial", "MyAccount", and "Logout".

- 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

← → ↻ 🏠 ⚠ Not secure | thermofluids.net

Thermodynamic Lookup Tables: *Evaluate Properties Manually and Visually*

Home » Property Tables

Tables A-E		Tables F-K		Hands-On Examples		Discussion of Tables	
Cells on a given row are linked to summary, animation, TESTapp, and tables for a given model. Click on the model name to go to the model page.							
<b>Table-A</b> SL Model	SL Animation	SL TESTapp	Common Sols/Liqs Table A-1	Elements Table A-2	Material properties ( $c_p =$ ...) SL (solid/liquid) model is substance and click Calculations		
<b>Table-B</b> PC Model	PC TESTapp	Steam (H <sub>2</sub> O)	p-Sat H <sub>2</sub> O Table B-1	T-Sat H <sub>2</sub> O Table B-2	super H <sub>2</sub> O Table B-3	compLiq H <sub>2</sub> O Table B-4	
		R-134a (CH <sub>2</sub> FCF <sub>3</sub> )	T-Sat R-134a Table B-6	super R-134a Table B-7	R-22 (CHClF <sub>2</sub> ) Table B-8	T-Sat R-22 Table B-8	
	PC Animation	R-12 (CCl <sub>2</sub> F <sub>2</sub> )	T-Sat R-12 Table B-10	super R-12 Table B-11	Ammonia (NH <sub>3</sub> ) Table B-13	T-Sat NH <sub>3</sub> Table B-13	
		Nitrogen (N <sub>2</sub> )	T-Sat N <sub>2</sub> Table B-14	super N <sub>2</sub> Table B-15	Propane (C <sub>3</sub> H <sub>8</sub> ) Table B-16	T-Sat C <sub>3</sub> H <sub>8</sub> Table B-16	
<b>Table-C</b> PG Model	PG Animation	PG TESTapp	Common Gases Table C-1	Material properties - $c_p$ , $c_v$ , $R$ , $k$ , etc. - using PG state TESTapp, select the working fluid and click Calculations			
			$c_p(T)$ Polynom	$c_p(T)$ Tabular	Polynomial relations and tabular data from the IG TESTapp, select the working fluid and click Calculations. You may also obtain the temperature from the pressure and enthalpy.		

Home **Property Tables** Animations Interactives TESTapps Problems Forum Tutoria

- 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

← → ↻ 🏠 ⚠ Not secure | thermofluids.net

Home » Property Tables

Tables A-E

Tables F-K

Hands-On Examples

Discussion of Tables

Cells on a given row are linked to summary, animation, TESTapp, and tables for a given model. C

PC TESTapp	Steam (H <sub>2</sub> O)	p-Sat H <sub>2</sub> O Table B-1	T-Sat H <sub>2</sub> O Table B-2	super H <sub>2</sub> O Table B-3	compLiq H <sub>2</sub> O Table B-4
	R-134a (CH <sub>2</sub> FCF <sub>3</sub> )	T-Sat R-134a Table B-6	super R-134a Table B-7	R-22 (CHClF <sub>2</sub> ) Table B-8	T-Sat R-22 Table B-8
PC Animation	R-12 (CCl <sub>2</sub> F <sub>2</sub> )	T-Sat R-12 Table B-10	super R-12 Table B-11	Ammonia (NH <sub>3</sub> ) Table B-13	T-Sat NH <sub>3</sub> Table B-13
	Nitrogen (N <sub>2</sub> )	T-Sat N <sub>2</sub> Table B-14	super N <sub>2</sub> Table B-15	Propane (C <sub>3</sub> H <sub>8</sub> ) Table B-16	T-Sat C <sub>3</sub> H <sub>8</sub> Table B-16

Table-B

PC Model

Table B-3, PC Model: *Superheated Vapor Ta*

☒ SI Units

☐ English Units

Superheated Table (PC Model), H<sub>2</sub>O

°C	m <sup>3</sup> /kg	kJ/kg	kJ/kg	kJ/kg-K	m <sup>3</sup> /kg	kJ/kg	kJ/kg	kJ/kg
T	p = 0.01 MPa (T <sub>sat</sub> = 45.81°C)				p = 0.05 MPa (T <sub>sat</sub> = 81.33°C)			
	v	u	h	s	v	u	h	s
Sat	14.674	2437.9	2584.7	8.1502	3.240	2483.9	2645.9	7.593
50	14.869	2443.9	2592.6	8.1749	-	-	-	-
100	17.196	2515.5	2687.5	8.4479	3.418	2511.6	2682.5	7.6947

- 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.

Home Property Tables Animations Interactives TESTapps Problems Forum Tutorial MyAccount



# Property Table Module—Interpolation is no Longer Necessary

PC-Model System-State:

- Material** Intrinsic properties of a substance -  $MM$ ,  $R$ , etc.
- Extrinsic** Properties that depend on observer -  $Vel$ ,  $z$ ,  $e$ , etc.
- Thermodyn**
- Extensive (Total)**

State-1 H2O

PC TESTapp

Table-B PC Model

Steam (H<sub>2</sub>O)

R-134a (CH<sub>2</sub>FCF<sub>3</sub>)

R-12 (CCl<sub>2</sub>F<sub>2</sub>)

R-22 (CHClF<sub>2</sub>)

Ammonia (NH<sub>3</sub>)

$p = 6.0 \text{ MPa}$  ( $T_{\text{sat}} = 275.64^\circ\text{C}$ )

$T$	$v$	$u$	$h$	$s$
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  $p_1$  and  $T_1$  and Calculate  $h_1$  as 3096.62 kJ/kg.



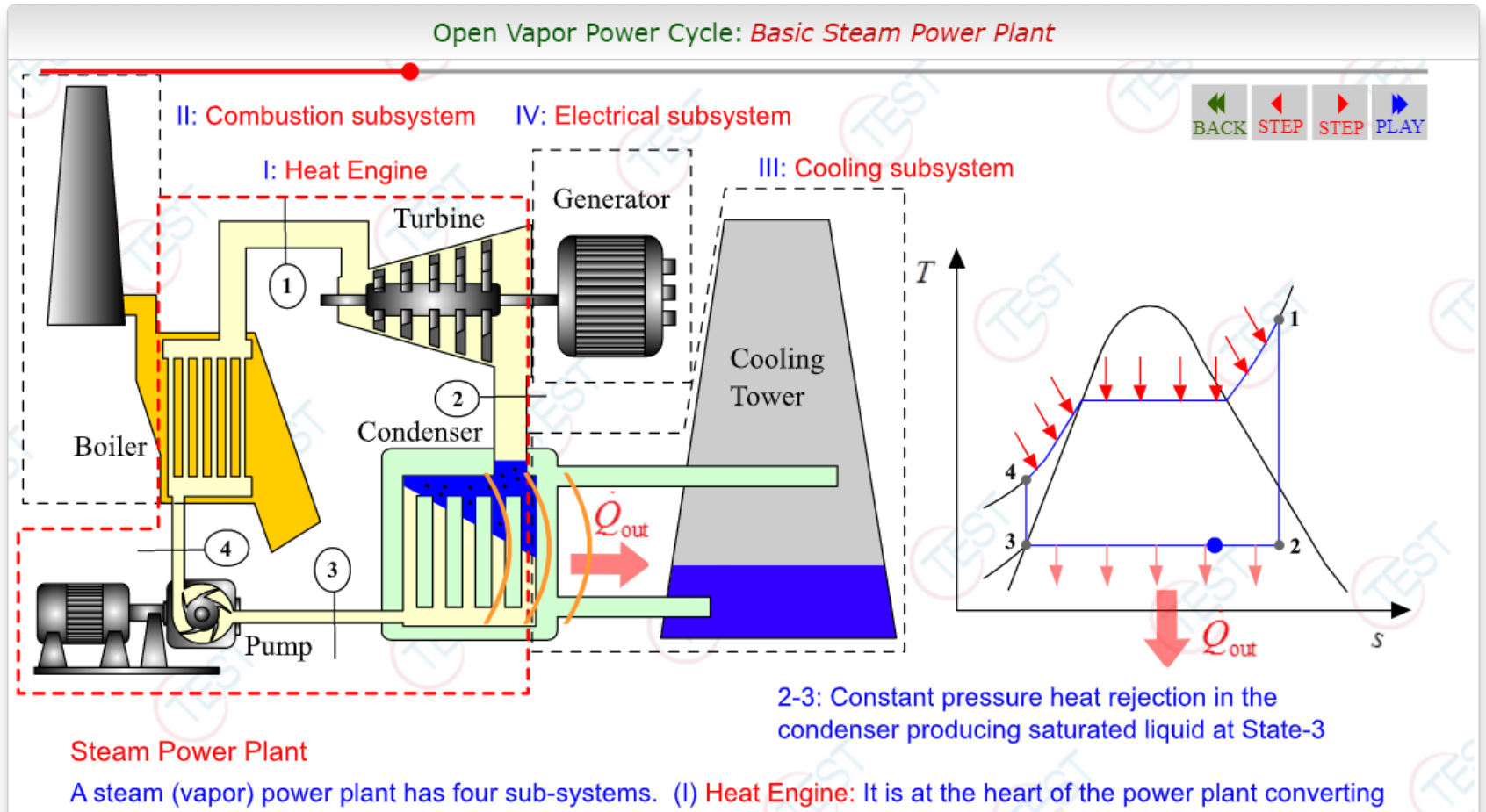
## Animations Module



# Animation Module– 16 Chapters of Animations

Navigation controls: Back, Forward, Search, and other interface elements.

9. Steam Power ▾ A. steamPower ▾ steamPowerPlant ▾ ☐ Alphabetical Order



- 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

PC Interactive (HTML5) Hands-On Examples Discussion of Interactives

HTML 5 based interactives can run on any device with a modern browser without the need for any special plug-in.

Move mouse over any widget (buttons, menu, tabs, etc.) to see helpful tip at the bottom help panel and more precise value at this top help panel.

State Panel Vapor Turbine Panel

Interactives: PC-Model, Vapor Turbine: Vtar, © 2017-2021 S. Bhattacharjee

Calculate Set Default Vary  $p_1$  from 106 kPa to 992.5 kPa and plot:  $\dot{W}_{\text{Ext}}$  with 20 points. Analyze

$\dot{Q}_{\text{dot}}$ , kW: 0.00  $\dot{W}_{\text{dotExt}}$ , kW: 3572.31  $\eta$ , %: 85.0000

Fig. 1. Vapor turbine at steady state.

Baseline Case (Ex. 4-7): An adiabatic steam turbine operates steadily with a mass flow rate of 5 kg/s. The steam enters the turbine at 500 kPa

Home Property Tables Animations Interactives TESTapps Problems Forum Tutorial MyAccount Logout Release Notes

- 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

Turbine

- 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.

### Sixteen Chapters of Multi-Media Problems

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



Home

Property Tables

Animations

Interactives

TESTapps

Problems

Forum

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MyAccount

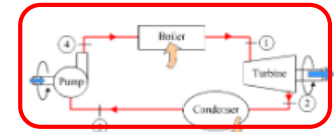



# Problems Module – Problems Linked to Animations

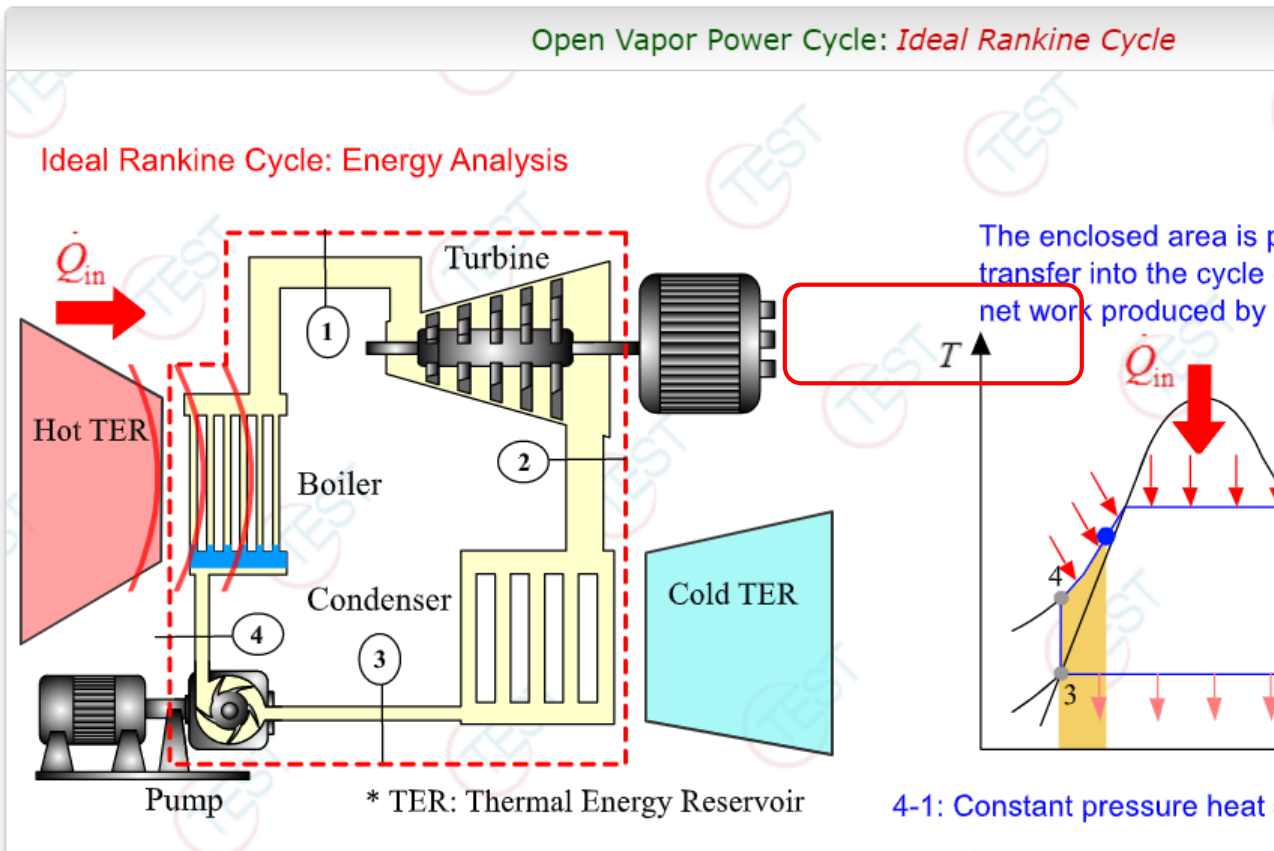


**9-1-5 [OPZ]** A steam power plant operates on the simple ideal Rankine cycle. Steam enters the turbine at 4 MPa, 500°C and is condensed in the condenser at a temperature of 40°C. (a) Show the cycle on a T-s diagram. If the mass flow rate ( $\dot{m}$ ) is 10 kg/s, determine (b) the thermal efficiency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

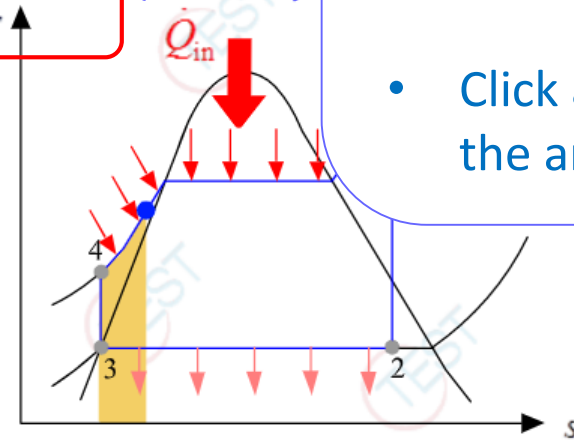
[Solution] [Discuss]



 **Anim. 9-1-5**



The enclosed area is p...  
transfer into the cycle (net work produced by t...)



4-1: Constant pressure heat addition in the boiler.

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

My Solution

Outcome Based Learning

Progress Report

Problem Type:

**Extra-Credit Problem:** Once you solve the preceding key problem (or a problem in this section, solve extra-credit problems to gain mastery of 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 attempts] will be used to calculate your score.

Part	Answer Value	Unit	Weight (%)
(a)	<input type="text"/>	%	50
(b)	<input type="text"/>	MW	50

Grade My Answers

- 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

ANSWERS (d) 47.70, (e) 40.070



**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 ( $\eta_{th}$ ) of the cycle and (c) the net power output ( $\dot{W}_{net}$ ) in MW.



[Solution] [\[X Discuss\]](#)

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



More Action..



Post



Question



Comment

From:

Prof. Subrata Bhattacharjee



Answer

Click here to post a question or comment on this problem. To respond to a comment, 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](#)



## 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 ( $\eta_{th}$ ) of the cycle and (c) the net power output ( $\dot{W}_{net}$ ) in MW.

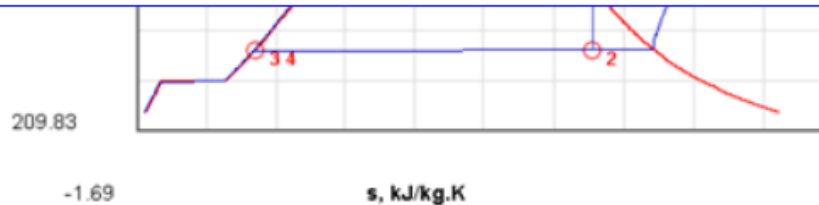
[\[X\] Solution](#) [\[Discuss\]](#)

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  $p_1, T_1$ ):

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

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

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

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

$$x_2 = \frac{s_2 - s_{f@40^\circ\text{C}}}{s_{fg@40^\circ\text{C}}} = \frac{7.0900 - 0.5725}{7.6847} = 0.8481;$$

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







## Problems Module – Generating a Report

### Create Groups and Monitor Progress

Progress Report for Group: me351-s18



Filter by

ALL p

ALL a

ALL T

Data Us

You can  
specify  
over th

- 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

#									
1.	JASMINE	CHENG		306	279	0	0	275.71	
2.	Dylan	Doan		206	180	0	0	174.20	
3.	Matthew	Keegan		214	207	0	0	169.46	
4.	BINH	VU		209	184	0	0	156.59	
5.	Ryan	Butler		177	170	0	0	145.77	
6.	Eli	Tagger		188	173	0	0	145.15	



## 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



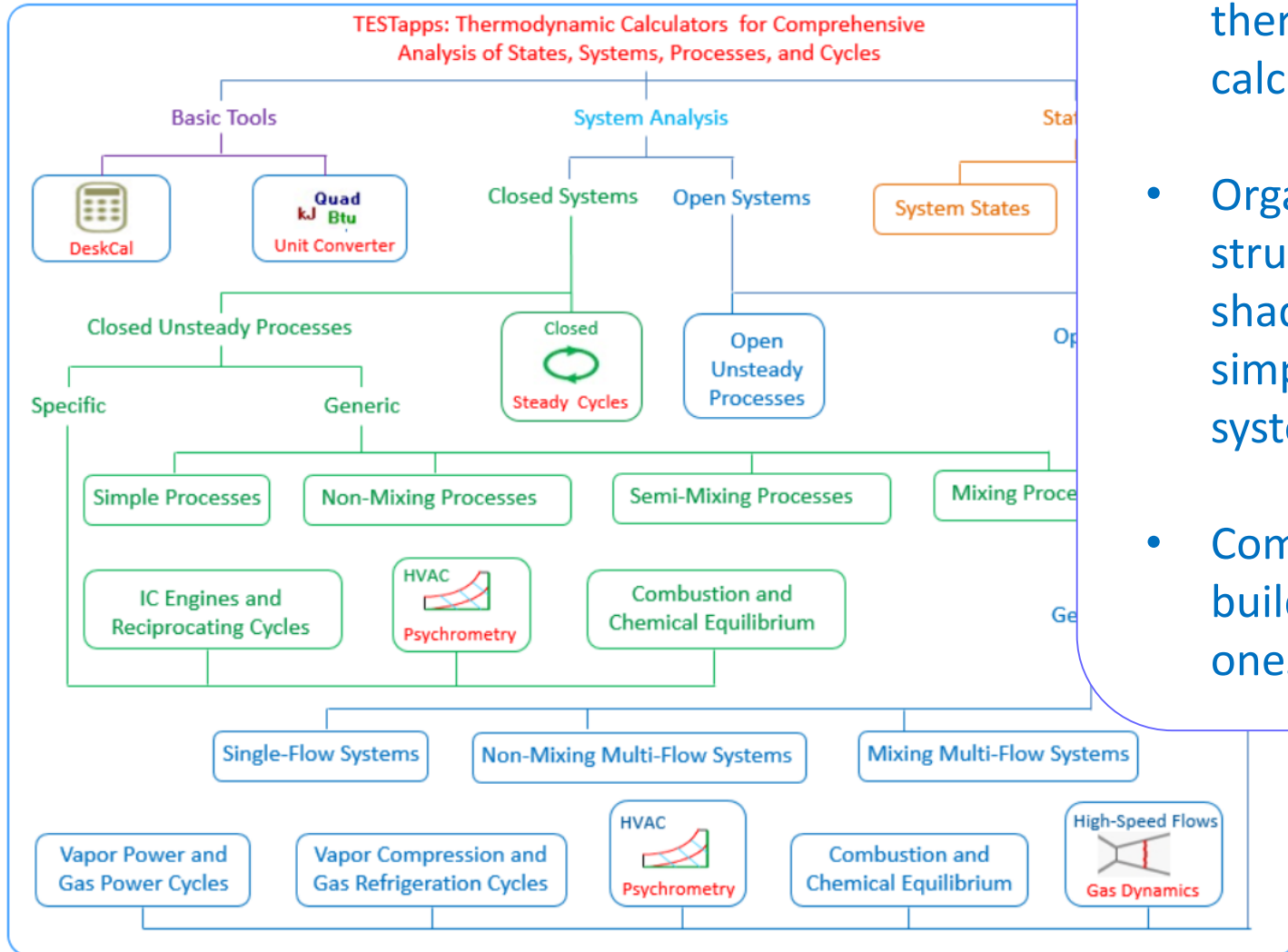
# TESTapp Module– Calculators Organized According to Thermodynamic Assumptions



Not secure | thermofluids.net

TESTapps Map: A Clickable Navigation Map of Thermodynamic Calculators

Home » TESTapps



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

Property Tables

Animations

Interactives

TESTapps

Problems

Forum

Tutorial

MyAccount

Logout

Release



# 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.

The screenshot shows the DeskCal web application interface. The browser address bar indicates the URL is thermofluids.net. The page title is "DeskCal: Programmable Engineering Calculator". The navigation bar includes tabs for "DeskCal", "Hands-On Examples", and "Discussion". The main content area displays the text "TESTapps can run on any device with a modern browser without the need for any special plug-in." and "DeskCal: A simple scientific calculator; V: hr, © 1998-2021 S. Bhattacharjee". Below this, there are buttons for "Calculate" and "Initialize". A red box highlights the user input area, which contains the following code:

```
#---User-codes block begins here-----  
#---find the hypotenuse of a right angled triangle with sides 3m and 4m respectively.  
am=3;  
bm=4;  
cm = sqrt(am^2+bm^2);
```

Below the input area, there is a checkbox labeled "Enter key as Calculate" which is checked, and buttons for "Calculate" and "Initialize". The output area, titled "Interpreting User-Codes entered in the Input Area above...", shows the interpreted code:

```
am = 3 = 3;  
bm = 4 = 4;  
cm = sqrt(am^2+bm^2) = 5;
```

The bottom navigation bar includes links for "Home", "Property Tables", "Animations", "Interactives", "TESTapps", "Problems", "Forum", and "Tutor".



# Another Rudimentary TESTapp – The Engineering Unit Converter

ConverterPlus *Engineering Unit Converter*

Home » TESTapps » Converter Plus

ConverterPlus Hands-On Examples Discussion ?

TESTapps can run on any device with a modern browser without the need for any special plug-in.

ALL FAVORITE FREQUENT 10

Area ▼

Measures Customize ▼

2 = 1.260415

Bigha Kani

sq.chain [G]  
sq.chain [R]  
sq.link [G]  
sq.link [R]  
sq.perch  
sq.pole  
sq.rod  
square  
township  
Kani  
Gonda  
Bigha

township  
Kani  
Gonda  
Bigha  
mile<sup>2</sup>  
acre  
circular mil  
mil<sup>2</sup>  
in<sup>2</sup>  
yd<sup>2</sup>  
ft<sup>2</sup>

Info + Add Measure to FAV

- 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*

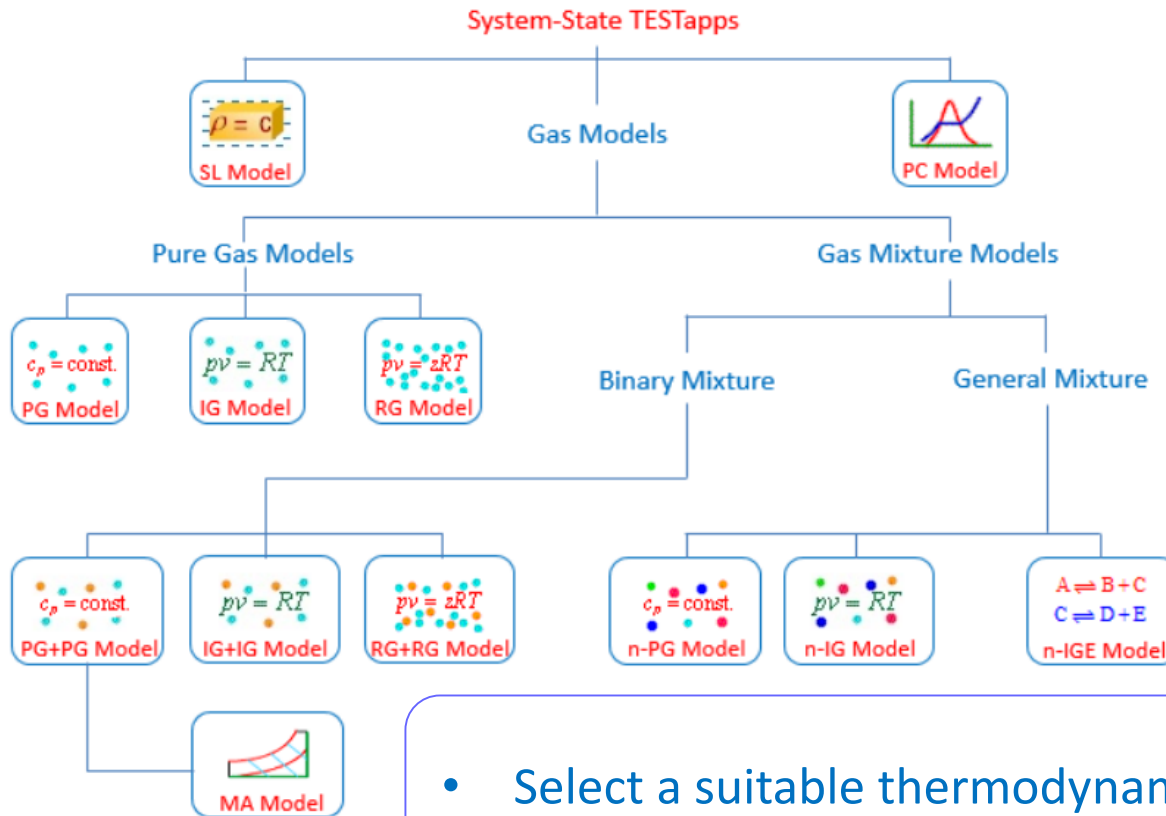
Home » TESTapps » System-State

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



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

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

Home » TESTapps » FlowState » PC Model

PC FlowState TESTapp

Hands-On Examples Discussion Forum ? Unit Converter

TESTapps can run on any device with a modern browser without the need for any special plug-in.

Move mouse over any widget (buttons, menu, tabs, etc.) to see helpful tip at the bottom help panel and more precise value at this top help panel.

☒ Mixed ☐ SI ☐ English ☐ Include Exergy ☐ Hide Explanations **Super-Calculate** **Super-Initialize** © 1998-2021 S. Bhattacharjee

State Panel Graphics Panel I/O Panel ? TESTapp: PC-Model, Flow-State: V: iu

◀ ©State-1 ▶ Calculate Initialize ⊖ ⊕ ? H2O Phase: Superheated Vapor

<input checked="" type="checkbox"/> $p_1$ 4.00000 MPa	<input checked="" type="checkbox"/> $T_1$ 500.000 deg	<input type="checkbox"/> $x_1$ frac	<input type="checkbox"/> $y_1$ frac	<input type="checkbox"/> $v_1$ 0.0864287 m <sup>3</sup> /kg	<input type="checkbox"/> $\rho_1$ 11.5702 kg/r
<input type="checkbox"/> $u_1$ 3099.47 kJ/kg	<input type="checkbox"/> $h_1$ 3445.19 kJ/kg	<input type="checkbox"/> $s_1$ 7.08997 kJ/kg	<input checked="" type="checkbox"/> $Vel_1$ 0.00 m/s	<input checked="" type="checkbox"/> $z_1$ 0.00 m	<input type="checkbox"/> $e_1$ 3099.47 kJ/kg
<input type="checkbox"/> $j_1$ 3445.19 kJ/kg	<input type="checkbox"/> $\dot{m}dot_1$ kg/s	<input type="checkbox"/> $\dot{V}dot_1$ m <sup>3</sup> /s	<input type="checkbox"/> $A_1$ m <sup>2</sup>	<b>MM1</b> 18.0150 kg/mol	

1

H2O

PC-M

- Mat
- Extr

**Help: For context sensitive instructions**  
Keep an eye on this message box for tooltip, message will appear here. Some important m clicking anywhere on this panel.

? Home Property Tables Animations

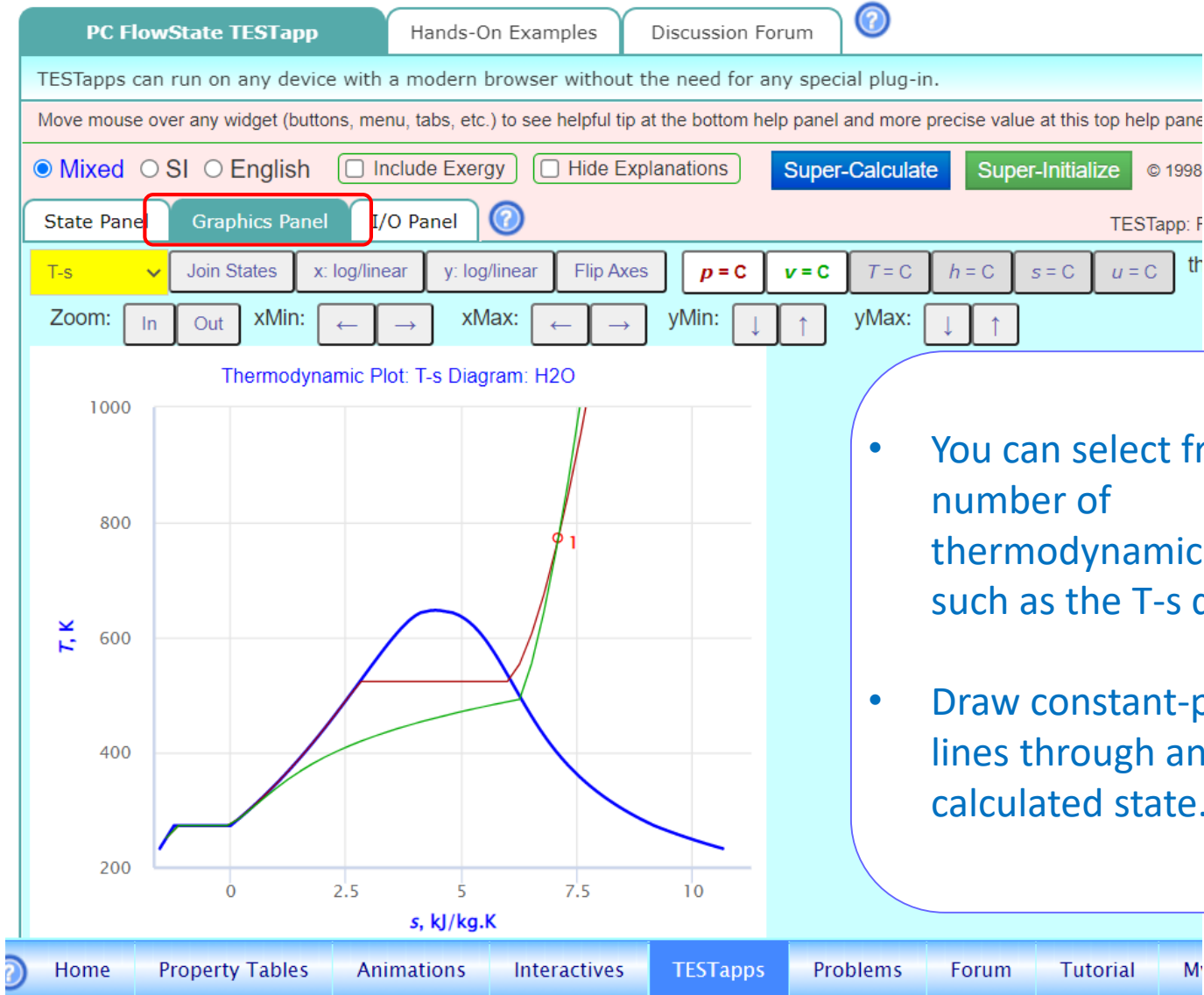
- Given  $p_1=4$  Mpa;  $T_1=500$  deg-C; determine  $h_1$  and  $s_1$ .
- Click the checkbox to enter a property. Checkboxes tests property dependency and does not allow over-specification of a state.
- Click Calculate to evaluate the state.



# TESTapp – Visualize the Calculated States

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

Home » TESTapps » FlowState » PC Model



- 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

**PC FlowState TESTapp** Hands-On Examples Disc

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State Panel Graphics Panel I/O Panel ?

◀ ©State-1 ▶ Calculate Initialize ⊖ ⊕

<input checked="" type="checkbox"/> <b>p1</b> =p1MPa MPa ▾	<input checked="" type="checkbox"/> <b>T1</b> =T1degC deg ▾	<input type="checkbox"/> <b>x1</b> frac
<input type="checkbox"/> <b>u1</b> 3099.47 kJ/k ▾	<input type="checkbox"/> <b>h1</b> 3445.19 kJ/k ▾	<input type="checkbox"/> <b>s1</b> 7.08997 kJ/k
<input type="checkbox"/> <b>j1</b> 3445.19 kJ/k ▾	<input type="checkbox"/> <b>mdot1</b> kg/s ▾	<input type="checkbox"/> <b>Voldot1</b> m <sup>3</sup> /s

**PC FlowState TESTapp** Hands-On Examples

TESTapps can run on any device with a modern browser without t

Move mouse over any widget (buttons, menu, tabs, etc.) to see helpful tip a

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State Panel Graphics Panel I/O Panel ?

Calculate Isolate User-Codes Load Initialize ?

```
#----User-codes block (do not alter this comment line);  
#----given data;|  
p1MPa = 4;  
T1degC = 500;  
#----answer,|  
h1kJpkg = h1;  
s1kJpkgK = s1;
```

☐ Enter key as Calculate Calculate Send Report

Interpreting expression(s) or user-codes entered in the Inp  
p1MPa = 4 = 4;  
T1degC = 500 = 500;  
h1kJpkg = h1 = 3445.18701171875;  
s1kJpkgK = s1 = 7.089969158172607;

- 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

☒ Mixed ☐ SI ☐ English ☐ Include Exergy ☐ Hide Explanations **Super-Calculate** Super-

State Panel Graphics Panel I/O Panel ?

Calculate Isolate User-Codes Load Initialize ?

States {  
State-1: H2O; PC-Model;  
Given: {p1 = "p1MPa" MPa; T1 = "T1degC" deg-C; Vel1 = 0.00 m/s; z1 = 0.00 m; }  
}  
#---User-codes block (do not alter this comment line).;  
#---given data;  
p1MPa = 4;  
T1degC = 500;  
#---answers;  
h1kJpkg = h1;  
s1kJpkgK = s1;

☐ Enter key as Calculate Calculate Send Report To Me and: pat@pat.com

State-1:H2O > PC-Model  
Given: p1 = "p1MPa" MPa; T1 = "T1degC" deg-C; Vel1 = 0.00 m/s; z1 = 0.00 m;  
Calculated: v1 = 0.08643 m^3/kg; rho1 = 11.57 kg/m^3; u1 = 3099 kJ/kg; h1 = 34  
s1 = 7.090 kJ/kg.K; e1 = 3099 kJ/kg; j1 = 3445 kJ/kg; MM1 = 18.02 kg/kmol

#---Detailed Output from user-codes (SI-unit values are used for properties used, if any):  
p1MPa = 4 = 4;  
T1degC = 500 = 500;  
h1kJpkg = h1 = 3445.18701171875;  
s1kJpkgK = s1 = 7.089969158172607;

Home Property Tables Animations Interactives **TESTapps** Problems Forum

- 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

PC SingleFlow TESTapp

Hands-On Examples Discussion Forum

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State Panel Graphics Panel **Device Panel** I/O Panel

◀ ©Device-1 [1-2] ▶ Calculate Initialize

☒  $\dot{Q}_{dot1}$  0.00 kW ☐  $\dot{W}_{dotExt1}$  12.3646 MW ☐  $\dot{S}_{dotGen1}$  0.00 kW ☒ TB1 298.150

Set Up the Open-Steady Device

Home Property Tables Animations Interactives **TESTapps** Problems Forum Tutorial

- 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?

☒ Mixed ☐ SI ☐ English ☐ Include Exergy ☐ Hide Explanations **Super-Calculate** Super-Initialize

State Panel Graphics Panel Device Panel **I/O Panel** ?

**Calculate** Isolate User-Codes **Load** Initialize ?

Given: {Qdot1 = 0.00 kW; TB1 = 298.150 K; }  
}  
  
#---User-codes block (do not alter this comment line).;  
#---given data; Let state-1 be the inlet and 2 the isentropic exit;  
**p1MPa = 4;**  
**T1degC = 600;**  
**T2degC = 40;**  
mdotkgps = 10;  
#---answer;  
powerOutputMW = WdotExt1/1000;

☒ Enter key as Calculate **Calculate** Send Report To Me and: pa

#---Detailed Output from user-codes (SI-unit values are used for properties use  
p1MPa = 4 = 4;  
T1degC = 600 = 600;  
T2degC = 40 = 40;  
mdotkgps = 10 = 10;  
**powerOutputMW = WdotExt1/1000 = 13.78373291015625;**

- 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.

**Help: For context sensitive instructions, click the help (encircled '?') button**

Keep an eye on this message box for tooltips, alert, and error messages. As you hover the pointer over a variable or b



# Vapor Power TESTapp – A Rankine Cycle Based Power Plant Simulation

## 9. Open Vapor Power Cycles



**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 ( $\eta_{th}$ ) of the cycle and (c) the net power output ( $\dot{W}_{net}$ ) in MW.

[\[X\] Solution](#) [\[Discuss\]](#)

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PC PowerCycle TESTapp

[Hands-On Examples](#)

[Discussion Forum](#)



Unit C

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[Super-Calculate](#)

[Super-Initialize](#)

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[State Panel](#)

[Graphics Panel](#)

[Device Panel](#)

[Cycle Panel](#)

[I/O Panel](#)



TESTapp: PC-Model, Open-Power

◀ ©Cycle-1 ▶

[Calculate](#)

[Initialize](#)



Cycle Type:

Power-Cycle

Cycle Status:

Complete

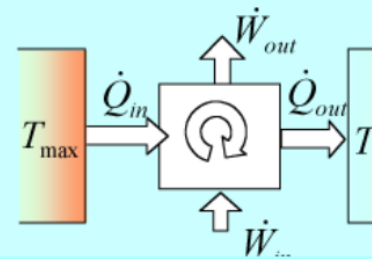
$\dot{Q}_{dotIn1}$	$\dot{Q}_{dotOut1}$	$\dot{Q}_{dotNet1}$	$\dot{W}_{dotIn1}$	$\dot{W}_{dotOut1}$	$\dot{W}_{dotNet1}$
32736.0 kW	20411.6 kW	12324.4 kW	40.1633 kW	12364.6 kW	12324.4 kW
$BWR1$	$\eta_{th1}$	$T_{Max1}$	$T_{Min1}$	$p_{Max1}$	$p_{Min1}$
0.324825 %	37.6479 %	773.150 K	313.148 K	4000.00 kPa	7.37993 kPa
$\eta_{Carnot1}$	$\dot{S}_{dotGenNet1}$				
59.4971 %	-41.3363 kW/				

Power-Cycle Equations:

$$\dot{Q}_{in} = \sum_{k=1}^n \max(\dot{Q}_k, 0); \quad \dot{Q}_{out} = -\sum_{k=1}^n \min(\dot{Q}_k, 0); \quad \dot{Q}_{net} = \dot{Q}_{in} - \dot{Q}_{out};$$

$$\dot{W}_{out} = \sum_{k=1}^n \max(\dot{W}_{ext,k}, 0); \quad \dot{W}_{in} = -\sum_{k=1}^n \min(\dot{W}_{ext,k}, 0); \quad \dot{W}_{net} = \dot{W}_{out} - \dot{W}_{in};$$

$$BWR = \frac{\dot{W}_{out}}{\dot{W}_{net}}; \quad \eta_{th} = \frac{\dot{W}_{net}}{\dot{Q}_{in}}; \quad \eta_{th} = 1 - \frac{T_{min}}{T_{max}}; \quad \dot{S}_{gen} = \sum \dot{S}_{gen}; \quad \therefore$$



- 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?

**PC PowerCycle TESTapp** Hands-On Examples Discussion Forum

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☒ Mixed ☐ SI ☐ English ☐ Include Exergy ☐ Hide Explanations **Super-Calculate** Super-Initialize © 1998-2021 S. Bh

State Panel Graphics Panel Device Panel Cycle Panel I/O Panel

Calculate Isolate User-Codes Load Initialize

```
#---given data; Let state-1 be the inlet and 2 the isentropic exit;
p1MPa = 4;
T1degC = 600;
T2degC = 40;
mdotkgps = 10;
#---answers;
efficiencyPct = etaTh1;
powerOutputMW = WdotExt1/1000;
```

☒ Enter key as Calculate Calculate Send Report To Me and: pat@pat.com

```
#---Detailed Output from user-codes (SI-unit values are used for properties used, if any):
p1MPa = 4 = 4;
T1degC = 600 = 600;
T2degC = 40 = 40;
mdotkgps = 10 = 10;
efficiencyPct = etaTh1 = 39.235597970468255;
powerOutputMW = WdotExt1/1000 = 13.78373291015625;
```

Home Property Tables Animations Interactives **TESTapps** Problems Forum

- 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.

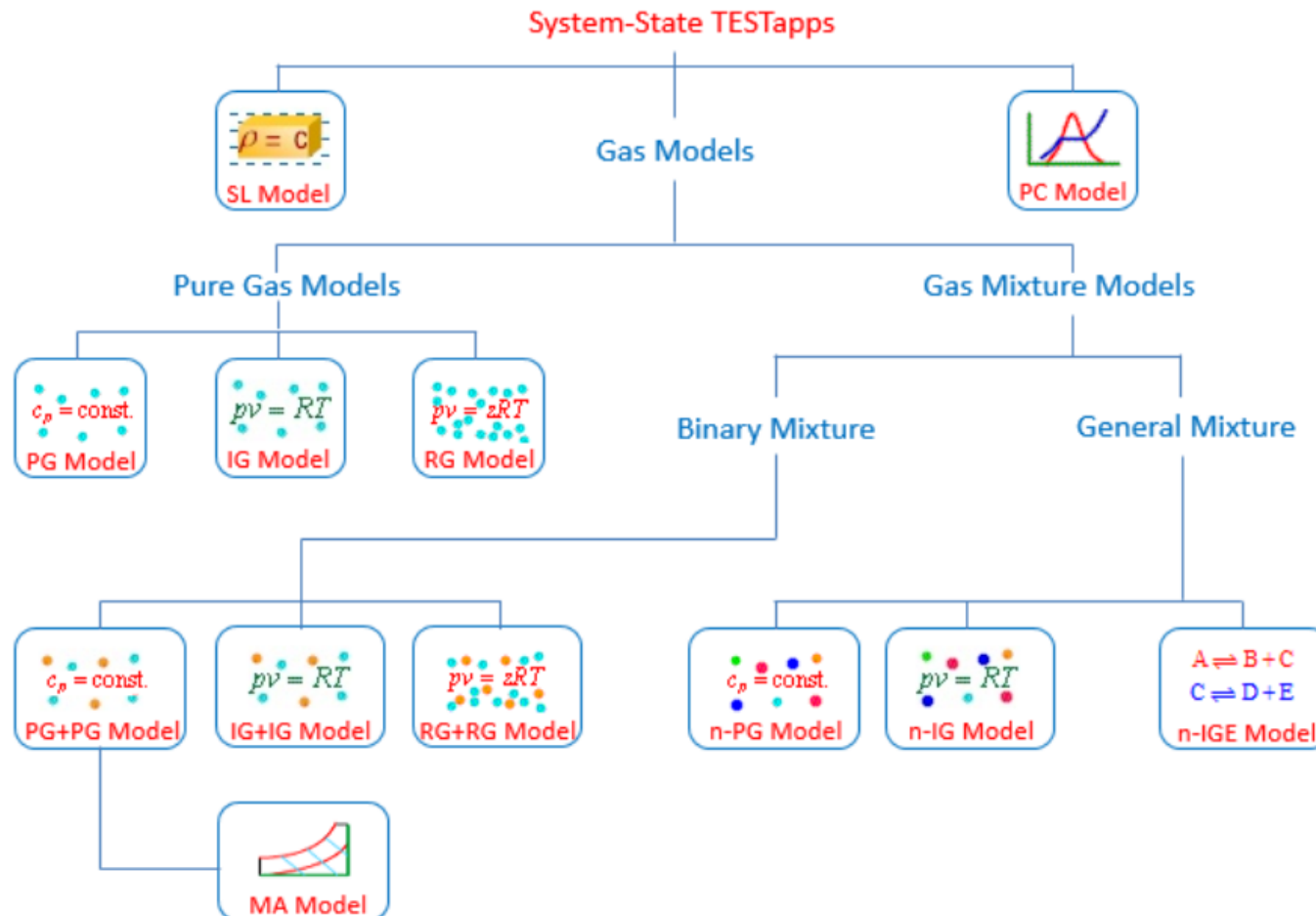


There is an App for Every Thermodynamic Problem



# 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

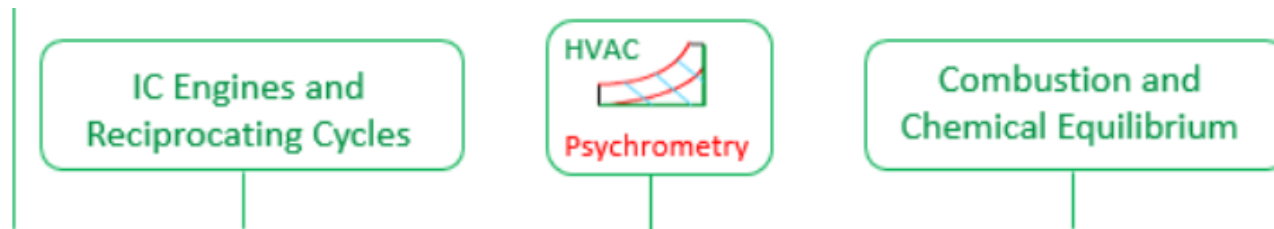
- The Simple Process is when the beginning state and the final state can be represented by just two unique states.
- Non-Mixing Process may involve more than one beginning or final state without the subsystems mixing.
- Semi-Mixing Process may involve more than one beginning or final state without the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

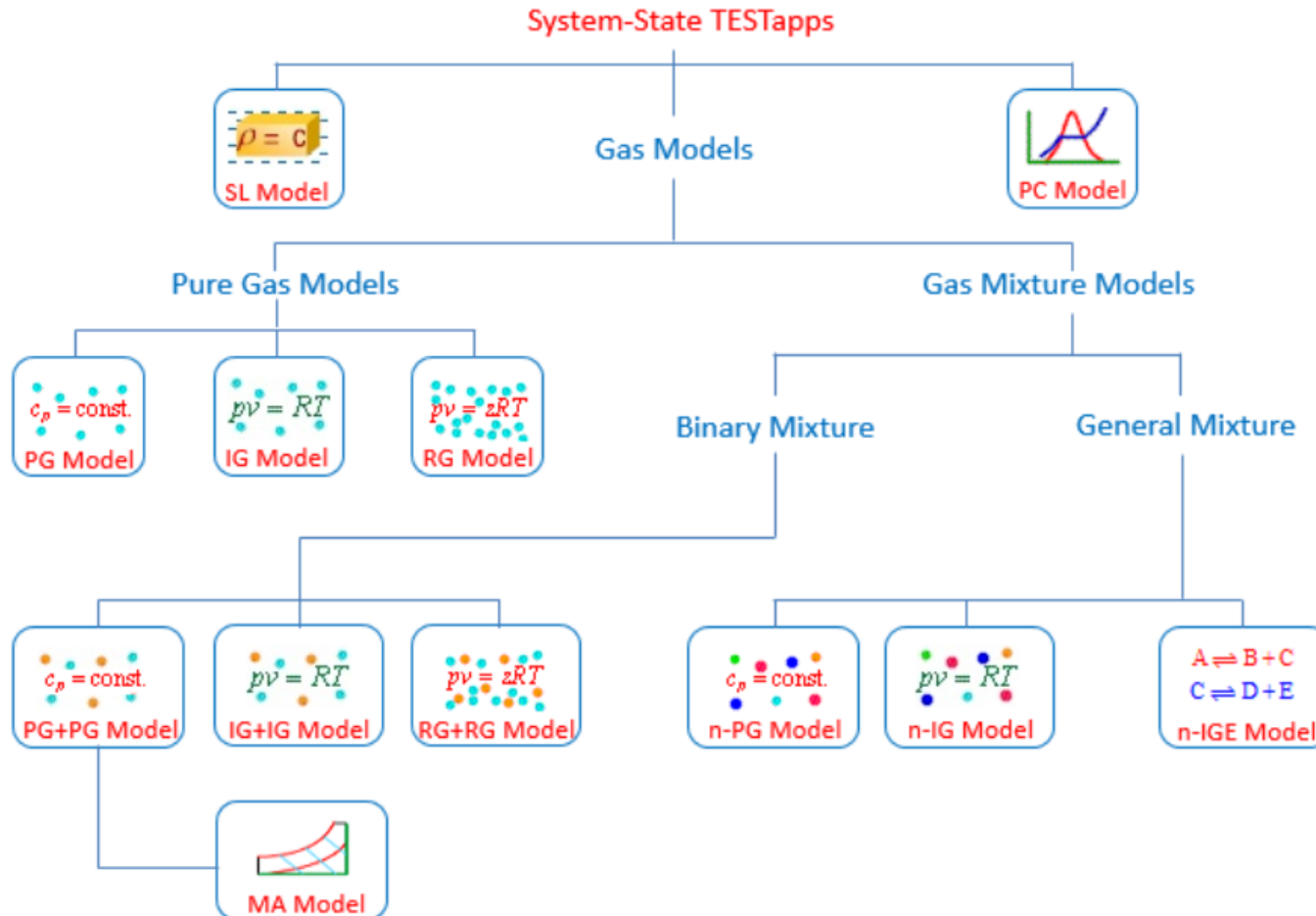
- The reciprocating engine cycles (Otto, Diesel) apps cover SI and CI engines.
- Moist air undergoing a closed process is analyzed by the closed HVAC app.
- The combustion and chemical equilibrium apps in this branch deals with combustion in a closed system.





# Flow State TESTapps – Many Thermodynamic Models

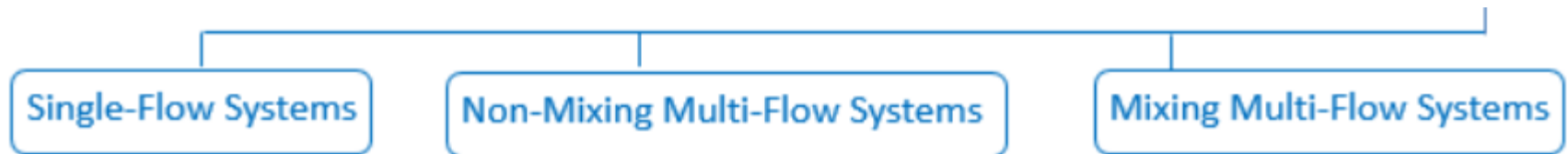
- Based on the working substance, select an appropriate model to launch the flow state TESTapp..





## Open-Steady Device TESTapps – Built Upon Flow State TESTapps

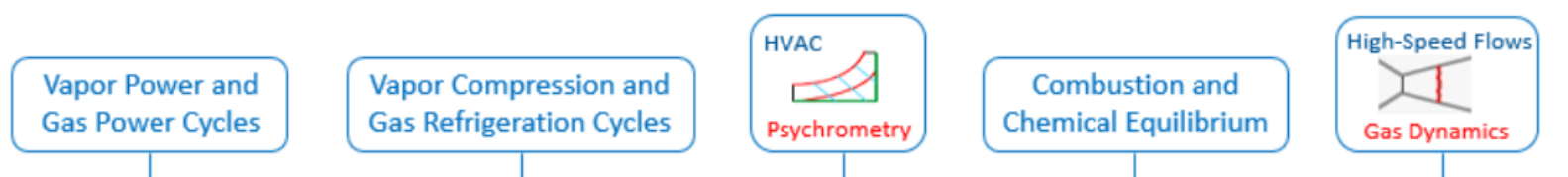
- The Single-Flow Systems have only one flow flowing through the system at steady state. Examples: turbine, pump, nozzle, compressor, etc.
- Non-Mixing Multi-Flow Systems have at least two flows which are not mixing. Example: A closed-type heat exchanger.
- Mixing Multi-Flow Systems have at least two 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".