



B.S. & M.S. Marine Environment and Engineering (1998 & 2000)

Ph.D. Civil, Architectural, & Environmental Engineering, majored in ocean engineering (2008)



Oregon State
University



B.S. Mechanical Engineering, minor in German (2009)

M.S. Mechanical Engineering, minor in Ocean Engineering (2011)

Course Agenda

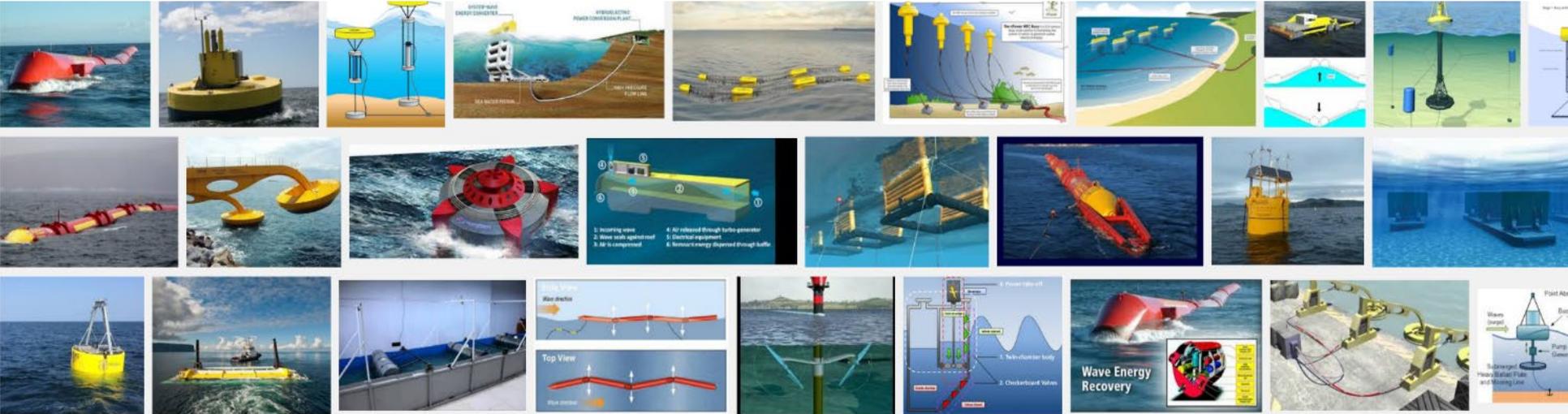
Session	Duration	Topic	Description
Lecture 1: WEC-Sim Theory and Workflow	0:20	WEC-Sim Overview	Overview of course topics and WEC-Sim code
	0:20	Theory & Workflow	Cummins' equation and WEC-Sim workflow (BEM->BEMIO->WEC-Sim) Description of what happens when you execute WEC-Sim (wecSim.m)
	0:50	Code Structure Overview	Overview of WEC-Sim's input file (wecSimInputFile.m), classes (*.m) and library blocks (*.slx)
Lecture 2: WEC-Sim Classes and Debugging	0:30	Wave Class	Describe how waves are modeled in WEC-Sim using waveClass.m and variant subsystems
	0:30	Body Class	Describe how bodies are modeled in WEC-Sim using bodyClass.m and variant subsystems
	0:30	Debugging/Homework Q&A	Discuss common errors with WEC-Sim: incorrect setup, path, and BEM data, coordinate systems and data at cg.
Lecture 3: WEC-Sim Features	0:15	Multiple Conditions Run	Show how to use wecSimMCR for RM3
	0:15	Mooring	demonstrate the WEC-Sim Applications for Mooring, https://github.com/WEC-Sim/WEC-Sim_Applications/tree/master/Mooring
	0:15	Boundary Element Method Input/Output (BEMIO)	Run BEMIO using statespace, and changing other flags for RM3
	0:15	GitHub	Overview of how to use GitHub for version control and collaborative development.
	0:15	WEC-Sim Applications	Review of relevant WEC-Sim applications cases
	0:15	Homework Q&A	

- Basic WEC-Sim theory and workflow
- How to modify the code if needed
 - Detailed code structure
 - Deep dive into different classes
- How to debug the code
- How to use WEC-Sim for different applications



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WEC-Sim Overview

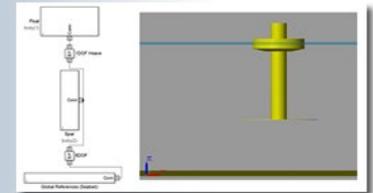
Yi-Hsiang Yu (NREL)

WEC-Sim (Wave Energy Converter Simulator)

- Simulates wave energy converter dynamics
- Time-domain equation of motion solver based on Cummins' formulation
- Open source code developed in MATLAB/SIMULINK
- Joint NREL/Sandia project funded by the US Department of Energy
- First Release: v1.0 in June 2014
- Current Release: v4.2 in Dec 2020



WEC-Sim
Wave Energy Converter
SIMulator



License:

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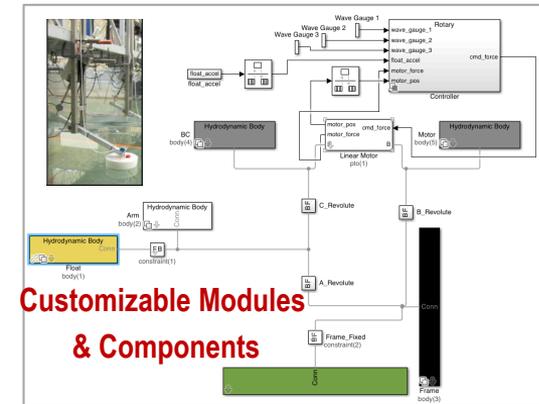
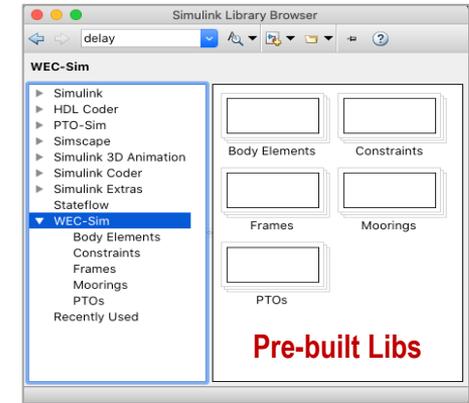
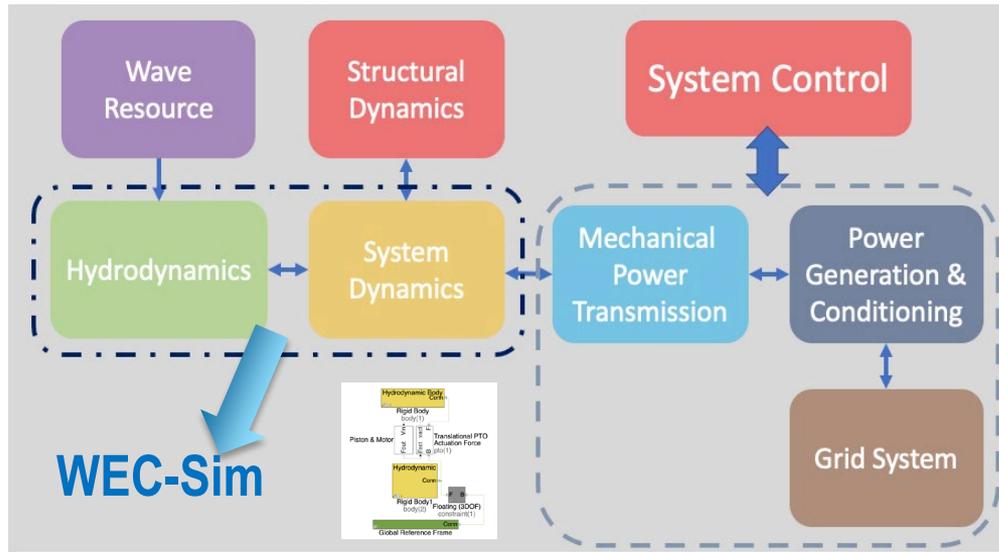
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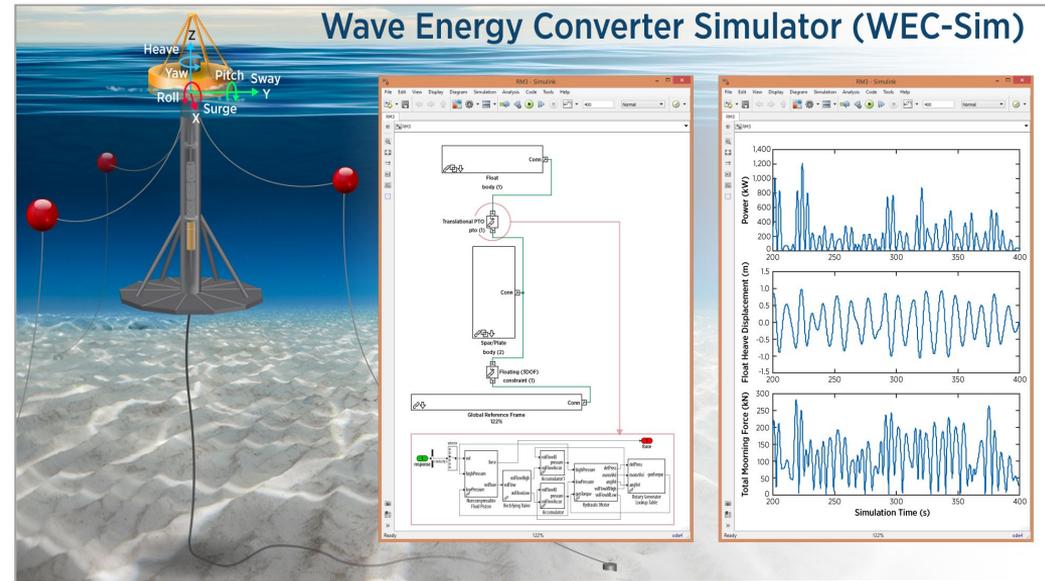
Why use WEC-Sim?

- Provide hydrodynamic representation of the WEC that consists of multiple bodies (pre-built libs)
- Allows user specific modules for system control and other applications



Why use WEC-Sim?

- WEC-Sim has the ability to model the dynamics of devices that are comprised of rigid/flexible bodies, power-take-off (PTO) systems, and mooring systems.
- WEC-Sim uses hydrodynamic coefficients derived from frequency-domain boundary element (BEM) simulations to model the relevant hydrodynamics.
- Time-domain simulations are performed by solving the governing WEC equations of motion in 6 degrees-of-freedom.



- Dynamics simulated by solving time-domain equation of motion (Cummins, 1962)

$$m\ddot{x}(t) = \boxed{f_{hs}(t)} + \boxed{f_{ex}(t)} + \boxed{f_{rad}(t)} + \boxed{f_v(t)} + \boxed{f_{pto}(t)} + \boxed{f_m(t)}$$

Hydrostatic restoring force
 Wave excitation & diffraction force (from BEM simulations)
 Radiation force: added mass and radiation damping (from BEM simulations)
 Viscous force
 Power take-off force
 Mooring force

- Use radiation and diffraction method and calculate the hydrodynamic forces from frequency-domain Boundary Element Method (BEM)

$$f_{rad}(t) = \underbrace{-A_\infty}_{\text{BEM}} \ddot{x} - \int_0^t \underbrace{K(t-\tau)}_{\text{BEM}} \dot{X}(\tau) d\tau$$

$$f_{ex}(t) = \Re \left[\underbrace{R_f F_X(\omega_r)}_{\text{BEM}} e^{i(\omega_r t + \phi)} \int_0^\infty \sqrt{2S(\omega_r)} d\omega_r \right]$$

$$= \int_{-\infty}^\infty \eta(\tau) \underbrace{f_e(t-\tau)}_{\text{BEM}} d\tau$$

- CAD (Computer-aided design), e.g., Rhinoceros, SolidWorks, ANSYS, etc.
- BEM (Boundary Element Method), e.g., WAMIT, NEMOH, AQWA
- WEC-Sim (Wave Energy Converter Simulator)
 - <http://wec-sim.github.io/WEC-Sim/>
 - Requires MATLAB, Simulink, Simscape, and Simscape Multibody
 - Full functionality has been verified on 2019b through 2020a.



Required Toolbox	Oldest Compatible Version
MATLAB	Version 9.7 (R2019b)
Simulink	Version 10.0 (R2019b)
Simscape	Version 4.7 (R2019b)
Simscape Multibody	Version 7.0 (R2019b)

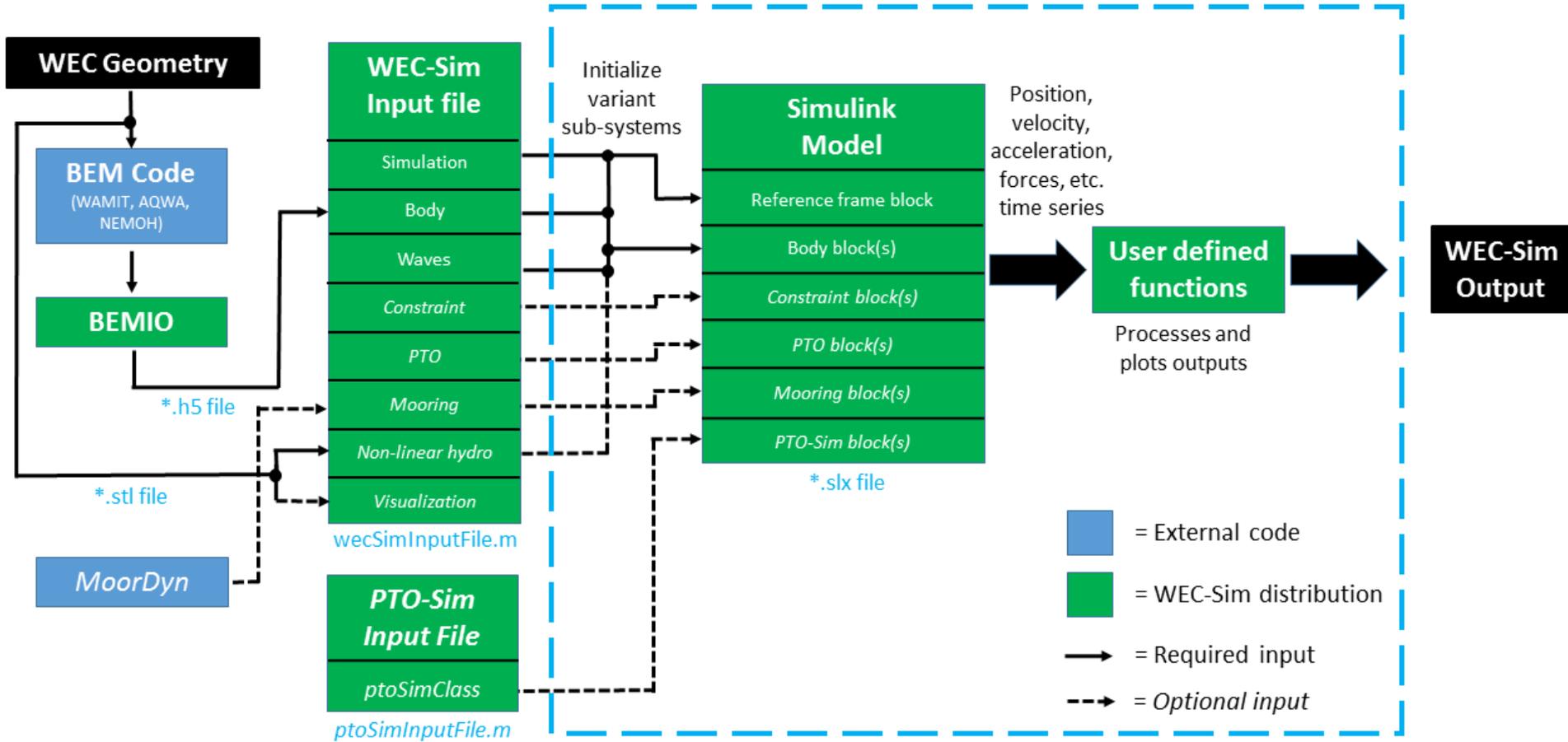
- ParaView (Optional)
 - <http://www.paraview.org/>
 - Optional, for additional visualization and analysis capabilities
 - BSD License,
<https://www.paraview.org/paraview-license/>
- MoorDyn (Optional)
 - <https://github.com/WEC-Sim/moorDyn>
 - Optional, for additional mooring simulation features
 - GNU General Public License v3.0



MOORDYN

wecSim.m

Reads input file, runs Simulink model, calls user-defined functions for output processing



<https://github.com/WEC-Sim>

The screenshot shows the GitHub repository page for WEC-Sim. The page header includes the repository name 'WEC-Sim' and a subtitle 'Wave Energy Converter Simulator'. Below the header, there are navigation tabs for 'Repositories 7', 'Packages', 'People 8', 'Teams 4', 'Projects', and 'Settings'. A search bar is present with the text 'Find a repository...'. The main content area displays a list of repositories:

- WEC-Sim**: Wave Energy Converter Simulator (WEC-Sim). Language: Matlab. 18 stars, 32 forks. Updated 5 days ago.
- WEC-Sim_Applications**: Applications of the WEC-Sim code. Language: Matlab. 1 star. Updated 5 days ago. A 'Past year of activity' badge is visible.
- WDRT**: WEC Design Response Toolbox (WDRT). Language: Python. 1 star, 2 forks. Updated 20 days ago.
- moorDyn**: Updated on Jun 8.
- bemio**: Boundary Element Method I/O (bemio). Language: Python. 4 stars, 11 forks. Updated on Jun 7.

Blue dashed boxes and arrows highlight the 'WEC-Sim', 'WEC-Sim_Applications', and 'moorDyn' repositories, pointing them to their respective descriptions on the right side of the slide.

WEC-Sim Source Code

Additional Applications

Compiled MoorDyn Library

To use MoorDyn in WEC-Sim,

1. Please Download MoorDyn from the repo <https://github.com/WEC-Sim/moorDyn>
2. Place all the files and folders under WEC-Sim/source/functions/moorDyn folder

<http://wec-sim.github.io/WEC-Sim/>

WEC-Sim
v4.2

Search docs

Getting Started
Overview
Theory
Code Structure
Tutorials
Advanced Features
Webinars
License
Acknowledgements
Publications
Release Notes
WEC-Sim API
Terminology

Other Versions v: master

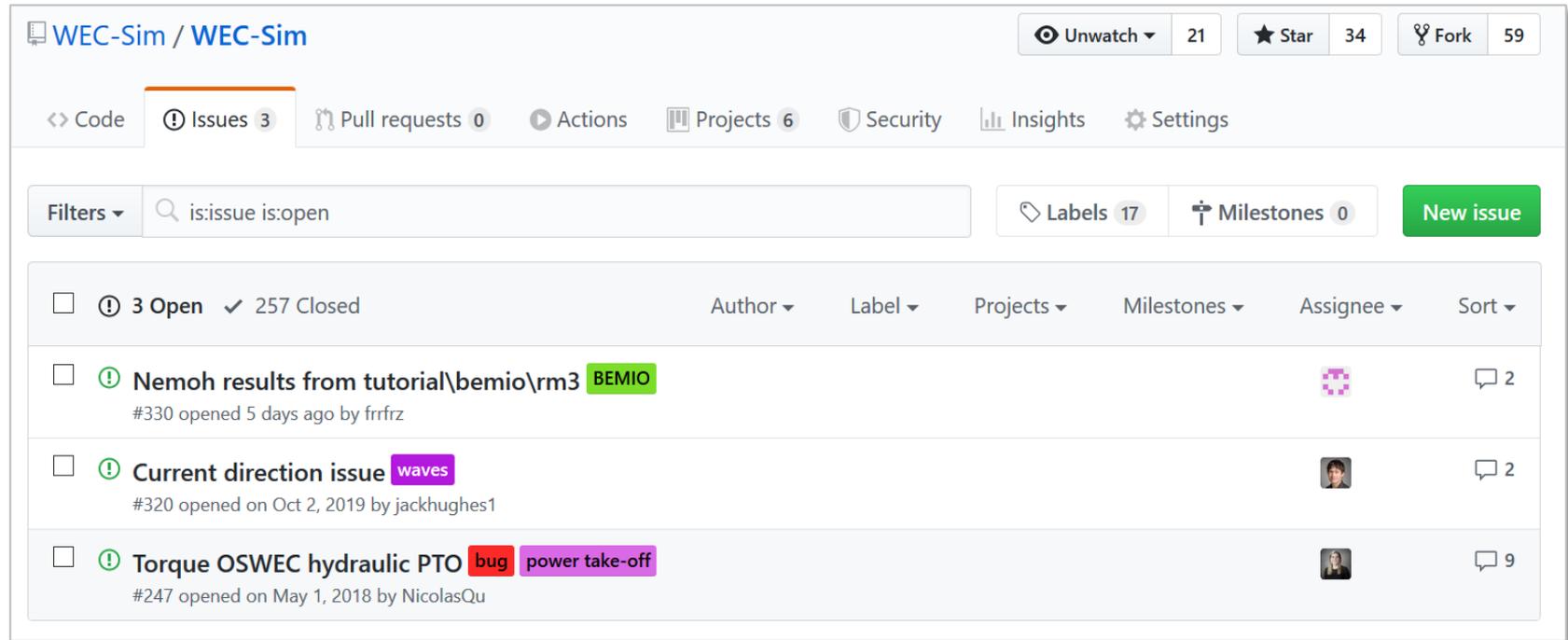
» WEC-Sim (Wave Energy Converter SIMulator) [View page source](#)

WEC-Sim Wave Energy Converter SIMulator

WEC-Sim (Wave Energy Converter SIMulator)

WEC-Sim (Wave Energy Converter SIMulator) is an open-source code for simulating wave energy converters. The code is developed in MATLAB/SIMULINK using the multi-body dynamics solver Simscape Multibody. WEC-Sim has the ability to model devices that are comprised of bodies, joints, power take-off systems, and mooring systems. WEC-Sim can model both rigid bodies and flexible bodies with generalized body modes. Simulations are performed in the time-domain by solving the governing wave energy converter equations of motion in the 6 Cartesian degrees-of-freedom, plus any number of user-defined modes. The [WEC-Sim Applications repository](#) contains a wide variety of scenarios that WEC-Sim can be used to model, including desalination, mooring dynamics,

<https://github.com/WEC-Sim/WEC-Sim/issues>



WEC-Sim / WEC-Sim

Unwatch 21 Star 34 Fork 59

<> Code Issues 3 Pull requests 0 Actions Projects 6 Security Insights Settings

Filters is:issue is:open Labels 17 Milestones 0 New issue

3 Open 257 Closed Author Label Projects Milestones Assignee Sort

- Nemoh results from tutorial\bemio\rm3** BEMIO 2
#330 opened 5 days ago by frrfrz
- Current direction issue** waves 2
#320 opened on Oct 2, 2019 by jackhughes1
- Torque OSWEC hydraulic PTO** bug power take-off 9
#247 opened on May 1, 2018 by NicolasQu

Thank you!

Webinar slides and recordings available online:
<http://wec-sim.github.io/WEC-Sim/master/man/webinars.html>



Webinars

The WEC-Sim team hosted a WEC-Sim Online Training Course, and a series of Advanced Features Webinars. Recordings of each are available below, along with the presentation slides.

Online Training Course

The WEC-Sim team hosted a WEC-Sim Online Training course on August 17, 2017. Recordings of each of the course topics are available below, along with the presentation slides.

WEC-Sim Overview

The WEC-Sim Overview presentation is available for download here ([📄 WEC-Sim Overview Slides](#)), and the recording is available below.



Theory & Workflow

The WEC-Sim Theory & Workflow presentation is available for download here ([📄 Theory & Workflow Slides](#)), and the recording is available below.