

Construction Operation Simulation

Lecture #7

Introduction to DES Software

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Outline

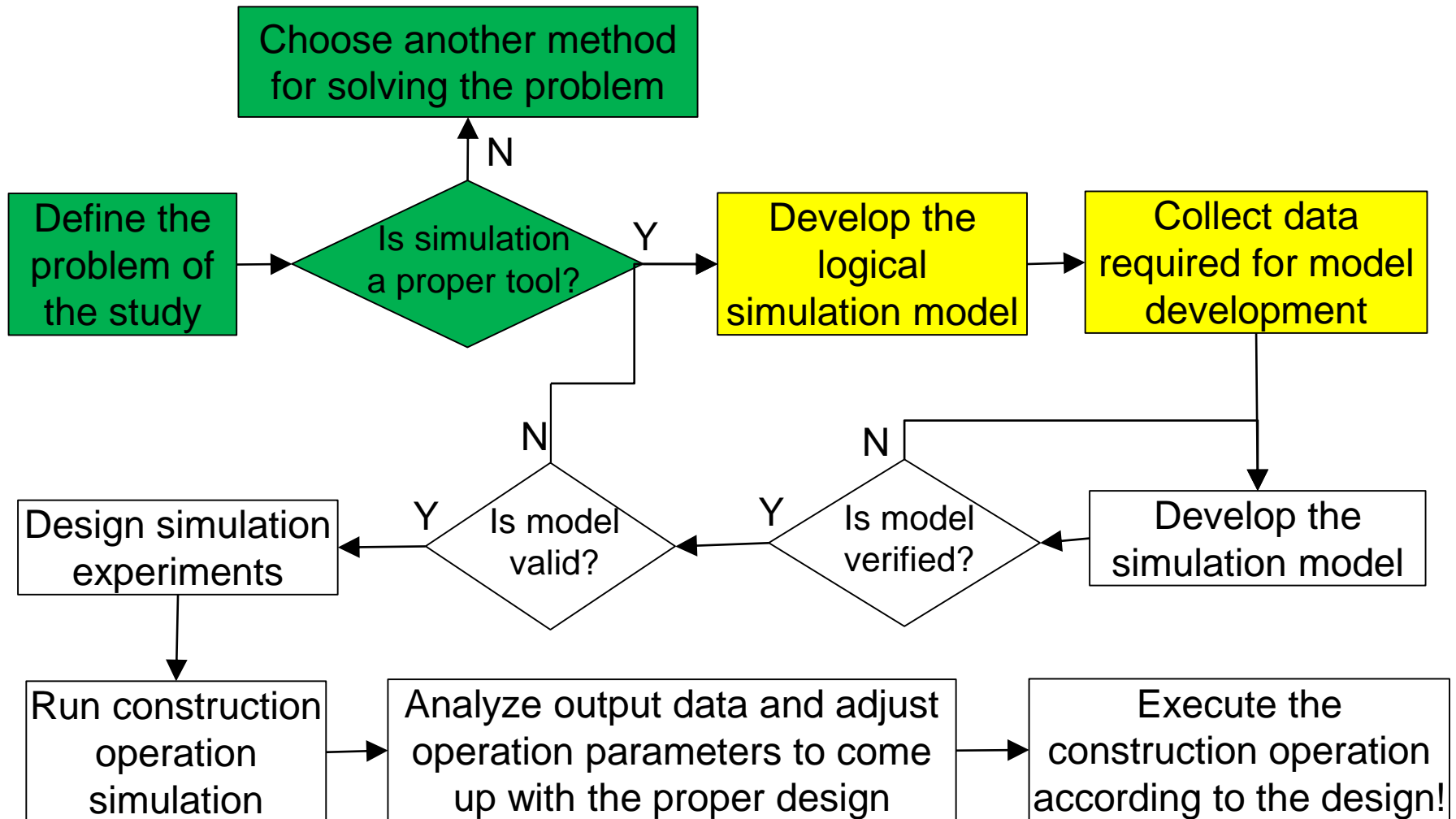
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- Introduction
- AnyLogic Modeling Environment
- Basic DES Elements in AnyLogic
- First Models in AnyLogic

Introduction

Main steps in simulation studies

4



Major DES Simulation Packages

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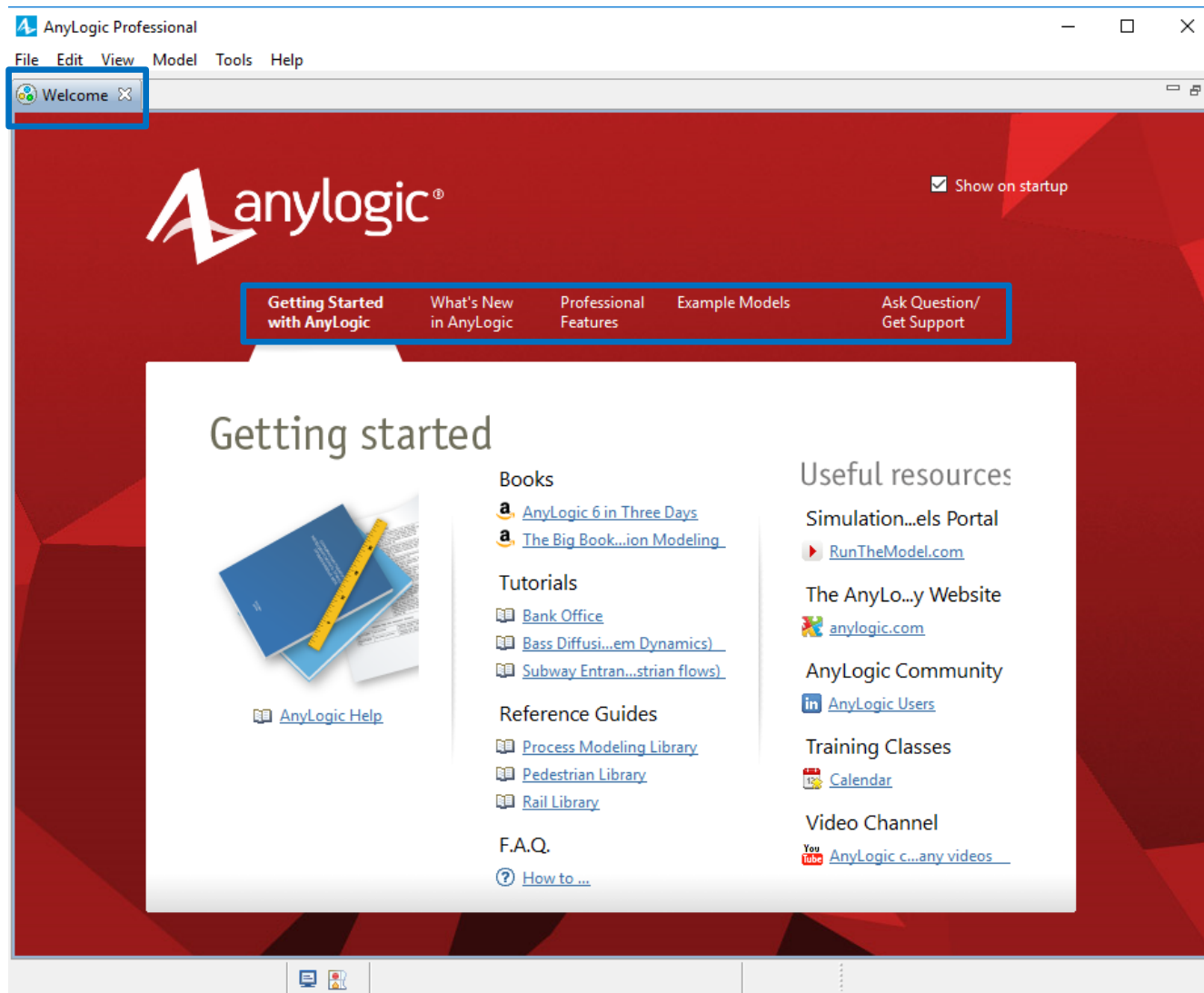
- Some famous DES software can be listed as in below (listed based on Alexa traffic-rank for websites in April 2017):
 - AnyLogic (www.AnyLogic.com)
 - Arena (www.arenasimulation.com)
 - FlexSim (www.flexsim.com)
 - Promodel (www.promodel.com)
 - Simul8 (www.simul8.com)
 - Lanner(www.lanner.com)
 - ExtendSim (www.extendsim.com)
- A more comprehensive list of commercial and open source simulation software is presented at: en.wikipedia.org/wiki/List_of_discrete_event_simulation_software
- In this course we are going to introduce AnyLogic which is one of the most famous commercial DES software developed in World.
- You can use following website for comparing different software capabilities:

<http://www.capterra.com/simulation-software/>

AnyLogic Modeling Environment

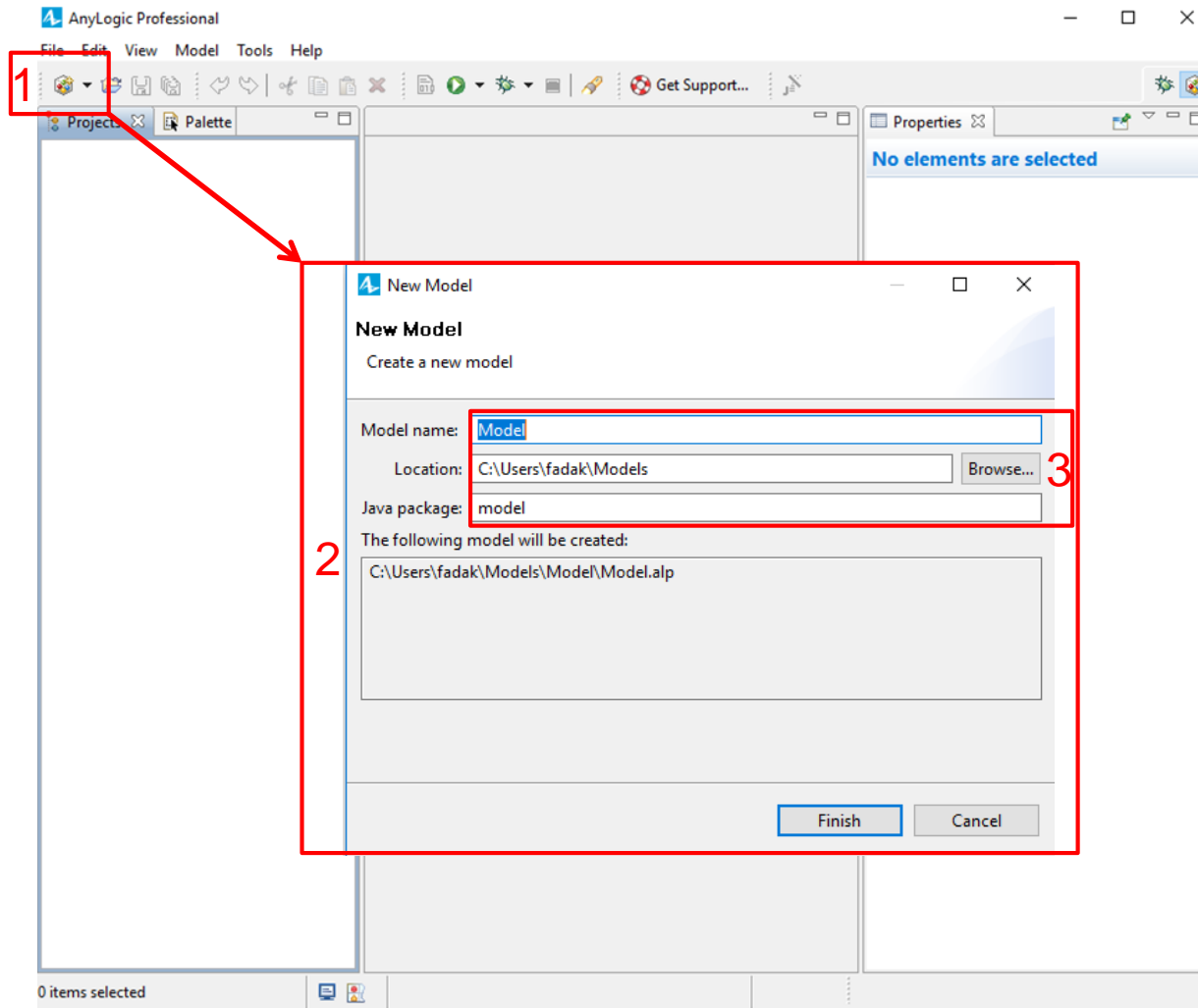
Start Working with AnyLogic

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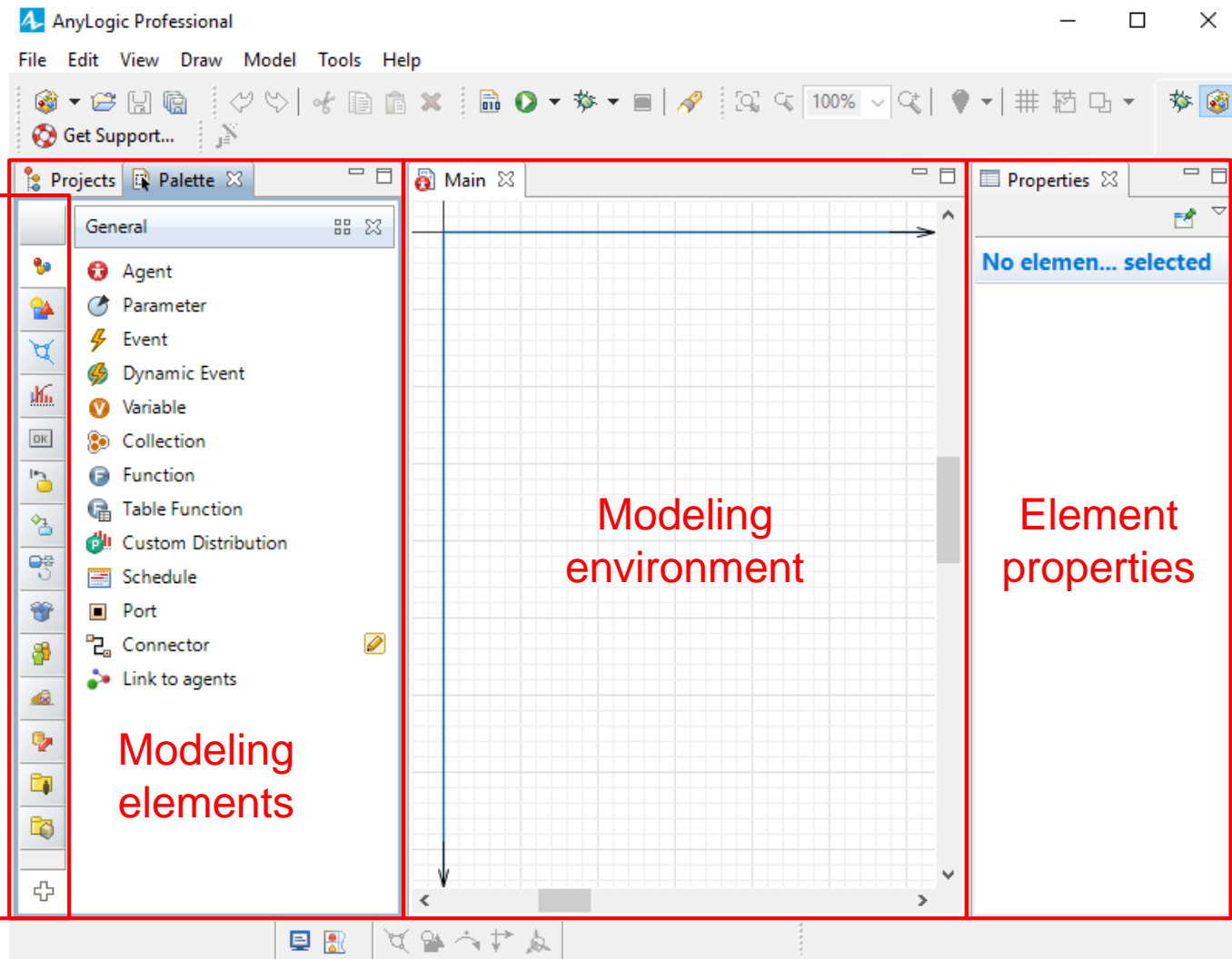
Start Working with AnyLogic

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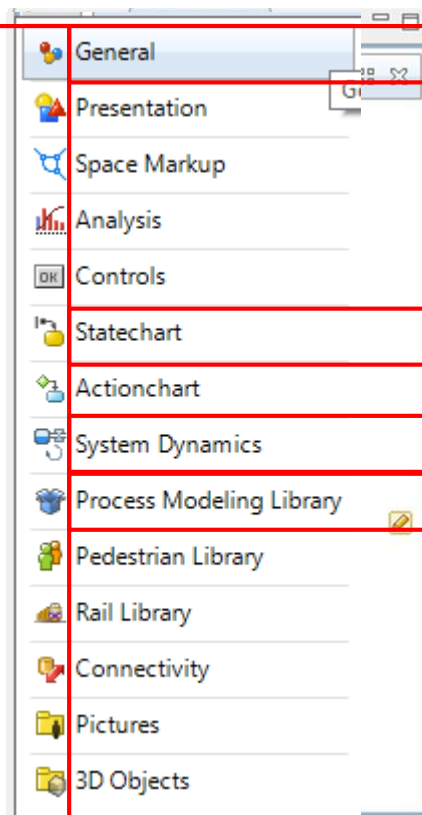
Working Environment

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Working Environment

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Modeling
element
categories

General Elements

Agent Based Sim. Elements

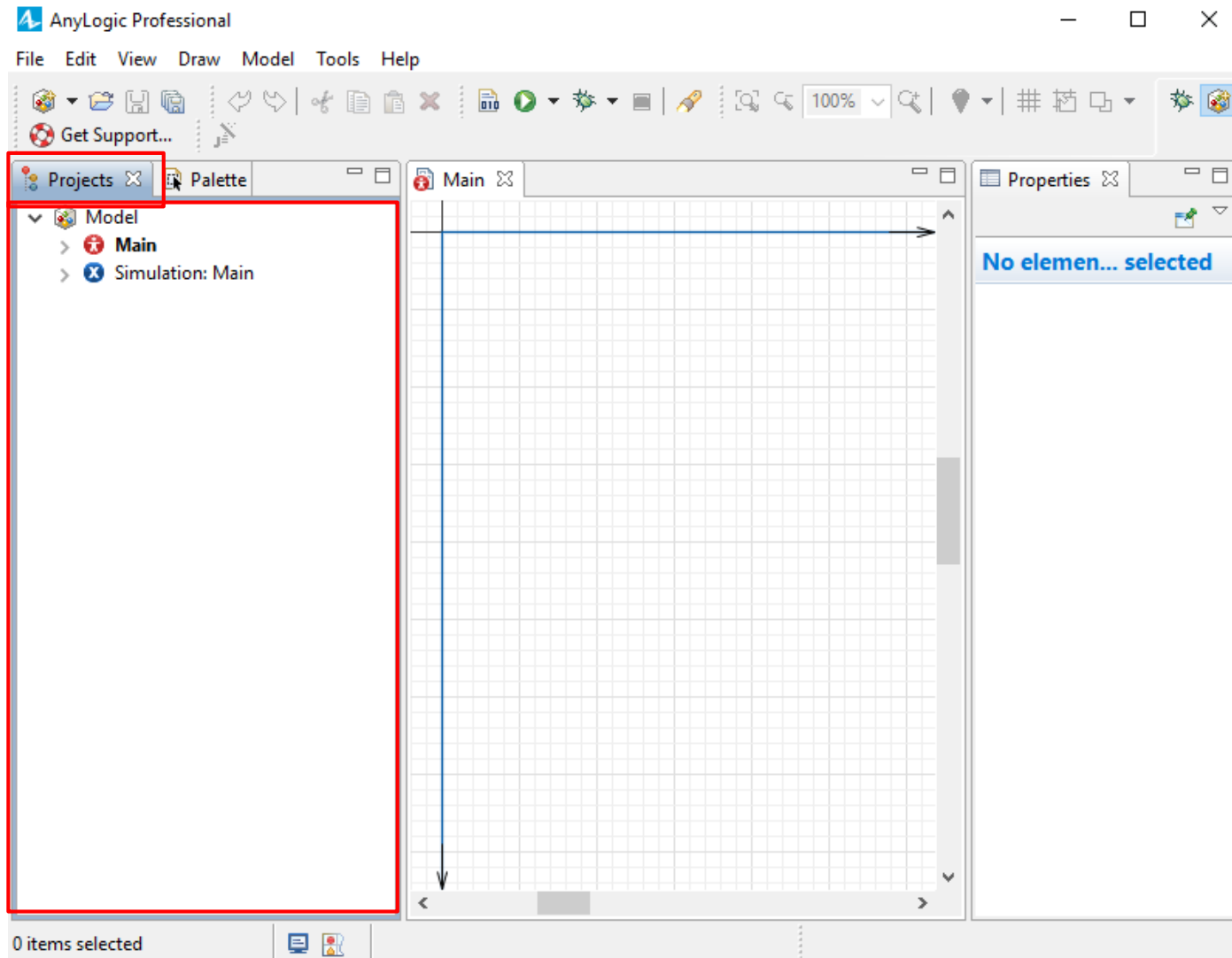
SD Elements

DES Elements

Working Environment

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Explore
project
models and
sub-models




Basic DES Elements in AnyLogic

DES Elements

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- With DES software you can quickly develop simulation models much quicker than directly coding the model by using prepared modeling elements.

 What kind of simulation model elements can we expect from DES software?

DES Elements

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- We can expect following modeling elements in any DES software:
 - Entity generator
 - Resource element
 - Activity or task element
 - Entity destroy (for the entities exit the system; this element is technically important for removing non-usable entities from the computer memory)
 - Conditional branch (when entities are directed to different routes according to different conditions, e.g. for inspection stations)
 - Merge or consolidate entities element (when several entities, usually representing different system components originated from different sources are joined and form a new entity, e.g., after loading a truck with asphalt in asphalt plant or after hocking a crane to a steel element in steel construction)
 - Split or divide entity element (when an entity is split in several components and each component continues its route in a different way, e.g., after dumping asphalt from a truck in paving operation or after un-hocking a steel element from a crane in steel construction)

 By learning one DES software other DES software can be more quickly learned!

Source Element

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- Source element introduces (generates) entities to the model!

The screenshot shows the 'Process Modeling Library' on the left and the 'Properties' panel for the 'source - Source' element on the right. A red arrow points from the 'Source' element in the library to the 'Main' workspace. Red boxes highlight specific settings in the Properties panel, each with a red text annotation.

Process Modeling Library:

- Entity Type
- Resource Type
- Blocks
 - Source** (highlighted with a red box)
 - Sink
 - Delay
 - Queue
 - Select Output
 - Select Output5
 - Hold
 - Match
 - Split
 - Combine
 - Assembler
 - Resource Pool
 - Seize
 - Release
 - Service
 - Resource Task Start
 - Resource Task End
 - Resource Task

Properties - source - Source:

- Name: ☒ Show name ☐ Ignore (Set a relevant name)
- Entity type: Agent
- Arrivals defined by: (Entity arrival rate: 1 per time unit)
- Arrival rate:
- Multiple entities per arrival: ☐ (Multiple entities may arrive)
- Limited number of arrivals: ☐ (Limited number can arrive)
- New entity: (to create a custom type, drag it from the palette)
- Location of arrival:
- Advanced**
 - Custom time of start: ☐ (Arrival can be set from a specific time)
 - Add entities to: ☒ default population ☐ custom population
 - Forced pushing: ☒
- Actions**
 - On before arrival:
 - On at exit:
 - On exit:
- Advanced**
 - ☒ Single agent ☐ Population of agents
 - Model/library: Process Modeling Library ([change...](#))
 - Visible: ☒ yes
 - ☐ Visible on upper level

Source Element

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- Source element introduces (generates) entities to the model!

Properties

source - Source

Name: ☒ Show name ☐ Ignore

Entity type:

Arrivals defined by:

Interarrival time:

Multiple entities per arrival:

Limited number of arrivals:

Rate: entity arrival per time unit

Interarrival: time between two entity arrival

Rate schedule: reads the rate from a scheduled table

Arrival schedule: reads interarrival from a table

Calls of inject function: entity arrives based on conditions set in the model using inject function

Source Element

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- Set of predefined probability distribution functions are available in AnyLogic.
- By typing first letters of the function and pushing Ctrl+Space you can get access to them!

Properties

source - Source

Name: ☒ Show name ☐ Ignore

Entity type:

Arrivals defined by:

Interarrival time:

Interarrival time:

Multiple entities per arrival: ☐

Limited number of arrivals: ☐

New entity:

☐ Agent

(to create)

Location of arrival:

☐ Not specified

Advanced

Custom time of start:

☐

nor

- normal(...) : double - Utilities
- normal(...) : double - Utilities
- NORTH : CellDirection - AgentConstants
- NORTHEAST : CellDirection - AgentConstants
- NORTHWEST : CellDirection - AgentConstants
- NormalDataCollector - com.sun.corba.se.impl.orb
- NormalizedStringAdapter - javax.xml.bind.annotation.adapter
- Normalizer - java.text
- Normalizer - sun.text
- NormalizerBase - sun.text.normalizer
- NormalizerImpl - sun.text.normalizer

Please Enter or double-click to see options...

Resource Element

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- Service element represents Activities in a construction operation

The screenshot displays the 'Process Modeling Library' on the left and the 'Properties' panel for a 'resourcePool - ResourcePool' element on the right. The 'Resource Pool' element is highlighted in the library. The 'Properties' panel shows various configuration options for the resource pool, with red boxes and annotations highlighting specific fields.

Properties Panel:

- Name:** resourcePool (Annotated: Set a relevant name)
- Unit type:** Agent
- Resource type:** Moving (Annotated: Type of resource-animation use)
- Capacity defined:** Directly
- Capacity:** 1 (Annotated: Maximum available resources)
- New resource unit:** Agent (to create a custom type, drag it from the palette)
- Speed:** 10
- Home location (nodes):** (Empty field with icons)
- Shifts, breaks, failures, maintenance...**
 - 'End of shift' priority: 100
 - 'End of shift' preemption policy: No preemption
 - 'End of shift' may preempt: ☒
 - Breaks: ☐
 - Failures / repairs: ☐
 - Maintenance: ☐
 - Custom tasks: ☐
- Advanced**
 - Add units to: ☒ default population

Service Element

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- Service element represents Activities in a construction operation

The screenshot displays the configuration interface for a Service Element. On the left, the 'Process Modeling Library' pane shows various blocks, with 'Service' highlighted. The main workspace shows a diagram with a 'service' element. The 'Properties' pane on the right is titled 'service - Service' and contains the following settings:

- Name:** service (with a red box around the text field and the label 'Set a relevant name')
- Entity type:** Agent
- Seize:** (alternative) resource sets (with a red box around the radio button and the label 'Add resources used')
- Resource sets (alternatives):** (empty list with a red box around the 'Add list' button and the label 'Maximum size of Q')
- Queue capacity:** 100 (with a red box around the text field and the label 'Duration')
- Maximum queue capacity:** (empty text field)
- Delay time:** triangular(0.5, 1, 1.5) (with a red box around the text field and the label 'Duration')
- Send seized resources:** (empty checkbox)
- Entity location (queue):** (empty dropdown menu)
- Entity location (delay):** (empty dropdown menu)
- Priorities / preemption:**
 - Task priority:** 0
 - Task may preempt:** (checked checkbox)
 - Task preemption policy:** No preemption
- Advanced:**
 - Customize resource choice:** (empty checkbox)
 - Queue: exit on timeout:** (empty checkbox)
 - Queue: enable preemption:** (empty checkbox)

Sink Element

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- Sink element is used for open loop systems; it destroys entities when they leave the system.

The screenshot displays the 'Process Modeling Library' interface. On the left, the 'Blocks' category is expanded, and the 'Sink' element is highlighted with a red rectangle. In the center, a diagram shows a 'sink' element (a square with an 'X') connected to a preceding element. On the right, the 'Properties' panel for the 'sink - Sink' element is shown. A red rectangle highlights the 'Name' field, which contains the text 'sink', and the 'Show name' checkbox, which is checked. To the right of this rectangle, the text 'Set a relevant name' is written in red. Below the 'Name' field, the 'Entity type' is set to 'Agent'. The 'Actions' section shows 'On enter' with a list icon. The 'Advanced' section has 'Single agent' selected, 'Model/library' set to 'Process Modeling Library', 'Visible' set to 'yes', and a 'Show presentation' button. The 'Description' section is empty.

Process Modeling Library

Entity Type

Resource Type

Blocks

Source

Sink

Delay

Queue

Select Output

Select Output5

Hold

Match

Split

Combine

Assembler

Resource Pool

Seize

Release

Service

Resource Task Start

Resource Task End

Resource Task

Properties

sink - Sink

Name: sink ☒ Show name ☐ Ignore **Set a relevant name**

Entity type: Agent

Actions

On enter: [List Icon]

Advanced

☒ Single agent ☐ Population of agents

Model/library: Process Modeling Library [\(change...\)](#)

Visible: ☒ yes

☐ Visible on upper level

Show presentation

Description

First Models in AnyLogic

Modeling steps

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- Steps required for developing a simulation models using DES software:
 - 1) Recognize model elements (Entity, resource, activity)
 - 2) Determine initial condition
 - 3) Setup the simulation environment
 - 4) Start developing the model logic within the software
 - 5) Run the model

Single Queue - Example 1

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- **Example 1:** *Single queue example:* Suppose an asphalt plant with a single asphalt loading station. Asphalt hauling trucks from different paving project arrive to the asphalt plant randomly during the day (from 7am to 5pm). Time between truck arrival time has an exponential distribution with the average of 15 minutes. If loading station is idle, truck directly goes to the loading station and asphalt loading gets started. Loading duration has a normal distribution with the average of 10 minutes and standard deviation of 2 minutes. If loading station is busy, truck stays in the line and waits until its turn. We are going to use AnyLogic to develop the simulation model of this operation.



Single Queue - Example 1

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1- Recognize model elements (Entity, resource, activity):

Entity: Truck

Resource: Asphalt plant

Activity:

- Time between truck arrival: $\exp(\lambda=4 \text{ per hour or } 1/15 \text{ per minute})$
- Loading: $N(,10 \text{ minutes}, 2 \text{ minutes})$

Event:

- No need for separately identifying events, events are automatically determined start and finish of activities!

System state:

No need for separately identifying system state, since system state is a part of other elements (e.g., queue part of resource and activity and resource state part of resource element)

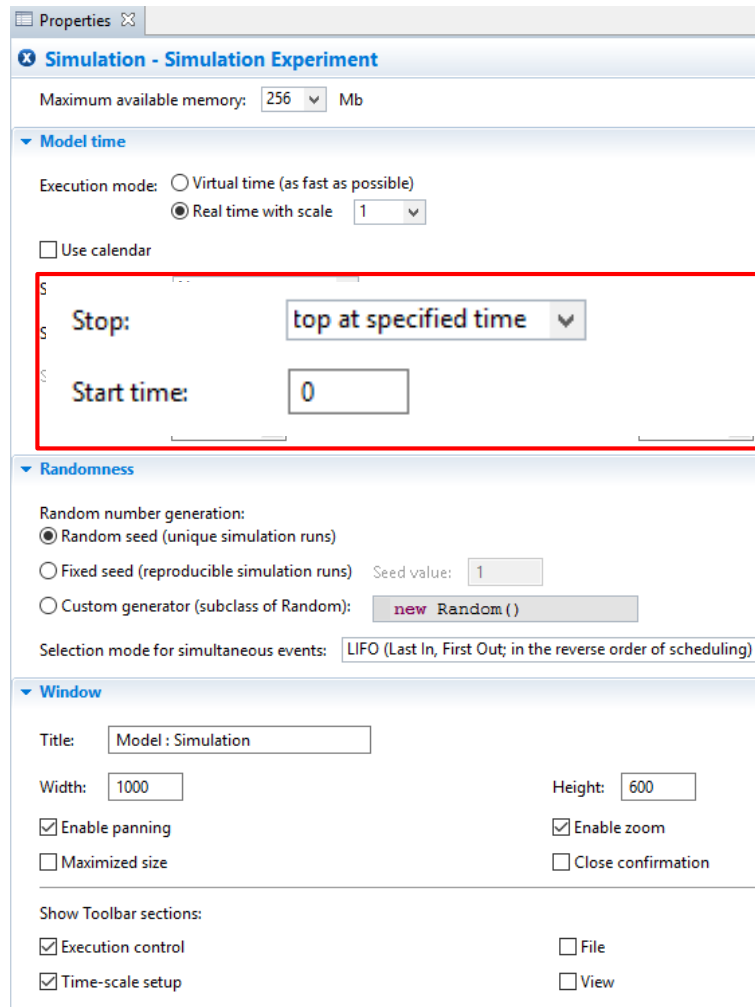
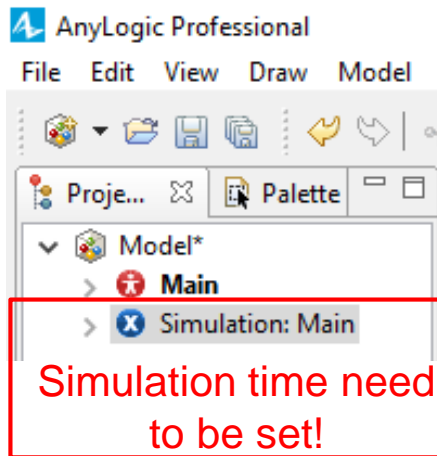
2- Determine initial condition:

No entity in the system. First entity will arrive with a random-exponential distribution after 7 am.

Single Queue - Example 1

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3- Setup the simulation environment:

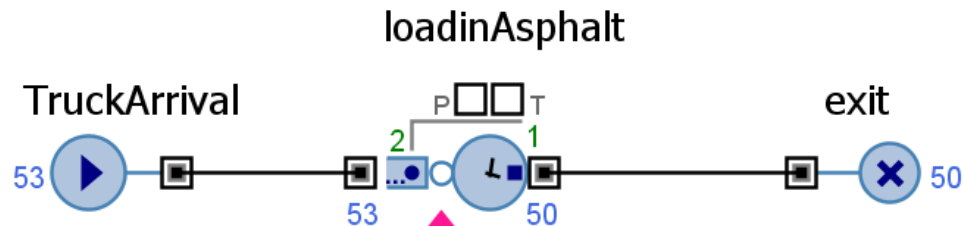


Single Queue - Example 1

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4,5- Start developing and running the model logic in AnyLogic:

Hands on AnyLogic



asphaltPlant



Earthmoving - Example 2

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- **Example 2:** Suppose our earthmoving example with 3 trucks and 1 loader in the system with working hours from 7 am to 7 pm. There is no limitation in number of dumping sites.

Different operation activities have following durations:

- Loading: N(10 minutes, 2 minutes)
- Trip to dumping site: N(5 minutes, 1 minute)
- Dumping 2 minutes
- Trip from dumping: Uniform (3 minutes, 6 minutes)

Time of each truck arrival at the morning has a uniform distribution between 6:50 am to 7:15 am.

1- Model elements: Entity: truck; Resource: loader; Activities: Loading, Trip to dumping site; Dumping; Trip from dumping site.

2- Initial condition: No entity in the system; Schedule truck arrival uniformly distributed from 6:50 to 7:15.

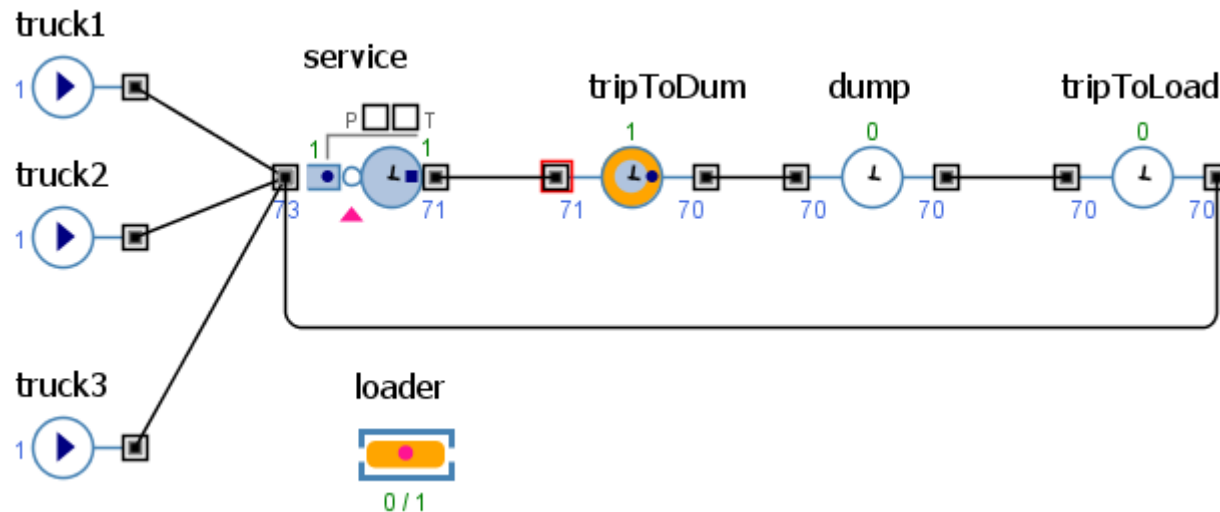
3- Setup the simulation environment: Setup stop time at 730 (why? ).

Earthmoving - Example 2

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3- Start developing the model logic in AnyLogic:

Hands on AnyLogic



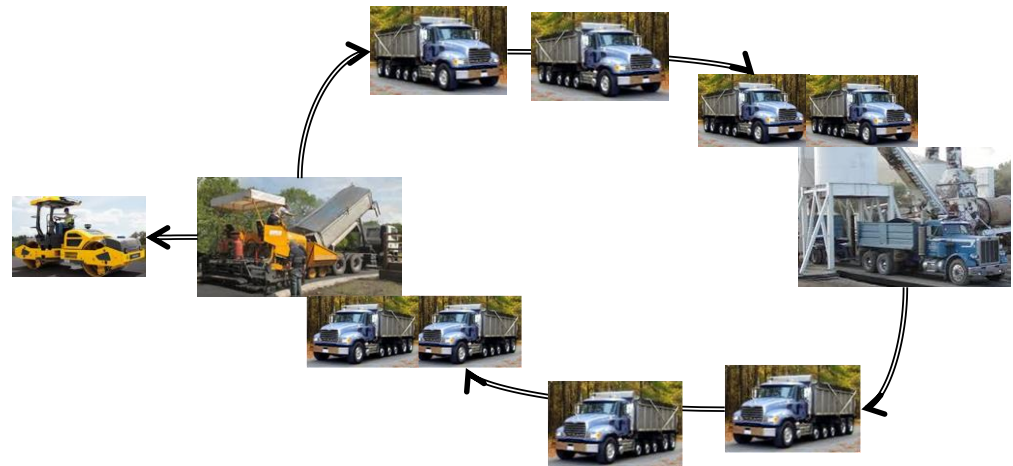
Home assignment 8

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In our paving example suppose trucks trip to asphalt plant is normally distributed with the mean of 9 minutes and SD of 1 minutes. There are two asphalt loading stations with a constant loading duration of 6 minutes. The return trip to the paving site has a normal distribution of 12 minutes and SD of 2 minutes. Spreading has a uniform duration between 2 to 3 minutes. Compacting of each batch of asphalt has a triangular distribution with minimum of 1, maximum of 5 and mod of 2 minutes. There are total 6 trucks working in the operation. Time of each truck arrival at the morning has a uniform distribution between 6:55 am to 7:10 am. Operation stops at 6 pm in the evening. Develop the simulation model of the operation using AnyLogic.

□ **(Due in one week)**



Reference

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- <http://www.AnyLogic.com/learn-simulation>



Thank you!