STEM FOR STUDENTS
DRIVE IT HOME
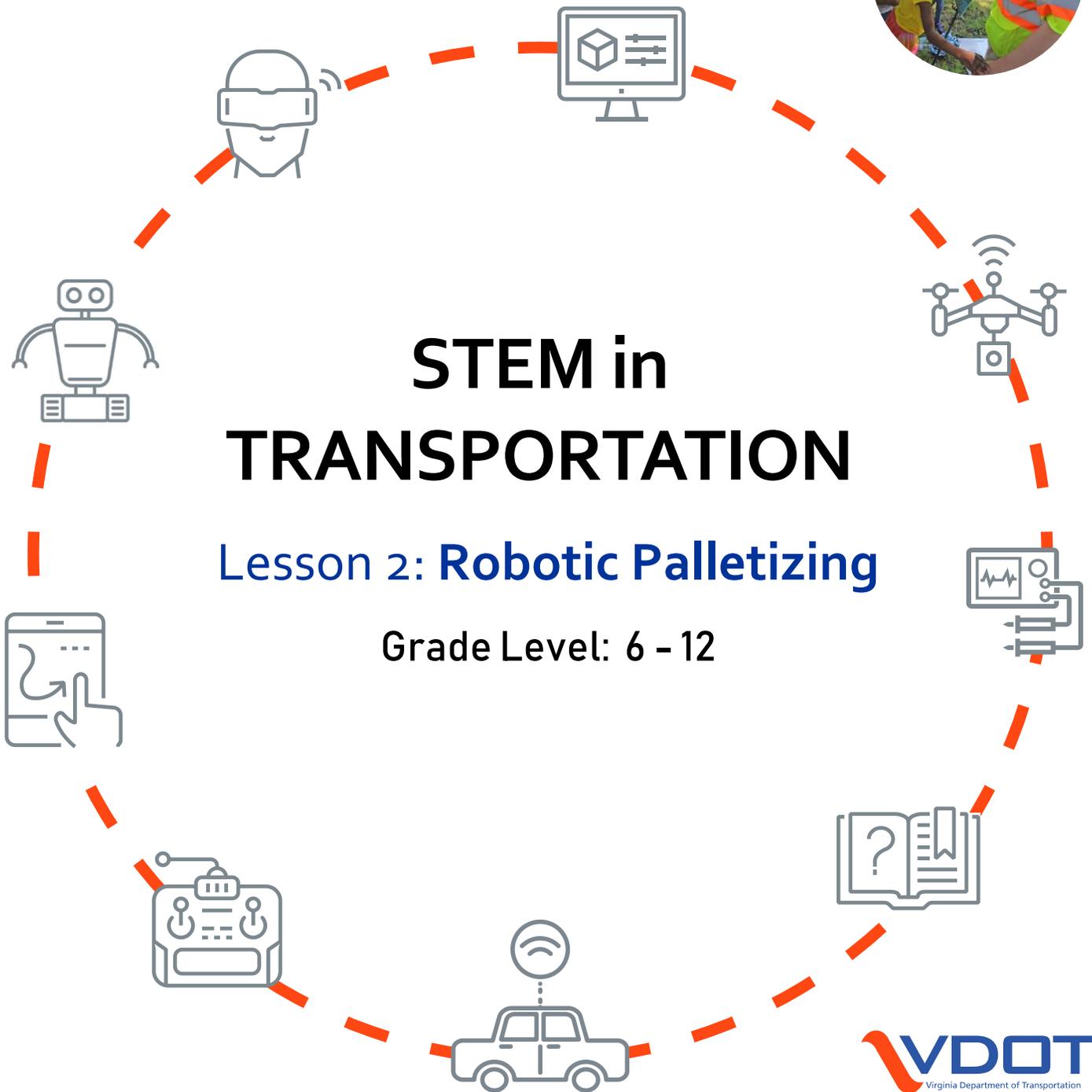
STEM in TRANSPORTATION

Lesson 2: **Robotic Palletizing**

Grade Level: 6 – 12

VDOT
Virginia Department of Transportation

Robotic Palletizing

Background Knowledge

Before goods are shipped in trucks or containers, they are usually placed in protective packaging and arranged on pallets for efficient transport. Stacking goods on a pallet is a repetitive job that can cause injury to workers. Because of this, many factories that require a high volume of palletization have turned to using robots to perform palletizing tasks.

Procedure

1. Show the Robot Palletization slides to provide some background information about robots used for palletizing.
2. Explore how students would program a robot to stack a certain pallet configuration using dimensions of a product's case and the Cartesian coordinate system.
3. Give students a case dimension and have them determine a pallet configuration that would fit on a standard 48" x 40" pallet. It may be helpful for students to cut out scaled cases and arrange them on graph paper to determine a good case arrangement.
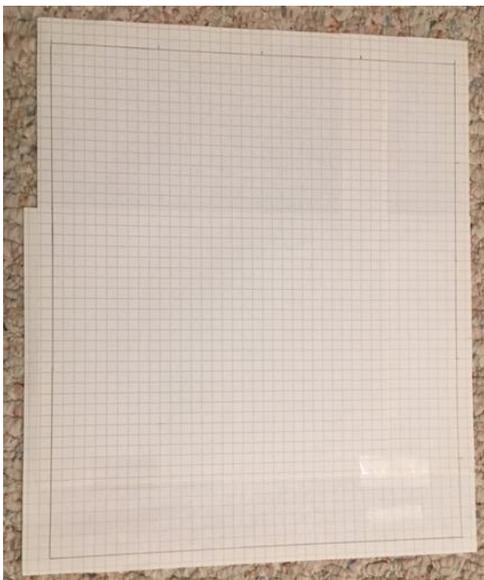
Graph paper taped together for 48"x 40" size where 1 square = 1 inch

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STANDARDS OF LEARNING
MATH: 6.8, 8.7
COMPUTER SCIENCE: GRADES 3-7, MSCSE.1, CSP.2

Objective
Students will:
- Investigate the use of robots in a palletizing situation
- Develop programming logic for a robotic palletizer
- Utilize Cartesian coordinates in their robot program

Materials
- Graph paper or CAD program
- Pencil
- Construction paper
- Scissors
- Loose leaf paper

The case configuration below shows an arrangement of 11 cases on a 48"x 40" pallet. You can see that 11"x14" cases do not fill up all of the space on a pallet. If you add cases to fill the pallet, some cases would overhang the pallet, increasing the risk of damaged cartons and product. Overhanging product may also prevent optimal use of space in a shipping container (tractor-trailer, rail car, or ship container).
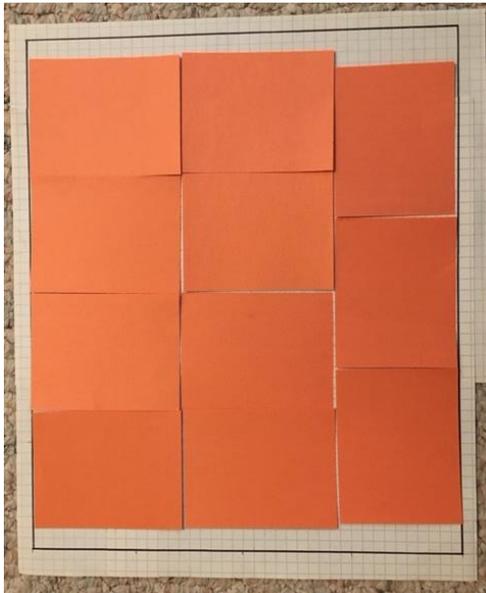
A possible pallet arrangement for 11" x 14" cases. Eleven cases fit without overhang.

4. Have students draw or graph the top view of their pallet configuration, labelling each bottom left case corner with the Cartesian coordinate that corresponds to its position.

(0.5,35)   (14.5,35)

(28.5,31)

(0.5,24)   (14.5,24)

(28.5,17)

(0.5,13)   (14.5,13)

(0.5,2)   14.5, 2"   (28.5,3)
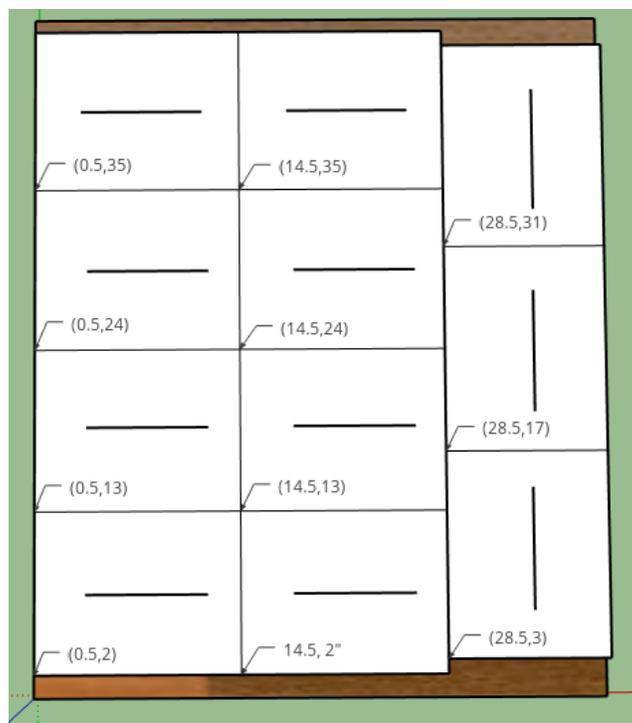
5. Now students can write a logical programming sequence using Cartesian coordinates and the programming commands listed here so that a robot can properly stack their designed pallet configuration:

    PU = pick up a case

    MT(0,0) = move the bottom left corner of the case to Cartesian coordinate (0,0)

    PR = place & release the case

    RT = return to pickup location

    T90 = turn the case 90 degrees

    R{1-4,6} = repeat steps 1-4, 6 times

    *Assume a continuous flow of cases arriving at the pickup location.

    Example program for the 11"x14" case configuration from the prior page:

1: PU	15: R{3-5,1}
2: MT(0.5,2)	16: MT(0.5,35)
3: PR	17: R{3-5,1}
4: RT	18: MT(14.5,35)
5: PU	19: R{3-5,1}
6: MT(14.5,2)	20. T90
7: R{3-5,1}	21. MT(28.5,3)
8: MT(0.5,13)	22: R{3-5,1}
9: R{3-5,1}	23. T90
10: MT(14.5,13)	24. MT(28.5,17)
11: R{3-5,1}	25: R{3-5,1}
12: MT(0.5,24)	26: T90
13: R{3-5,1}	27: MT(28.5,31)
14: MT(14.5,24)	28: R{3-4,1}

6. Have students exchange their robot code with another student or team and see if they can place the cases in the correct configuration by following the other team's program code.

7. View this video showing robotic palletizers at work and how they have benefited the company https://www.youtube.com/watch?v=7U1-X50gsKA   (4:40 minutes)

Extensions

1. Students can read "The Science of Palletizing" provided by Palletizing.com
   https://palletizing.com/wp-content/uploads/sites/3/2017/11/Science-of-Palletizing.pdf

2. Have students research palletizing technology and compare and contrast 2-3 different industrial palletizing robots
   a. Companies to explore are Columbia, Fanuc, PalletizUR, Stäubli, Kawasaki, and many others

3. The Center for Packaging & Unit Load Design (CPULD) at Virginia Tech is a leading packaging research facility right in the state of Virginia. Have students explore their website and write a summary paragraph about an article in one of their newsletters.
   https://www.unitload.vt.edu/about-us.html

Careers to Explore

- Electronic Technician
- Manufacturing Engineer Technician
- Manufacturing Engineer
- Packaging Engineer
- Robotics Engineer

Terminology

Pallet Configuration: the stacking pattern, rotation of layers, and number of items per row and per pallet

Pallet: a small, low, portable platform on which goods are placed for storage or moving, as in a warehouse or vehicle

Palletize: the process of stacking packages (i.e., boxes, bags, containers, etc.) in an organized fashion on a pallet

Logistics: The commercial activity of transporting goods to customers

Program Logic: the linear sequence of steps that need to occur for a task to be completed by a robot or other computer-automated system

Optimize: to make the best or most effective use of a situation, opportunity, or resource

Axis: A direction used to specify a robot's motion in a linear or rotary mode

Standard: a common size or specification for goods that makes operations across an industry more efficient (ex: pallet sizes, container lengths, etc.)

Overhang: when items on a pallet sit with edges outside the dimensions of the pallet on which they are placed

Columnar: a pallet stacking pattern that maintains the same box arrangement on each layer; this is the best way to stack a pallet to fully utilize the strength of cardboard cases

Interlocking: a pallet stacking pattern that alternates the box arrangement of layers to add horizontal stability

Corrugated Fiberboard: a material consisting of folded sheets and one or two flat linerboards used for making cardboard boxes
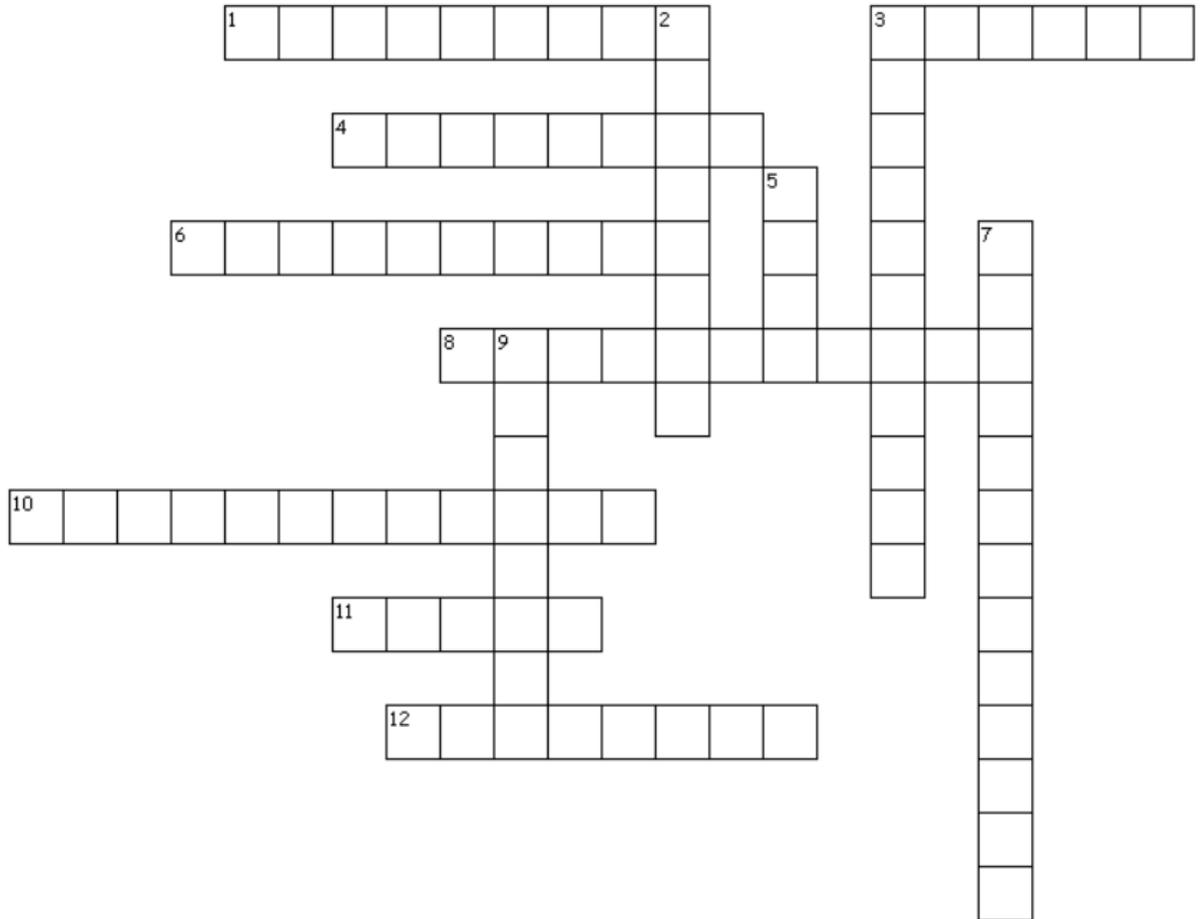
Compression Strength: a measure of how much force a container can withstand being placed on top of it without failing (crushing or deforming)

Robotic Palletizing

WORD BANK

- Configuration
- Pallet
- Palletize
- Logistics
- Logic
- Optimize
- Axis
- Standard
- Overhang
- Columnar
- Interlocking
- Corrugated
- Compression

Across

1. The commercial activity of transporting goods to customers
3. A small, low, portable platform on which goods are placed for storage or moving, as in a warehouse or vehicle
4. A pallet stacking pattern that maintains the same box arrangement on each layer; this is the best way to stack a pallet to fully utilize the strength of cardboard cases
6. _____ fiberboard is a material consisting of folded sheets and one or two flat linerboards used for making cardboard boxes.
8. _____ strength is a measure of how much force a container can withstand being placed on top of it without failing (crushing or deforming).
10. A pallet stacking pattern that alternates the box arrangement of layers to add horizontal stability
11. Program _____ is the linear sequence of steps that need to occur for a task to be completed by a robot or other computer-automated system.
12. When items on a pallet sit with edges outside the dimensions of the pallet on which they are placed

Down

2. Many industries use _____ pallet sizes to make their transportation and warehouse operations as efficient as possible by optimizing the number of pallets on a truck or in a storage area.
3. The process of stacking packages (i.e., boxes, bags, containers, etc.) in an organized fashion on a pallet.
5. A direction used to specify a robot's motion in a linear or rotary mode
7. The pallet _____ is the stacking pattern, rotation of layers, and number of items per row and per pallet.
9. To make the best or most effective use of a situation, opportunity, or resource

Robotic Palletizing Worksheet

Background Knowledge

Before goods are shipped in trucks or containers, they are usually placed in protective packaging and arranged on pallets for efficient transport. Stacking goods on a pallet is a repetitive job that can cause injury to workers. Because of this, many factories that require a high volume of palletization have turned to using robots to perform palletizing tasks.

Directions:

1) Label the x and y axes and the origin point on your graph paper. If needed, tape graph paper together to make a sheet large enough for a 48 x 40 block area.

2) Arrange the colored cases within the 48 x 40 "pallet" on the graph paper.
   To protect your cases of product, <u>do not let any cases hang off the pallet</u>.

3) Once you have the cases arranged in an efficient configuration within the pallet space, draw the configuration onto your graph paper and label the lower, left corner of each carton with the corresponding coordinate point.

4) Using the programming commands below, write a code for your robot to follow to properly place each of your cases in the configuration you came up with. Use the empty table below to write your code or use a separate sheet of paper.

   Remember to add steps for each movement a robot would need to perform to stack your pallet layer. <u>You only need to program one layer of cases</u>.

5) Exchange robot program and product cases with another team to see if they can create the correct pallet stacking configuration by following your robot code.

Robot Program Commands

PU   = pick up a case

MT(0,0) = move the bottom left corner of the case to Cartesian coordinate (0,0)

PR   = place & release the case

RT   = return to pickup location

T90   = turn the case 90 degrees

R{1-4,6}   = repeat steps 1-4, 6 times

*Assume a continuous flow of cases arriving at the pickup location.

Team Members: _____

Case Size: _____

Program:

1:	26:
2:	27:
3:	28:
4:	29:
5:	30:
6:	31:
7:	32:
8:	33:
9:	34:
10:	35:
11:	36:
12:	37:
13:	38:
14:	39:
15:	40:
16:	41:
17:	42:
18:	43:
19:	44:
20:	45:
21:	46:
22:	47:
23:	48:
24:	49:
25:	50: