Massachusetts Institute of Technology
Department of Aeronautics and Astronautics
Cambridge, MA 02139

Unified Engineering
Fall 2004

Problem Set #3

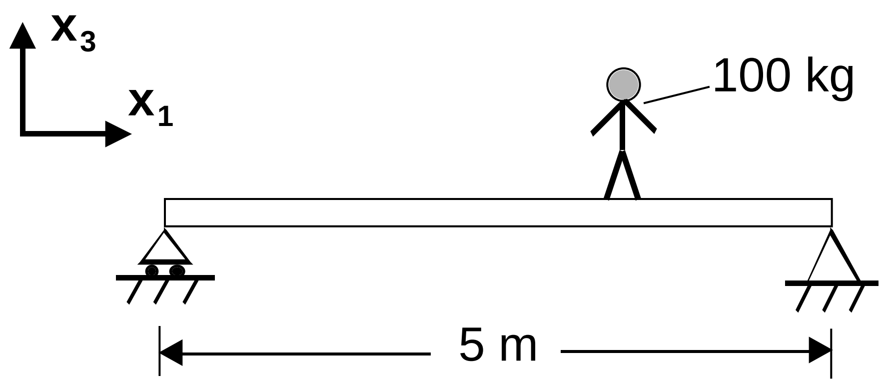
Due Date: Tuesday, Sept. 28, 2004 at 5pm

	Time Spent (minutes)
M4	
M5	
M6	
C4,C5,C6, C7	
Study Time	

Name: ________________

Unified Engineering Problem Set #3 **Units M1.3, M1.4**
Fall, 2004

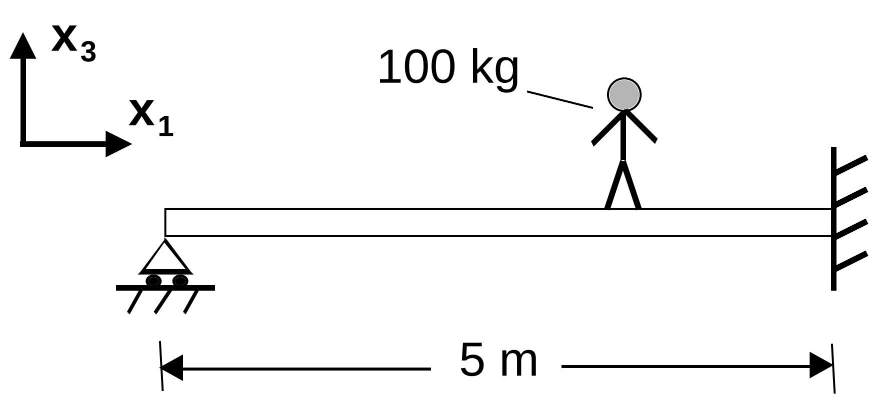
M4. A 5-meter long beam is attached via a roller at one end and is pinned at the other end. This configuration is known as *simply-supported*. A 100 kg person walks back and forth across this beam. This situation is illustrated below.



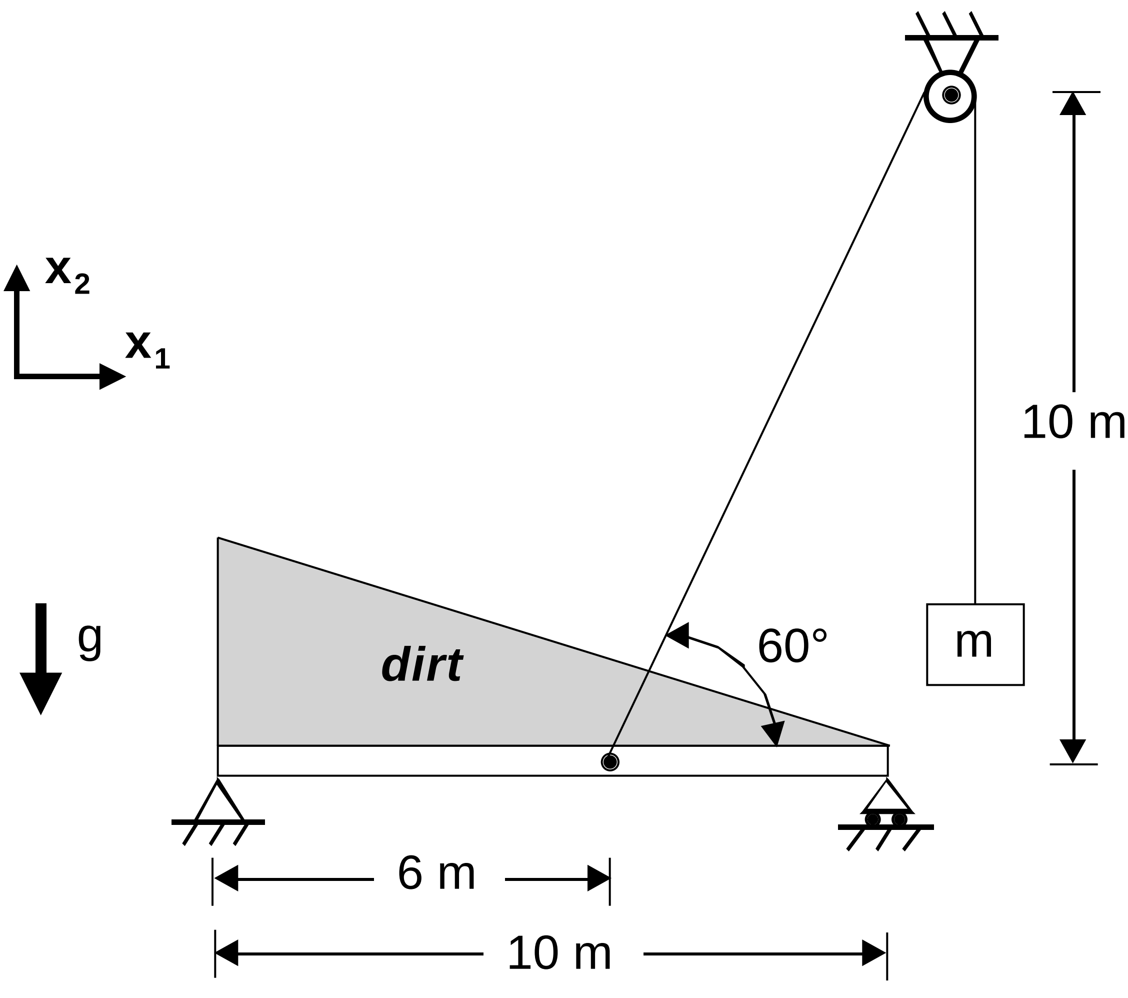
(a) Draw the free body diagram for this situation (choose any location for the person).

(b) Determine the reaction forces as a function of the point on the beam at which the person is located.

(c) The end with the roller is now clamped, as in the accompanying picture. Draw the free body diagram for this case and then determine the reaction forces or as much about the reaction forces as possible. If the reaction forces cannot be exactly determined, explain the reasons for that.



M5. A total of 1000 kg of dirt is distributed over a 10 meter long beam in a linear fashion (see accompanying figure) such that the maximum amount of dirt is at one end and the other end has no dirt. The beam is supported by a pin at the end with the maximum amount of dirt and by a roller at the other end. In addition to the dirt, the beam has a cable attached to it 6 meters from the pinned end. This cable makes a 60° angle with the beam and goes through a pulley attached by a pin to a ceiling 10 meters above the beam. At the other end of the cable is a mass of 300 kg. This overall situation is illustrated in the accompanying figure.

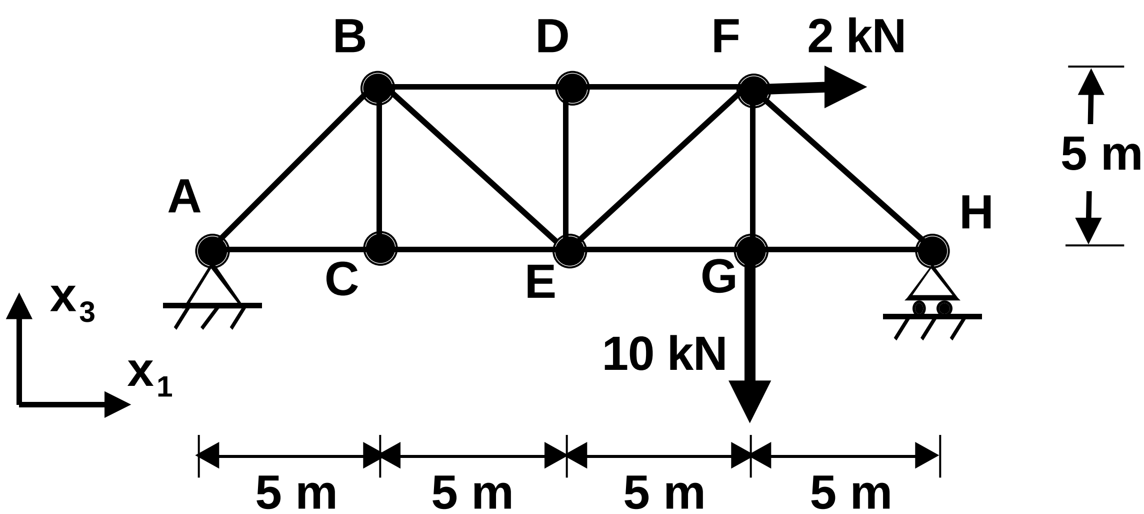


(a) Draw the free body diagram for this general case

(b) If possible, determine the reaction loads; if not possible, indicate why this cannot be done.

(c) Determine if the mass hanging from the cable can be changed in such a way that the reaction(s) at the roller is(are) zero. Explain your reasoning

M6. A 5-meter high truss has a 20-meter span and is made up of thirteen individual bars of various lengths in four bays as shown in the accompanying illustration. Each bay of the truss is 5 meters long. The truss is simply-supported being pinned at the left end and attached via a roller support at the other. Loads are applied at various joints as noted.



(a) Draw the free body diagram for this situation.

(b) Determine the reaction forces.

(c) Can the loads in bar DE be determined without performing any calculations? Explain clearly.

(d) Determine the load in bar CE by the *method of sections.*

(e) Check the result for the load in bar CE by the *method of joints.*

(f) Using whatever approach you would like, determine the load in all bars. Draw a clear diagram showing the entire configuration and the manner in which loads are carried.

C&P Problem Set 3
This problem set will cover lectures **C4**, **C5**, **C6** and **C7**

1. (a, b, c) **12 points**
   a. Convert 27_{10} from decimal into binary and hexadecimal notation
   b. Convert FA_{16} from hexadecimal into binary and decimal
   c. Convert 10111001_2 from binary into decimal and hexadecimal

2. (a, b, c) **35 points**

   a. Write an algorithm to carry out integer subtraction using only addition. Assume that the numbers are stored in num1 and num2, and the operation to be performed is num1-num2. Turn in a hard copy of your algorithm.

   b. Implement your algorithm as a **Pep/7** program. Turn in a hard copy of your assembly code and an electronic copy of your code

      Hint: How do you find the 2's complement?

   c. Implement your algorithm as an **Ada95** program. Turn in a hard copy of your code listing and an electronic copy of your code.

      Hint: Think about modular numbers (`mod`)

3. (a, b, c) **53 points**
   a. Build the maze rover as shown in figure 1. (Instructions can be found on the C&P website in a document entitled "maze_robot.pdf" and "maze robot wiring diagram.pdf")

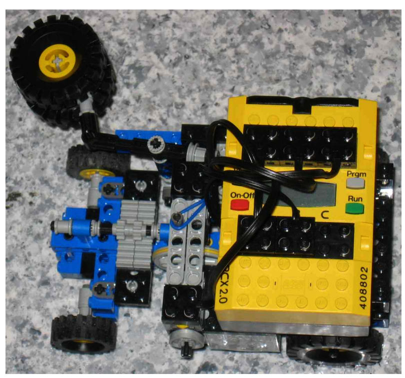


Figure 1. Maze Rover

   b. Write an algorithm to enable the rover to navigate a maze (shown in Figure 2), using the right hand rule, i.e., the rover will turn 90 degrees to the right when it encounters an obstacle. Use the touch sensor connected to the rover bumper (shown in Figure 1) to determine whether an obstacle is encountered. Your rover should stop moving when it detects the end of the maze (using the light sensor to detect a black surface). Turn in a hardcopy of your algorithm.

The solving of the maze requires four different segments of code to work in tandem.

1.) *Right wall following*. Use the right bump sensor to determine when the robot is touching the right wall.
2.) *Turning a corner*. This should be incorporated into right wall following, so when the bumper doesn't detect a wall, the robot should make the right turn.
3.) *Stuck in a right front corner*. Some sort of time out code should be used to make the robot turn left when it believes it is stuck in a corner.
4.) *Use the light sensor with a threshold to detect the black square that denotes the end of the maze.*

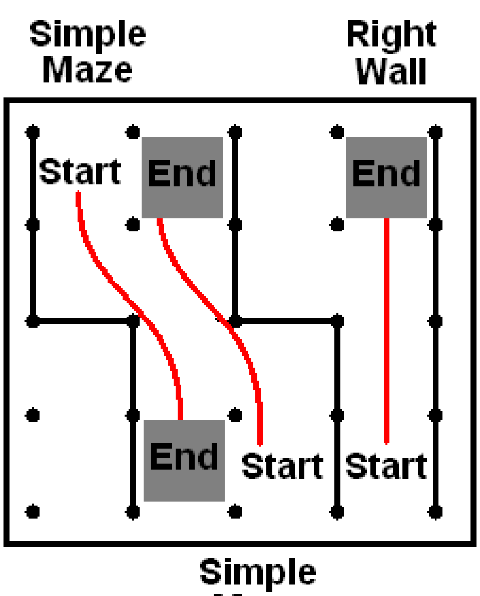
Note that making the robot navigate the maze is tricky – it requires some testing of the hardware. Common Problems Include:

1.) Using loops to check whether or not a sensor has been triggered may not work if the sensor happens to not get triggered at the exact same time the loop in the code is checking the sensor value.
2.) The robot wanders too far away from the right wall and gets stuck when attempting to turn back into the right wall.
3.) When executing the time out left turn, the forward wall is short, and if the 90 degree left turn is not 'tight' the robot might never even detect the wall infront of it after the turn.
4.) Robot gets stuck on the corner of the wall in a right handed turn.

Testing:

It will be VERY important to test the robot out in the maze.

Two mazes with the configurations shown in Figure 2 have been setup in lab. There is one right wall following maze, two simple mazes, and one hard maze.



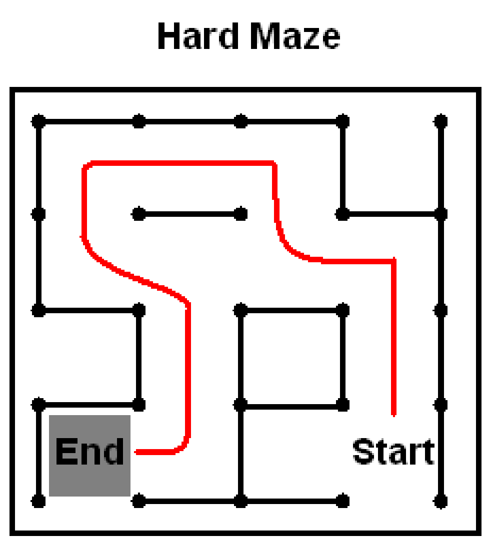


Figure 2. Simple Maze

Students should strive to solve the hard maze, but can do so through solving the simpler mazes first. The mazes *may* have minor physical alterations for the testing of the submitted code, so students should not expect to program the robot to run a pre-programmed path.

Turning it in & Grading Scheme:

Build the robot: 8 points
Right Wall following: + 25 points
Solves the Simple Maze: +15 points
Solves the Hard Maze: +10 points
Fails to stop at the end of the maze: - 5 points.

Please insert a comment or make a note on the hardcopy at the TOP of the page of the submitted code to tell the TA's which maze your robot was able to solve successfully.

Hint:

- How do you connect the light sensor to your rover?
- In the previous problem set, the turn procedure provided a limited turn of the steering. Does changing the duration for which the steer motor is turned on provide a tighter turn radius?
- What is the power level of the drive motor?

c. Implement your algorithm as an Ada95 program. Does your rover successfully navigate the test maze? Turn in an electronic copy of your code and a hard copy of your code listing.

Hint:

- Which sensor port will you connect the light sensor to on the maze rover?
- At what point in the program, will you read the information from the light sensor?