Connecting Industry to Mathematics Instruction
NSF ATE Award # 1954291

Solutions: Egress Mobility - Staircase Design

Student Activity Sheet

In partnership with

WAKE TECH

WAKE COUNTY PUBLIC SCHOOL SYSTEM

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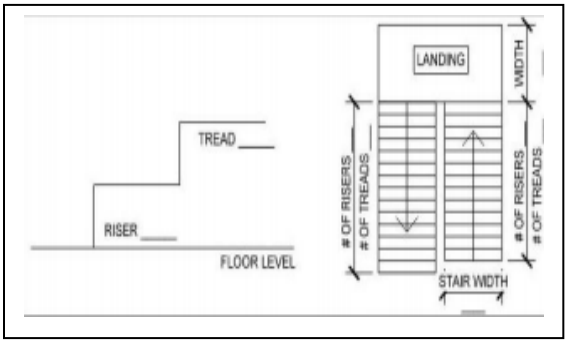
Below are the building codes for stairs for non-residential buildings. These codes are to help people safely exit from a building quickly in case of emergencies. If you were a building inspector, you would be tasked with taking measurements of stairs to check if they comply with the building code. So, read through the building codes below and then take measurements of a staircase in one of your school's buildings. (A floor plan of the building may be needed to accurately determine the square footage for occupancy.)

- Minimum stair width is 44 inches
- 1-foot horizontal spacing distance between stairs after a landing
- Egress capacity for stairs is 0.3 inches/occupant
- Maximum vertical travel distance before a required landing is 12 feet
- Landing width must be at least the stair width
- Tread minimum = 11 inch and maximum = 12 inch
- Riser minimum = 4 inch and maximum = 7 inch
- Risers and Treads can be fabricated to the nearest .001 inch

Task 1. Initial thought questions

a) What is the tread and riser of a stair?
Tread is the part of the step you put your foot on (run)
Riser is the vertical connecting for the treads (rise)

b) Why would a larger building possibly require a wider staircase?
Larger buildings probably will have a larger occupant load, so to get people out quickly in case of an emergency, the stairs would need to be wider.



c) Why are there established minimum and maximum code restraints for step tread and riser?
Safety reasons mostly

d) What could be a reason an architect might design for steeper stairs?
Steeper stairs would result in a smaller space needed to connect the floors with a stairwell, which results more building space for other more important usages.

e) How would various riser and tread lengths affect cost?

Less material would be needed if we use smaller treads and larger risers. Using a maximum riser would result in less number of stairs needed. Less material means smaller costs.

f) What would be the stair width minimum if the building total square footage is 10,000 sq ft and designed for 50 sq ft per occupant?
10000/50 = 200 occupants then multiply by .3 in/occupant = 60 inches of stair width needed. This is larger than 44 in minimum, so the stair width would need to be at least 60 inches wide.

Task 2. Measure an interior staircase at your school to determine if the stairs meet all the building codes stated above. Include all measurements for each item listed below and state why or why not your staircase meets each building code criteria. For schools, recommended space per student is 50 sq ft. Does your school's staircase satisfy a) tread width, b) riser height, and c) stair width? Verify your claims by supporting documentation.

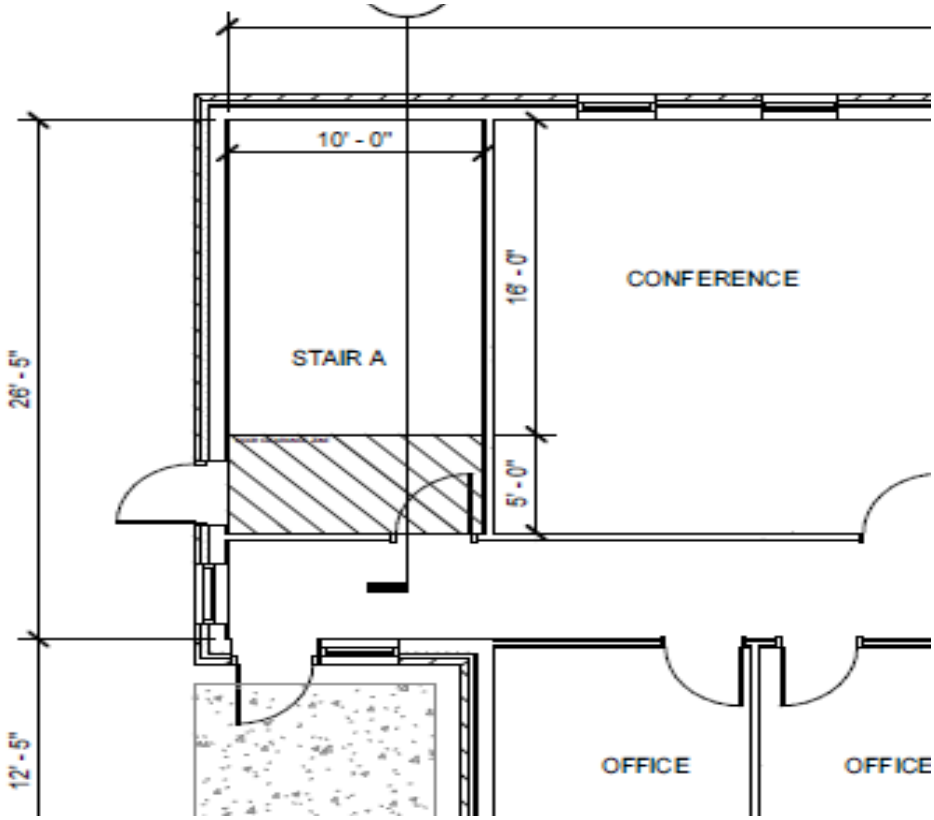
Item to measure	Measurement with units
Stair width	
Horizontal spacing distance between stairs	
Area of adjoining floors needed to egress using stairs	
Landing dimension	
Two different treads	
Two different risers	

Students should measure several risers and treads for consistency. You may want to provide a floor plan for the students to determine occupancy loads for the building, which will be needed to determine the stair width minimum.

Task 3. You are a newly hired architect for Moseley Architects, and you have been tasked with creating the design for stairs connecting floors within stairwell A shown below. Using the given building code requirements for stairs, determine the best design possible to connect the first and second floors. The stairwell dimensions are below on the drawing.

Requirements and given information include:

- 13 feet between floors vertically
- For this building use 100 square foot per occupant
- Total floor area of the two-story building is 8,121 sq ft



Task 3a. Determine the minimum stair width needed to satisfy the building codes and egress requirements for this building.

8121 sq ft / 100 sq ft/occupant = 81.21 occupants

81.21 occupants * 0.3 in per occupant = 24.4 inches which is less than the minimum 44 inches

So, stair width will be 44 inches

Task 3b. Determine the minimum number of risers and treads needed to connect the first and second floors.

13 feet is 156 inches between floors. Divide 156 inches by 7 inches (using the maximum riser to keep stairs compact) to result 22.3 risers needed. Round this up to 23 risers, which would design one less step on the switch back. So, we need 12 risers on the first set of stairs and 11 treads since the last riser would then reach the landing. And, we need 11 risers on the switchback and 10 treads for the same reason.

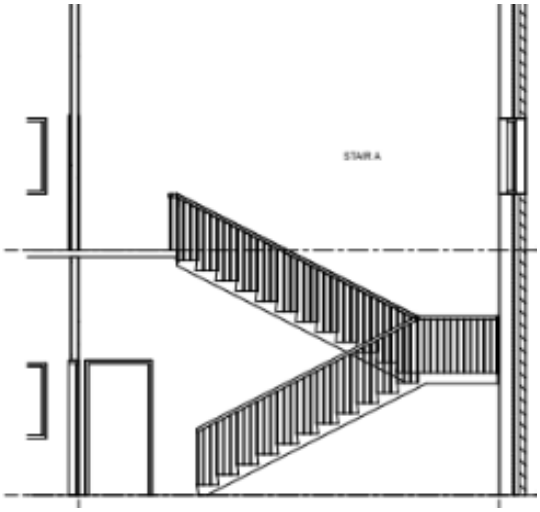
Task 3c. Determine the exact dimensions needed for each riser, tread, and stair width. Create a scale drawing for your design stairwell that shows a side view of the stairs and landing. Give the scale you use in your drawing (ex: 1 inch = 1 foot).

Width = 44 inches (The landing width also needs to be 44 inches.)

Riser = 6.783 inches (156 inches divided by 23 risers result 6.783 inches for each riser.)

Tread = 12 inches (using 16 feet of space to put the stairs and subtracting the 44 inch landing width on the switchback results 148 inches to use horizontally for the 11 treads. If we use the maximum 12 inch tread, then 12*11 = 132 inches horizontally for the 11 treads.)

Example drawing below (not to scale)



In task 3d, you are putting an outside exit door here

Task 3d. The building owner has decided to put an exit door under the stair landing. The minimum height needed for this door is 7.5 ft vertically from floor to landing. Re-design your staircase to be able to add in this exit door. Give number of steps before and after the landing, the dimensions of each riser, tread, and stair width, and the width of the landing.

There are several good answers to solve this problem. There are two common approaches.

Method 1: You could use the same riser of 6.783 inches and determine the number of risers needed to put your landing above the 7.5 feet door requirement. (This is the one I choose below.)

Method 2: You could change the riser dimension prior to the landing and need one less riser to reach the 7.5 foot requirement. 7.5 * 12 = 90 inches ; 90 divided by 7 inch max riser = 12.86 or 13 risers needed ; 90 inches divided by 13 risers = 6.923 inch risers prior to the landing. This riser height would need to slightly adjusted for the switchback stairs using 5.5 remaining feet to climb.

Method 1 details:

Using the same 6.783 inch riser, you would need 14 risers to reach the 7.5 feet minimum height. (7.5 feet = 90 inches, then divided by 6.783 inches results 13.3 risers and we round to 14 risers to reach the minimum 7.5 feet. Therefore, we will only need 9 more risers on the switchback stairs. Now the question is “What tread width is needed to make sure the 14 risers can fit in the 16 feet of horizontal space?” Using 16 feet of space to put the stairs and subtracting the 44 inch landing width on the switchback results 148 inches to use horizontally for the 13 treads. If we use the maximum 12 inch tread, then 12*13 = 156 inches needed horizontally for the 13 treads, which is too big. So, take the 148 inches of space and divide by the 13 treads to get the tread width maximum of 11.384 inches.

Riser = 6.783 inches and we will put 14 risers prior to the landing and the remaining 9 on the switchback climb.
Tread = 11.384 inches
Stair width and landing width = 44 inches