QUANTITY TAKE-OFF

Quantity take off problems are relatively easy to figure out. You just need to know a little bit about geometry and use a little bit of engineering common sense. I will show you a couple tricks of the trade that will make life a little easier and then some example problems for you to practice to gain experience and confidence. The most likely questions that you will see during the exam are quantity take off for:

**Trick of the Trade #1:** To find the length of Excavation – Be careful to fully understand what the given dimension are measuring. The below is the example of a footing plan. If the dimension are given for the centerline or the outer perimeter your calculation is different.

If the dimension are the centerline the calculation are easy.  
The Length of Trench equals = 42+17+20+24+63+41 = 207 ft

However if the dimension are the outside perimeter use **Horizontal In-In and Vertical Out-Out Method.** Which just means measure the walls in the Horizontal distance on the inside and in the vertical distance on the outside. 
The Length of Trench equals = 38+17+20+24+59+41= 199 ft
A contractor is excavating the above trench. He is supposed to dig the trench 5 ft deep x 3 ft wide. The soil was tested to have an approximate swell factor of 15% and a shrinkage factor of 12%. The contractor is placing a 8” water pipe in the trench and then backfilling with the soil that was removed. The above dimensions are on centerline.

Does the contractor have enough soil to backfill the trench, or will he/she have to need more? If he needs more soil, how much does he/she need to bring in. Answer in LCY.

Ans.

a. It fits
b. 14.5 LCY
c. 12.34 LCY
d. 7.25 LCY
Step 1: Find length of trench
Trench = 42ft + 17ft + 20ft + 24ft + 63ft + 41ft = 207 ft

Step 2: Find the Volume of the soil in the trench
5ft x 3ft x 207ft = 3105 ft³

Step 3: Find the Volume after compaction
(3105 ft³)(1-.12) = (3105 ft³)(.88) = 2732.4 ft³

Step 4: Find the Volume of the soil needed
Volume of Trench – Volume of Pipe
3105 ft³ - πr²d(207ft) = πr²((8/12)²/4)(207ft)
3105 ft³ - 72.25 ft³ = 3032.75 ft³

Step 5: Find out if you need more soil
Volume of compacted soil need – Volume of compacted soil available
3032.75 ft³ - 2732.4 ft³ = 300.35 ft³ → So the KTR needs to bring in more soil

Step 6: How much soil does the contractor need to bring in
Volume of compacted soil = (1-Shrinkage factor) x BCF
300.35/.88 = 341 BCF, LCF = BCF x 1.15 = 392/27 = 14.5 LCY
MASONARY QUANTITY TAKE-OFF

There are tables available for estimating the number of bricks required, but for the PE Exam it is relatively easy to just reason out most answers.

For figuring out the number of bricks required in a wall there is a Five step process.

**Trick of the Trade #2: Estimating number of bricks**

Step 1: Calculate the net surface area of the wall. (ft$^2$ or m$^2$)
  - Gross surface Area – openings surface area
  - Do not double count area of corners

Step 2: Calculate the surface area of one brick as positioned(including the mortar joint.
  - Standard brick size is 8’x2.25’x3.75’
  - plus half the joint thickness on each side

Step 3: Divide Net wall area by surface area of the brick.

Step 4: Multiply the number by the number of rows of bricks required.

Step 5: Add an amount for waste (A factor of 2-10% is usually added)
**MASONARY QUANTITY TAKE-OFF**

If you need to figure out the quantity of mortar required.

**Trick of the Trade #3: Quantity of mortar**

Step 1: Calculate out the volume of mortar of one brick. (ft$^3$ or m$^3$)
- $V_{\text{volume per brick}} = (t)(w)(L+H+t)$
- $t =$ mortar thickness
- $w =$ brick width/depth
- $L =$ brick length
- $H =$ brick height

Step 2: Multiply the mortar required/brick by the total number of bricks.

Step 3: If more than one row – the volume of mortar needed to fill the gap between rows need to be added. This is volume is the joint thickness times the net area of the wall.

Step 4: Add an amount for waste (A factor of 25% is usually added)
QUANTITY TAKE OFF – MASONRY

PRACTICE PROBLEM #2
Find the quantity of standard size bricks (8inx3.75inx2.25in) you should have delivered to your project if the following conditions are given:
- Wall is 8 ft high, 14 ft wide
- two opening, one 48in x 72in, one 32in x 48in
- Mortar joints are .5in thick
- 2 rows are required
- Allow for 3% brick waste

a. 1275
b. 953
c. 477
d. 982
QUANTITY TAKE OFF – MASONRY
SOLUTION#2

Step 1: Calculate the net surface area of the wall. (ft\(^2\) or m\(^2\))
- Gross surface Area – openings surface area
  \[
  \frac{(8\text{ft} \times 14\text{ft}) - (48\text{in} \times 72\text{in}) - (32\text{in} \times 48\text{in})}{144} = \frac{77.33\text{ ft}^2}{144}
  \]

Step 2: Calculate the surface area of one brick as positioned (including the mortar joint).
- The thickness of mortar = .5in
- So each side of the brick carries .25in, two sides so add .5in to dimension of the brick
  \[
  \text{Surface area of one brick} = \frac{(8\text{in} + .5)(2.25 + .5)}{144} = \frac{.1623\text{ ft}^2}{144}
  \]

Step 3: Divide Net wall area by surface area of the brick.
\[
\frac{77.33\text{ ft}^2}{.1623\text{ ft}^2} = 476.5 = \text{number of bricks}
\]

Step 4: Multiply the number by the number of rows of bricks required.
\[
(476.5)(2\text{ rows}) = 952.9\text{ bricks}
\]

Step 5: Add an amount for waste (A factor of 2-10% is usually added)
\[
(952.9\text{ bricks})(1.03) = 982\text{ bricks}
\]
QUANTITY TAKE OFF – MASONRY

PRACTICE PROBLEM #2A
Estimate the quantity of mortar required in problem #1. The joint thickness between rows is \( \frac{1}{2} \) in thick. Assume 25% waste.

a. 20.5 ft\(^3\)
b. 18.3 ft\(^3\)
c. 14.6 ft\(^3\)
d. 11.4 ft\(^3\)

SOLUTION #2A

Step 1: Calculate out the volume of mortar of one brick. (ft\(^3\) or m\(^3\))
- Volume per brick = \( t \times w \times (L+H+t) \)
- Volume per brick = \( 0.5 \times 3.75 \times (8.0+2.25+.5) \) = 0.01166 ft\(^3\)

Step 2: Multiply the mortar required/brick by the total number of bricks.
- Volume of mortar = \( 0.01166 \text{ ft}^3/\text{brick} \times 982 \text{ bricks} \) = 11.4 ft\(^3\)

Step 3: Volume between rows = \( \frac{1}{12} \times (77.33) \) = 3.2 ft\(^3\)

Step 4: Mortar Req. = 1.25(11.4+3.2) = 18.3 ft\(^3\)
Board Feet is a measurement of lumber volume. A board foot is equal to 144 cubic inches of wood. Actually it’s easy to calculate using the following formula:

→ (Thickness(in) x Width(in) x Length(in))/144 = Board Feet

Or

→ # piece of lumber (P) x (Thickness(in) x width(in))/12 x Length = Board Feet

Note: Lumber is specified by its rough size. This is why a 1” x 4” board is actually ¾” thick and a 2” x 4” board is actually 1-1/2” thick.

When you are figuring up board feet, keep in mind a waste factor. If you purchase good clear material add about 15% for waste, if you elect to use lower grade material you will have to allow for defects and more wasted material add about 30%.

Ex. What is the board feet for one 2x4 that is 10 feet long?

Solution: 1 x (2inx4in)/12 x 10ft = 5 2/3 board feet
As everyone knows rebar is added to concrete in order to provide tensile strength since concrete is very weak in tension.

The following are tables for rebar, and wire fabric which are required to know for quantity take so you can know pounds of steel required.

### Table 12-1 ASTM standard reinforcing bar sizes

<table>
<thead>
<tr>
<th>Size Number</th>
<th>Metric Size Number</th>
<th>Weight lb/ft</th>
<th>Weight kg/m</th>
<th>Diameter in.</th>
<th>Diameter mm</th>
<th>Section Area sq in.</th>
<th>Section Area mm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>10</td>
<td>0.376</td>
<td>0.560</td>
<td>0.375</td>
<td>9.52</td>
<td>0.11</td>
<td>71</td>
</tr>
<tr>
<td>4</td>
<td>13</td>
<td>0.668</td>
<td>0.994</td>
<td>0.500</td>
<td>12.70</td>
<td>0.20</td>
<td>129</td>
</tr>
<tr>
<td>5</td>
<td>16</td>
<td>1.043</td>
<td>1.552</td>
<td>0.625</td>
<td>15.88</td>
<td>0.31</td>
<td>200</td>
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<tr>
<td>6</td>
<td>19</td>
<td>1.502</td>
<td>2.235</td>
<td>0.750</td>
<td>19.05</td>
<td>0.44</td>
<td>284</td>
</tr>
<tr>
<td>7</td>
<td>22</td>
<td>2.044</td>
<td>3.042</td>
<td>0.875</td>
<td>22.22</td>
<td>0.60</td>
<td>387</td>
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<tr>
<td>8</td>
<td>25</td>
<td>2.670</td>
<td>3.973</td>
<td>1.000</td>
<td>25.40</td>
<td>0.79</td>
<td>510</td>
</tr>
<tr>
<td>9</td>
<td>29</td>
<td>3.400</td>
<td>5.059</td>
<td>1.128</td>
<td>28.65</td>
<td>1.00</td>
<td>645</td>
</tr>
<tr>
<td>10</td>
<td>32</td>
<td>4.303</td>
<td>6.403</td>
<td>1.270</td>
<td>32.26</td>
<td>1.27</td>
<td>819</td>
</tr>
<tr>
<td>11</td>
<td>36</td>
<td>5.313</td>
<td>7.906</td>
<td>1.410</td>
<td>35.81</td>
<td>1.56</td>
<td>1006</td>
</tr>
<tr>
<td>14</td>
<td>43</td>
<td>7.650</td>
<td>11.384</td>
<td>1.693</td>
<td>43.00</td>
<td>2.25</td>
<td>1452</td>
</tr>
<tr>
<td>18</td>
<td>57</td>
<td>13.600</td>
<td>20.238</td>
<td>2.257</td>
<td>57.33</td>
<td>4.00</td>
<td>2581</td>
</tr>
</tbody>
</table>

**Figure 12-28** Reinforcing bar identification marks. (Courtesy of Concrete Reinforcing Steel Institute)
# QUANTITY TAKE-OFF
## REBAR

<table>
<thead>
<tr>
<th>Wire Size Number</th>
<th>Diameter</th>
<th>Area</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>in.</td>
<td>sq in.</td>
<td>lb/ft</td>
</tr>
<tr>
<td>Smooth</td>
<td>mm</td>
<td>mm²</td>
<td></td>
</tr>
<tr>
<td>W31 D31</td>
<td>0.628</td>
<td>0.31</td>
<td>1.054</td>
</tr>
<tr>
<td>W28 D28</td>
<td>0.597</td>
<td>0.28</td>
<td>0.952</td>
</tr>
<tr>
<td>W26 D26</td>
<td>0.575</td>
<td>0.26</td>
<td>0.934</td>
</tr>
<tr>
<td>W24 D24</td>
<td>0.553</td>
<td>0.24</td>
<td>0.816</td>
</tr>
<tr>
<td>W22 D22</td>
<td>0.529</td>
<td>0.22</td>
<td>0.748</td>
</tr>
<tr>
<td>W20 D20</td>
<td>0.505</td>
<td>0.20</td>
<td>0.680</td>
</tr>
<tr>
<td>W18 D18</td>
<td>0.479</td>
<td>0.18</td>
<td>0.612</td>
</tr>
<tr>
<td>W16 D16</td>
<td>0.451</td>
<td>0.16</td>
<td>0.544</td>
</tr>
<tr>
<td>W14 D14</td>
<td>0.422</td>
<td>0.14</td>
<td>0.476</td>
</tr>
<tr>
<td>W12 D12</td>
<td>0.391</td>
<td>0.12</td>
<td>0.408</td>
</tr>
<tr>
<td>W11 D11</td>
<td>0.374</td>
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</tr>
<tr>
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<td>0.357</td>
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<td>0.340</td>
</tr>
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<td>W9.5 D9</td>
<td>0.348</td>
<td>0.095</td>
<td>0.323</td>
</tr>
<tr>
<td>W9 D9</td>
<td>0.338</td>
<td>0.09</td>
<td>0.306</td>
</tr>
<tr>
<td>W8.5 D8</td>
<td>0.329</td>
<td>0.085</td>
<td>0.289</td>
</tr>
<tr>
<td>W8 D8</td>
<td>0.319</td>
<td>0.08</td>
<td>0.272</td>
</tr>
<tr>
<td>W7.5 D7</td>
<td>0.309</td>
<td>0.075</td>
<td>0.255</td>
</tr>
<tr>
<td>W7 D7</td>
<td>0.299</td>
<td>0.07</td>
<td>0.238</td>
</tr>
<tr>
<td>W6.5 D6</td>
<td>0.288</td>
<td>0.065</td>
<td>0.221</td>
</tr>
<tr>
<td>W6 D6</td>
<td>0.276</td>
<td>0.06</td>
<td>0.204</td>
</tr>
<tr>
<td>W5.5 D5</td>
<td>0.265</td>
<td>0.055</td>
<td>0.187</td>
</tr>
<tr>
<td>W5 D5</td>
<td>0.252</td>
<td>0.05</td>
<td>0.170</td>
</tr>
<tr>
<td>W4.5 D4</td>
<td>0.239</td>
<td>0.045</td>
<td>0.153</td>
</tr>
<tr>
<td>W4 D4</td>
<td>0.226</td>
<td>0.04</td>
<td>0.136</td>
</tr>
<tr>
<td>W3.5 D3</td>
<td>0.211</td>
<td>0.035</td>
<td>0.119</td>
</tr>
<tr>
<td>W2.9 D2</td>
<td>0.192</td>
<td>0.029</td>
<td>0.099</td>
</tr>
<tr>
<td>W2.5 D1</td>
<td>0.178</td>
<td>0.025</td>
<td>0.085</td>
</tr>
<tr>
<td>W2 D1</td>
<td>0.160</td>
<td>0.02</td>
<td>0.068</td>
</tr>
<tr>
<td>W1.4 D1</td>
<td>0.134</td>
<td>0.014</td>
<td>0.048</td>
</tr>
</tbody>
</table>
**QUANTITY TAKE-OFF**

**REBAR**

**Trick of the Trade #3:** When calculating the number of bars required find the total length divided by the spacing of the bars and add 1.

Example: You are building a 60 ft x 7.5 ft concrete wall. The design is the diagram below with 9 inch spacing of vertical rebar. Figure out the lbs of rebar required.

![Diagram of rebar placement](profile-view.png)

**Step 1:** Figure out the steel in the horizontal direction.
- It is given that there are 4 #3 bars = .376 lbs/ft
- It is given that the horizontal distance is 60 ft
- American Concrete Institute recommends concrete cover for slabs, joints, walls NOT exposed to ground 3/4 in

\[
\text{lbs of #3 rebar} = (4)(60\text{ft}-((2)(3/4\text{in})/12))(.376\text{lbs/ft}) = 90 \text{ lbs}
\]

**Step 2:** Figure out the steel in the vertical direction.
- It is given there are #4 = .668 lbs/ft
- Using the above trick of trade, \(((60\text{ft})(12\text{in}/\text{ft})/9\text{in}) = 80 \text{ bars} + 1 = 81 \text{ bars required}
- ACI recommends concrete cover for concrete exposed to the ground of 1.5 inches, so you should estimate 1.5 in off the ground and .75 in on top of wall.
- So the total length on one #4 rebar is 7.5 ft - ((1.5/12) - (.75/12)) = 7.31 ft

\[
\text{lbs of #4 rebar} = 81(7.31\text{ft})(.668\text{lbs/ft}) = 396 \text{ lbs}
\]

**Step 3:** Find the total lbs of rebar
- 90 lbs + 396 lbs = 486 lbs
Question #3: Find the weight of the steel rebar in concrete filled drilled shaft which is 35 ft deep. The design calls for 8 vertical #10 rebars, and the ties every 5ft are #4 rebar. The diameter of the cylinder is 2 ft. Disregard any concrete cover offset for steel length.

Answer #3:

Step 1: Find pounds of steel in the vertical direction.
- given 8 vertical bars = 8
- Total length of vertical bars = 35ft/bars x 8 bars = 280 ft
- weight of #10 = 4.303 lbs/ft
- total weight in the vertical direction = (4.303 lbs/ft)(280ft) = 1,205 lbs of #10 rebar

Step 2: Find pounds of steel in the horizontal direction.
- Find number of ties, using trick of trade #3, 35/5 +1 = 8 ties
- Find length of ties = circumference of the circle = Pi(2ft) = 6.283 ft
- Total length = (6.283 ft)(8) = 50.3 ft
- Weight of #4 rebar = .668lbs/ft
- Total Weight of #4 rebar = (.668lbs/ft)(50.3ft) = 33.6lbs

Step 3: Find total weight of Rebar.
- 1205lbs + 33.6lbs = 1238.6lbs
QUANTITY TAKE-OFF

ROOFING

Roof material quantity take-off are pretty easy trig problems, but I will go over it quick to make sure you get it, because most likely a question will be on the PE exam.

Trick of the Trade #4: When thinking of roof problems you just need to worry about three things.
1. The angle of the roof, or the rise/run of the roof
2. The width of the house plus the overhang of the roof
3. Always remember to add in all sections of the roof and multiply by length of rafters and by the length of the house

Example: Find the Roofs area if the roof has a 1/5 rise over run angle with a 3ft overhang. The length of the house is 75ft. The width of the house is 50 ft.

Step 1: Find the length of the roof
  - BC = 28ft
  - tan ABC = 1/5 = .20
  - tan⁻¹ 0.20 = 11.3°
  - AB cos 11.3 = BC
  - AB = BC/cos 11.3 = 28/cos 11.3
  - AB = 28ft/.9806 = 28.55ft

Step 2: Find the Area of the Roof
  - Area = 2 sides x (length of the rafter) x (length of the building)
  - Area = 2 x 28.55ft x 75ft
  - Area = 4,283ft²