

**American University of Beirut**

Faculty of Engineering & Architecture

Mechanical Engineering

**Tensile Testing for Metallic Materials**

**(Lab02)**

MECH 341 – Engineering Materials Lab

Section 4 (5:00 pm)

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**I. Objective:**

We performed in this experiment a tensile test on a high carbon steel specimen in the purpose of determining its mechanical properties and comparing these properties to those of the low carbon steel, to reveal the effect of carbon content in steel on varying its mechanical properties. This experiment is conducted in the same manner as the previous one: extracting the load deformation curve and then computing the stress strain curve which we use to calculate the same mechanical properties such as: modulus of elasticity , modulus of resilience, modulus of toughness, yield strength, tensile strength, ductility and energies at yield and break. However in this experiment we are interested additionally in comparing these properties with those of low carbon steel.

**II. Problem Approach:**

1. **Identifying the problem**

The machinery chosen for this experiment is the same as the previous one for low carbon steel. However, a serious point that needs our attention in this experiment is the specimen’s geometry: since we are interested in reaching the fracture point when conducting the tensile test so that we have the complete information about high carbon steel, we have to make sure that the load provided by the UTM machine is sufficient to attain fracture; our background information about high carbon steel states that for a cross-sectional diameter of 11 mm (as the one for the low carbon steel of the previous experiment), the load needed to achieve fracture exceeds 100 KN which is the maximum load that can be provided by the UTM machine. This dictates that we need to decrease the cross-sectional diameter of the high carbon steel specimen to 8 mm to observe fracture. Another issue is the strain rate: we increase the 3 mm/min strain rate used in the previous experiment to 5 mm/min, considering that high carbon steel exerts higher resistance to load than low carbon steel and increasing the strain rate allows us to obtain the same amount of deformation in a period of time shorter than that achieved with a 3 mm/min rate. Furthermore a higher strain rate increases brittleness of the specimen. All other experiment specifications are similar to those used for low carbon steel.

1. **Procedure**

The performance of the tensile test on the low carbon steel specimen requires the following steps:

1. A dog-bone specimen is prepared (Appendix A, figure 1), having a length of 200 mm, a cross-section diameter of 8 mm and a gage length of 25 mm.
2. The Hounsfield UTM testing machine is set to a strain rate of 5 mm/min.
3. The specimen is fixed tightly between the grips in a manner that ensures a pure axial force.
4. The force is applied until fracture occurs. During this step, the elongation is calculated by the extensometer equipped within the UTM machine and then displayed on its screen along with the corresponding force. At the same time, the force vs. elongation curve is sketched on the screen of the computer connected to the machine.

**III. Analysis & Calculations:**

**a. Engineering Stress:**

$$σ=\frac{F}{A\_{0}}$$

Where:

* $σ$ is the engineering stress
* F is the force applied (the data were given)
* Ao is the initial cross sectional area (Ao = 5.02x10-5 m2)

In order to check the results, please refer to Appendix C column IV

**b. Engineering Strain:**

$$ε=\frac{l-l\_{0}}{l\_{0}}=\frac{Δl}{l\_{0}}$$

Where:

* $ε$ is the engineering strain
* $Δl$ is the extension (the data were given)
* $l\_{o}$ is the initial gage length (25 mm)

In order to check the results, please refer to Appendix C column III

**c. True Stress:**

$$σ\_{T}=\frac{F}{A\_{i}}=σ(1+ε)$$

Where:

* $σ\_{T}$ is the true stress
* $A\_{i}$ is the instantaneous cross sectional area at which deformation is occurring

In order to check the results, please refer to Appendix C column VI

**d. True Strain:**

$$ε\_{T}=ln\left(\frac{l\_{i}}{l\_{o}}\right)=ln(1+ε)$$

Where:

* $ε\_{T}$ is the true strain
* $l\_{i}$ is the instantaneous gage length which deformation is occurring

In order to check the results, please refer to Appendix C column V

**e.** **Proportional Limit Stress:**

$σ\_{pl}$ = 426.5MPa; it is determined from the stress-strain curve at the point where it become non-linear. (Appendix B; Figure 2; point A)

**f. Upper Yield Point Stress:**

$σ\_{y-upper}$ = 465.53 MPa; it is the first stress maximum from the stress-strain curve where the curve goes horizontal. (Appendix B, Figure 2; point B)

**g. Lower Yield Point Stress:**

$σ\_{y-lower}$ = 443.25 MPa; it is the first stress minimum from the stress-strain curve subsequent to the upper yield point stress. (Appendix B, Figure 2; point C)

**h. Modulus of Elasticity:**

$E=\frac{Δσ}{Δε}=$ 124.0 GPa; it is determined by the slope of the initial linear elastic part of the stress-strain curve. (Appendix B, Figure 4)

**i. 0.2% Offset Yield Stress:**

$σ\_{0.2\% y}$ = 446.4 MPa; it is determined by the stress value at which a line drawn with slope E starting at 0.2% (0.002) strain intersects the curve. (Appendix B, figure 5; point B)

Note that: $σ\_{y-lower}<σ\_{0.2\% y}<σ\_{y-upper}$

**j. Ultimate Tensile Stress:**

$σ\_{ult}=$ 686.75 MPa; it is determined by the largest value of stress on the curve. (Appendix B, Figure 2; point D)

**k. Engineering Fracture Stress:**

$σ\_{fracture}=\frac{Fracture Load}{Initial Area}=\frac{F\_{f}}{A\_{0}}=\frac{33160}{\frac{π}{4}(8x10^{-3})^{2}}^{N}/\_{m^{2}}$= 659.69 MPa (Appendix B, figure 2; point E)

**l. True Fracture Stress:**

$σ\_{True fracture}=\frac{Fracture Load}{Fracture Area}=\frac{F\_{f}}{A\_{i}}=\frac{33160}{\frac{π}{4}(6.8x10^{-3})^{2}}^{N}/\_{m^{2}}$ = 913.075 MPa

(Appendix B, figure 3; point A)

**m. Modulus of Resilience:**

$U\_{r}=\frac{1}{2}σ\_{y}ε\_{y}$ ; It is defined as the area under elastic portion of the stress strain curve.

Also, $=Eε\gg ε=\frac{σ}{E}$ ; $U\_{r}=\frac{1}{2}σ\_{y}\frac{σ\_{y}}{E}=\frac{σ\_{y}^{2}}{2E}$

$U\_{r}=$1.224 MPa

**n. Modulus of toughness**

$U\_{t}$ is defined by the area under the entire stress strain curve, since the difference between two consecutive values are an ε (too small), we can assume a linear relation between those values and the area under the corresponding curve is equal to the trapezoid area. Then Ut is the sum of all the areas under the stress strain curve and is defined by:

$$U\_{t}=\sum\_{i=0}^{n-1}\frac{1}{2}\left(σ\_{i+1}+σ\_{i}\right)(ε\_{i+1}-ε\_{i})$$

$U\_{t}=$ 100.499 MPa, (refer to Appendix C Column VII)

**o. Energy at yield**

It is area under the elastic portion of the load-deformation curve;

Energyyield= 1538.4 N.mm

**p. Energy at break**

It is area under the entire load-deformation curve;

Energybreak= 126290.4 N.mm

(Refer to Appendix C Column VIII)

**q. Percent Elongation**

$$\%El=\frac{l-l\_{0}}{l\_{0}}x100=\frac{204.02-200}{200}x100=2.01 \%$$

**r. Percent Elongation L” Gage length**

$$\%El=\frac{l\_{g}-l\_{g0}}{l\_{g0}}x100=\frac{29.02-25}{25}x100=16.08\%$$

**s. Percent reduction of Area:**

$$\%RA=\left(\frac{A\_{0}-A\_{f}}{A\_{0}}\right)x100=\frac{\frac{1}{4}πd\_{o}^{2}-\frac{1}{4}πd\_{f}^{2}}{\frac{1}{4}πd\_{o}^{2}}x100=\frac{8^{2}-6.8^{2}}{8^{2}}x100$$

$\%RA=$27.75 %

**IV. Comparison:**

|  |  |  |
| --- | --- | --- |
|  | **Low carbon steel** | **High carbon steel** |
| Engineering Stress Strain Curve | Appendix B; Figure 7 |
| True Stress Strain Curve | Appendix D; Figure 8 |
| Load Deformation Curve | Appendix B; Figure 9 |
| Proportional Limit Stress | $σ\_{pl}$ = 490 Mpa | $σ\_{pl}$ = 426.5MPa |
| Yield Stress: | $σ\_{y}$ = 500.35 Mpa | $σ\_{y-upper}$ = 465.53 MPa $σ\_{y-lower}$ = 443.25 MPa |
| Modulus of Elasticity | E= 416.67 GPa | $$E=124.0 GPa$$ |
| 0.2% Offset Yield Stress | $σ\_{0.2\% y}$ = 496.14 Mpa | $σ\_{0.2\% y}$ = 446.4 MPa |
| Ultimate Tensile Stress | $σ\_{ult}=518.24$ Mpa | $σ\_{ult}=$ 686.75 MPa |
| Engineering Fracture Stress | $$σ\_{fracture}= 470.36 MPa$$ | $$σ\_{fracture}=659.69 MPa $$ |
| True Fracture Stress | $$σ\_{True fracture}= 663.73 MPa$$ | $$σ\_{True fracture }= 913.075 MPa$$ |
| Modulus of Resilience | $U\_{r}= $3004.17 Pa | $U\_{r}=$1.224 MPa |
| Modulus of toughness | $U\_{t}=$73.62 Mpa | $U\_{t}=$ 100.499 MPa |
| Energy at yield | Energyyield= 633.15 N.mm | Energyyield= 1538.4 N.mm |
| Energy at break | Energybreak= 174919.5 N.mm | Energybreak= 126290.4 N.mm |
| Percent Elongation | $$\%El=1.83\%$$ | $$\%El=2.01 \%$$ |
| Percent Elongation L” Gage length | $$\%El=14.67\%$$ | $$\%El=16.08\%$$ |
| Percent reduction of Area | $$\%RA=29.13\%$$ | $\%RA=$27.75 % |

These comparisons have shown that high carbon steel possesses less yield strength (465 MPa) than low carbon steel (500 MPa), although this contradicts the expected results because high carbon steel is expected to have more strength than low carbon steel. Another result is that ultimate strength is as expected higher for high carbon steel (686.75 MPa) than low carbon steel(518 MPa). These values for tensile strength are used to get the carbon content from the graph relating tensile and yield strength and Brinell hardness to specimen composition. (Appendix B; Figure 10). We find that carbon content for our low carbon steel specimen was 0.25% and for our high carbon steel specimen 0.48%. And as a final example, ductility represented by percent reduction of area (27.75 % for high carbon and 29.13 % for low carbon steel) shows how high carbon steel is more brittle than low carbon steel although brittleness of this high carbon steel specimen is not very apparent in this experiment. We cannot compare energies at yield and break because they are extracted from load-deformation curves which include the effect of cross-sectional area different for the two specimens.

**V. Observation:**

|  |  |
| --- | --- |
| **Low carbon steel** | **High carbon steel** |
| 1. At the beginning of the experiment, there are no noticeable changes in the specimen. The graph appears to be linear and almost vertical with infinite slope.
 | Results at first are similar to those of low carbon steel: we see no changes in the specimen and the graph of load vs. deformation is linear (elastic region). (Appendix B; Figure 9) |
| 1. After a certain point, the yield point, the graph begins to take a horizontal shape but still there are no observable deformations. Until this point the force applied continues to increase.
 | At some point the graph starts to take a horizontal shape because the slip planes (45o angle) start to form and exert resistance to deformation. This describes the perfectly plastic behavior. After a small horizontal path, the strain hardening region begins where the curve begins to increase again until reaching the upper then lower yield point after which plastic deformation begins.  |
| 1. At the ultimate point, we notice that the force starts to decrease, and a neck starts to appear at the center of the gage length. This is due to the fact that when the surface area decreases due to necking, the force required to maintain the constant strain rate decreases.
 | The force starts decreasing after a critical point, the ultimate tensile strength, and necking occurs slightly. However, comparing the brittle nature of high carbon steel to the ductility of the low carbon steel, necking in the former case is less noticeable than the latter, and lasts a shorter period of time considering high carbon steel doesn’t experience plastic deformation before fracture as much as low carbon steel. More particularly, the specimen in our experiment showed to some extent more ductility than the costumed high carbon steel.  |
| 1. The force applied continues to decrease and the necking becomes more perceptible until the fracture point where the whole specimen breaks at the point where the neck became too accentuated emitting a loud sound and forming a cup-and-cone shape on the fracture surfaces.
 | At fracture, the specimen breaks at the neck site making a loud noise and the fracture surface appears strangely to have an almost cup-and cone shape with two aspects: one shiny smooth surface that corresponds to brittle behavior and another surface that displays 45 degrees slip planes indication the presence of plastic deformation. |
| 1. The fracture surface shows that the crack that led to fracture was initiated at the center of the cross sectional surface and then propagated to the circumference of that surface.
 | The fracture surface shows a line initiating crack: the crack was initiated at the line separating the two different surfaces described in part 4 and then propagated to the circumference of the surface. This is somehow different from the usual behavior of the brittle high carbon steel at fracture where the crack initiates from one point on the surface boundary and propagates in other directions all over the surface. |
| 1. The energy transferred to the specimen by the applied load is transformed into thermal energy. This energy appears as the surface close to the fracture point is slightly heated.
 | A minor heating also shows at the region near fracture. |

**VI. Conclusion:**

In this experiment we have determined mechanical properties of high carbon steel and demonstrated the effect of carbon content by comparison with low carbon steel. The comparisons included numerical values of properties, the meaning of the differences in values, differences in problem approach and procedure of the way the experiment is conducted and in the observations made at the end of each experiment. All these revealed how increasing carbon content in steel blocks the movement of dislocations which makes the steel more resistant to plastic deformation and therefore has lower ductility and higher strength and hardness. However, it should be noted that our high carbon steel specimen did not actually illustrate these effects because it turned out to have considerable high ductility since it was close to that of the low carbon steel from the previous experiment, and strangely lower yield strength than that of low carbon steel. These odd results could be a consequence of problems in manufacturing, material under study, or from measurements.

**VII. Appendix A:**

***Given Data***

|  |  |
| --- | --- |
| Specimen Number | 13 |
| Gage length | 25 mm |
| Cross Section Diameter (Initial) | http://www.sckcen.be/var/plain_site/storage/images/media/images/philippe_gouat/tensile_specimen/19376-1-eng-GB/tensile_specimen.jpg8 mm |
| Uniform Elongation Diameter  | 7.7 mm |
| Diameter at Fracture | 6.8 mm |

|  |  |
| --- | --- |
| Dimension | Drawing1-ModelValue (mm) |
| A- Length of narrow section | 80 |
| D- Diameter | 9 |
| C- Outer Diameter | 18 |
| R- Radius of fillet | 2 |
| L- Length overall | 200 |
| G- Gage Length | 25 |

Table 1: Specimen’s dimensions

Figure 1: Dog bone tensile test specimen

***Note:*** Elongation (Extension) and force applied data are found in Appendix C, Column I & II respectively.

**VIII. Appendix B**

***Figures & Graphs***

A

C

B

B

D

E

Figure 2: Engineering Stress vs. Engineering Strain curve, where point:

A: Proportional Stress limit.

B: Upper yield stress

C: Lower yield stress

D: Ultimate stress

E: Engineering fracture stress

A

Figure 3: True Stress vs. True Strain curve, where point:

A: True fracture stress

Figure 4: Best fit plot for the linear elastic region on an enlarged scale.

B

C

A

Figure 5: Plot of the 0.2% yield offset line on the stress strain curve on an enlarged scale.

A: Upper yield stress.

B: 0.2% offset yield stress.

C: Lower yield Stress.

Figure 6: Load deformation curve, force vs. elongation for a high carbon steel.

Curve A

Curve B

Figure 7: Engineering stress vs. engineering strain of low carbon steel and high carbon steel.

Curve A: Low Carbon

Curve B: High Carbon

Curve B

Curve A

Figure 8: True stress vs. True strain of low carbon steel and high carbon steel.

Curve A: Low Carbon

Curve B: High Carbon

Curve A

Curve B

Figure 9: Load deformation curve of low carbon steel and high carbon steel.

Curve A: Low Carbon

Curve B: High Carbon



Figure 10: Yield strength, tensile strength, and Brinell Hardness as a function of composition in wt % C.

**IX. Appendix C:**

***Calculation Table***

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **I** | **II** | **III** | **IV** | **V** | **VI** | **VII** | **VIII** |
| **Extension****(Elongation)** | **Force** | **Engineering Stain** | **Engineering****Stress** | **True****Stain** | **True****Stress** | **Trapezoid area Under Stress Strain Curve** | **Trapezoid area Under Load def. Curve** |
| **(mm)** | **(N)** | **(mm/mm)** | **(Pa)** | **(mm/mm)** | **(Pa)** | **(Pa)** | **(N.mm)** |
| 0 | 40 | 0 | 795774.729 | 0 | 795774.729 | - | - |
| 0.015 | 10120 | 0.0006 | 201331006.4 | 0.00059982 | 201451805 | 60638.03435 | 76.2 |
| 0.03 | 13800 | 0.0012 | 274542281.5 | 0.001199281 | 274871732.3 | 142761.9864 | 179.4 |
| 0.045 | 21440 | 0.0018 | 426535254.8 | 0.001798382 | 427303018.2 | 210323.2609 | 264.3 |
| 0.06 | 22280 | 0.0024 | 443246524.1 | 0.002397125 | 444310315.7 | 260934.5337 | 327.9 |
| 0.075 | 23200 | 0.003 | 461549342.8 | 0.002995509 | 462933990.9 | 271438.7601 | 341.1 |
| 0.09 | 23400 | 0.0036 | 465528216.5 | 0.003593536 | 467204118.1 | 278123.2678 | 349.5 |
| 0.105 | 23160 | 0.0042 | 460753568.1 | 0.004191205 | 462688733.1 | 277884.5354 | 349.2 |
| 0.12 | 22960 | 0.0048 | 456774694.5 | 0.004788517 | 458967213 | 275258.4788 | 345.9 |
| 0.135 | 22720 | 0.0054 | 452000046.1 | 0.005385472 | 454440846.3 | 272632.4222 | 342.6 |
| 0.15 | 22520 | 0.006 | 448021172.4 | 0.005982072 | 450709299.5 | 270006.3656 | 339.3 |
| 0.165 | 22280 | 0.0066 | 443246524.1 | 0.006578315 | 446171951.1 | 267380.309 | 336 |
| 0.18 | 22480 | 0.0072 | 447225397.7 | 0.007174204 | 450445420.6 | 267141.5765 | 335.7 |
| 0.195 | 22680 | 0.0078 | 451204271.4 | 0.007769737 | 454723664.7 | 269528.9007 | 338.7 |
| 0.21 | 22800 | 0.0084 | 453591595.5 | 0.008364916 | 457401765 | 271438.7601 | 341.1 |
| 0.225 | 22880 | 0.009 | 455183145 | 0.008959741 | 459279793.3 | 272632.4222 | 342.6 |
| 0.24 | 22880 | 0.0096 | 455183145 | 0.009554213 | 459552903.2 | 273109.887 | 343.2 |
| 0.255 | 22880 | 0.0102 | 455183145 | 0.010148331 | 459826013.1 | 273109.887 | 343.2 |
| 0.27 | 22840 | 0.0108 | 454387370.3 | 0.010742097 | 459294753.9 | 272871.1546 | 342.9 |
| 0.285 | 22800 | 0.0114 | 453591595.5 | 0.01133551 | 458762539.7 | 272393.6897 | 342.3 |
| 0.3 | 22800 | 0.012 | 453591595.5 | 0.011928571 | 459034694.7 | 272154.9573 | 342 |
| 0.315 | 22800 | 0.0126 | 453591595.5 | 0.012521281 | 459306849.7 | 272154.9573 | 342 |
| 0.33 | 22760 | 0.0132 | 452795820.8 | 0.013113639 | 458772725.7 | 271916.2249 | 341.7 |
| 0.345 | 22480 | 0.0138 | 447225397.7 | 0.013705647 | 453397108.2 | 270006.3656 | 339.3 |
| 0.36 | 22920 | 0.0144 | 455978919.7 | 0.014297305 | 462545016.2 | 270961.2952 | 340.5 |
| 0.375 | 23280 | 0.015 | 463140892.3 | 0.014888612 | 470088005.7 | 275735.9436 | 346.5 |
| 0.39 | 23200 | 0.0156 | 461549342.8 | 0.015479571 | 468749512.6 | 277407.0705 | 348.6 |
| 0.405 | 23600 | 0.0162 | 469507090.1 | 0.01607018 | 477113105 | 279316.9299 | 351 |
| 0.42 | 23920 | 0.0168 | 475873288 | 0.016660441 | 483867959.2 | 283614.1134 | 356.4 |
| 0.435 | 24200 | 0.0174 | 481443711.1 | 0.017250353 | 489820831.6 | 287195.0997 | 360.9 |
| 0.45 | 24360 | 0.018 | 484626810 | 0.017839918 | 493350092.6 | 289821.1563 | 364.2 |
| 0.465 | 24640 | 0.0186 | 490197233.1 | 0.018429135 | 499314901.6 | 292447.2129 | 367.5 |
| 0.48 | 24800 | 0.0192 | 493380332 | 0.019018006 | 502853234.4 | 295073.2695 | 370.8 |
| 0.495 | 25080 | 0.0198 | 498950755.1 | 0.01960653 | 508829980.1 | 297699.3261 | 374.1 |
| 0.51 | 25200 | 0.0204 | 501338079.3 | 0.020194707 | 511565376.1 | 300086.6503 | 377.1 |
| 0.525 | 25360 | 0.021 | 504521178.2 | 0.020782539 | 515116122.9 | 301757.7772 | 379.2 |
| 0.54 | 25480 | 0.0216 | 506908502.4 | 0.021370026 | 517857726 | 303428.9042 | 381.3 |
| 0.555 | 25760 | 0.0222 | 512478925.5 | 0.021957167 | 523855957.6 | 305816.2284 | 384.3 |
| 0.57 | 25880 | 0.0228 | 514866249.7 | 0.022543964 | 526605200.2 | 308203.5526 | 387.3 |
| 0.585 | 26160 | 0.0234 | 520436672.8 | 0.023130417 | 532614890.9 | 310590.8767 | 390.3 |
| 0.6 | 26240 | 0.024 | 522028222.2 | 0.023716527 | 534556899.6 | 312739.4685 | 393 |
| 0.615 | 26520 | 0.0246 | 527598645.3 | 0.024302293 | 540577572 | 314888.0603 | 395.7 |
| 0.63 | 26640 | 0.0252 | 529985969.5 | 0.024887716 | 543341616 | 317275.3845 | 398.7 |
| 0.645 | 26760 | 0.0258 | 532373293.7 | 0.025472796 | 546108524.7 | 318707.779 | 400.5 |
| 0.66 | 26880 | 0.0264 | 534760617.9 | 0.026057534 | 548878298.2 | 320140.1735 | 402.3 |
| 0.675 | 27120 | 0.027 | 539535266.3 | 0.026641931 | 554102718.5 | 322288.7653 | 405 |
| 0.69 | 27240 | 0.0276 | 541922590.5 | 0.027225986 | 556879654 | 324437.357 | 407.7 |
| 0.705 | 27480 | 0.0282 | 546697238.8 | 0.027809701 | 562114101 | 326585.9488 | 410.4 |
| 0.72 | 27560 | 0.0288 | 548288788.3 | 0.028393075 | 564079505.4 | 328495.8081 | 412.8 |
| 0.735 | 27640 | 0.0294 | 549880337.8 | 0.028976108 | 566046819.7 | 329450.7378 | 414 |
| 0.75 | 27840 | 0.03 | 553859211.4 | 0.029558802 | 570474987.7 | 331121.8648 | 416.1 |
| 0.765 | 28040 | 0.0306 | 557838085.1 | 0.030141157 | 574907930.5 | 333509.1889 | 419.1 |
| 0.78 | 28160 | 0.0312 | 560225409.2 | 0.030723173 | 577704442 | 335419.0483 | 421.5 |
| 0.795 | 28240 | 0.0318 | 561816958.7 | 0.03130485 | 579682738 | 336612.7104 | 423 |
| 0.81 | 28360 | 0.0324 | 564204282.9 | 0.031886189 | 582484501.7 | 337806.3725 | 424.5 |
| 0.825 | 28560 | 0.033 | 568183156.5 | 0.03246719 | 586933200.7 | 339716.2318 | 426.9 |
| 0.84 | 28680 | 0.0336 | 570570480.7 | 0.033047854 | 589741648.9 | 341626.0912 | 429.3 |
| 0.855 | 28760 | 0.0342 | 572162030.2 | 0.033628181 | 591729971.6 | 342819.7533 | 430.8 |
| 0.87 | 28880 | 0.0348 | 574549354.4 | 0.034208171 | 594543671.9 | 344013.4154 | 432.3 |
| 0.885 | 29080 | 0.0354 | 578528228 | 0.034787825 | 599008127.3 | 345923.2747 | 434.7 |
| 0.9 | 29200 | 0.036 | 580915552.2 | 0.035367144 | 601828512.1 | 347833.1341 | 437.1 |
| 0.915 | 29280 | 0.0366 | 582507101.7 | 0.035946127 | 603826861.6 | 349026.7962 | 438.6 |
| 0.93 | 29360 | 0.0372 | 584098651.1 | 0.036524775 | 605827120.9 | 349981.7258 | 439.8 |
| 0.945 | 29560 | 0.0378 | 588077524.8 | 0.037103088 | 610306855.2 | 351652.8528 | 441.9 |
| 0.96 | 29640 | 0.0384 | 589669074.2 | 0.037681067 | 612312366.7 | 353323.9797 | 444 |
| 0.975 | 29720 | 0.039 | 591260623.7 | 0.038258712 | 614319788 | 354278.9094 | 445.2 |
| 0.99 | 29840 | 0.0396 | 593647947.9 | 0.038836024 | 617156406.6 | 355472.5715 | 446.7 |
| 1.005 | 29920 | 0.0402 | 595239497.3 | 0.039413002 | 619168125.1 | 356666.2336 | 448.2 |
| 1.02 | 30000 | 0.0408 | 596831046.8 | 0.039989648 | 621181753.5 | 357621.1632 | 449.4 |
| 1.035 | 30200 | 0.0414 | 600809920.4 | 0.040565962 | 625683451.1 | 359292.2902 | 451.5 |
| 1.05 | 30280 | 0.042 | 602401469.9 | 0.041141943 | 627702331.6 | 360963.4171 | 453.6 |
| 1.065 | 30360 | 0.0426 | 603993019.3 | 0.041717593 | 629723122 | 361918.3468 | 454.8 |
| 1.08 | 30440 | 0.0432 | 605584568.8 | 0.042292912 | 631745822.2 | 362873.2764 | 456 |
| 1.095 | 30560 | 0.0438 | 607971893 | 0.0428679 | 634601061.9 | 364066.9385 | 457.5 |
| 1.11 | 30640 | 0.0444 | 609563442.4 | 0.043442558 | 636628059.3 | 365260.6006 | 459 |
| 1.125 | 30760 | 0.045 | 611950766.6 | 0.044016885 | 639488551.1 | 366454.2627 | 460.5 |
| 1.14 | 30800 | 0.0456 | 612746541.4 | 0.044590883 | 640687783.6 | 367409.1924 | 461.7 |
| 1.155 | 30960 | 0.0462 | 615929640.3 | 0.045164552 | 644385589.7 | 368602.8545 | 463.2 |
| 1.17 | 31040 | 0.0468 | 617521189.7 | 0.045737892 | 646421181.4 | 370035.249 | 465 |
| 1.185 | 31080 | 0.0474 | 618316964.5 | 0.046310903 | 647625188.6 | 370751.4463 | 465.9 |
| 1.2 | 31160 | 0.048 | 619908513.9 | 0.046883586 | 649664122.6 | 371467.6435 | 466.8 |
| 1.215 | 31240 | 0.0486 | 621500063.4 | 0.047455941 | 651704966.5 | 372422.5732 | 468 |
| 1.23 | 31280 | 0.0492 | 622295838.1 | 0.048027969 | 652912793.3 | 373138.7704 | 468.9 |
| 1.245 | 31440 | 0.0498 | 625478937 | 0.04859967 | 656627788.1 | 374332.4325 | 470.4 |
| 1.26 | 31520 | 0.0504 | 627070486.5 | 0.049171044 | 658674839 | 375764.827 | 472.2 |
| 1.275 | 31560 | 0.051 | 627866261.2 | 0.049742092 | 659887440.5 | 376481.0243 | 473.1 |
| 1.29 | 31640 | 0.0516 | 629457810.7 | 0.050312814 | 661937833.7 | 377197.2216 | 474 |
| 1.305 | 31680 | 0.0522 | 630253585.4 | 0.05088321 | 663152822.6 | 377913.4188 | 474.9 |
| 1.32 | 31760 | 0.0528 | 631845134.9 | 0.051453282 | 665206558 | 378629.6161 | 475.8 |
| 1.335 | 31880 | 0.0534 | 634232459 | 0.052023028 | 668100472.4 | 379823.2782 | 477.3 |
| 1.35 | 31920 | 0.054 | 635028233.8 | 0.05259245 | 669319758.4 | 380778.2078 | 478.5 |
| 1.365 | 32000 | 0.0546 | 636619783.2 | 0.053161548 | 671379223.4 | 381494.4051 | 479.4 |
| 1.38 | 32040 | 0.0552 | 637415558 | 0.053730322 | 672600896.8 | 382210.6024 | 480.3 |
| 1.395 | 32120 | 0.0558 | 639007107.4 | 0.054298773 | 674663704 | 382926.7996 | 481.2 |
| 1.41 | 32160 | 0.0564 | 639802882.1 | 0.054866901 | 675887764.7 | 383642.9969 | 482.1 |
| 1.425 | 32200 | 0.057 | 640598656.9 | 0.055434707 | 677112780.3 | 384120.4617 | 482.7 |
| 1.44 | 32240 | 0.0576 | 641394431.6 | 0.05600219 | 678338750.9 | 384597.9265 | 483.3 |
| 1.455 | 32360 | 0.0582 | 643781755.8 | 0.056569351 | 681249854 | 385552.8562 | 484.5 |
| 1.47 | 32400 | 0.0588 | 644577530.5 | 0.057136191 | 682478689.3 | 386507.7859 | 485.7 |
| 1.485 | 32480 | 0.0594 | 646169080 | 0.05770271 | 684551523.3 | 387223.9831 | 486.6 |
| 1.5 | 32520 | 0.06 | 646964854.7 | 0.058268908 | 685782746 | 387940.1804 | 487.5 |
| 1.515 | 32560 | 0.0606 | 647760629.4 | 0.058834786 | 687014923.6 | 388417.6452 | 488.1 |
| 1.53 | 32600 | 0.0612 | 648556404.2 | 0.059400343 | 688248056.1 | 388895.1101 | 488.7 |
| 1.545 | 32640 | 0.0618 | 649352178.9 | 0.059965581 | 689482143.5 | 389372.5749 | 489.3 |
| 1.56 | 32720 | 0.0624 | 650943728.3 | 0.0605305 | 691562617 | 390088.7722 | 490.2 |
| 1.575 | 32760 | 0.063 | 651739503.1 | 0.061095099 | 692799091.8 | 390804.9694 | 491.1 |
| 1.59 | 32800 | 0.0636 | 652535277.8 | 0.06165938 | 694036521.5 | 391282.4343 | 491.7 |
| 1.605 | 32880 | 0.0642 | 654126827.3 | 0.062223343 | 696121769.6 | 391998.6315 | 492.6 |
| 1.62 | 32920 | 0.0648 | 654922602 | 0.062786988 | 697361586.6 | 392714.8288 | 493.5 |
| 1.635 | 32960 | 0.0654 | 655718376.7 | 0.063350316 | 698602358.6 | 393192.2936 | 494.1 |
| 1.65 | 33000 | 0.066 | 656514151.5 | 0.063913326 | 699844085.4 | 393669.7585 | 494.7 |
| 1.665 | 33040 | 0.0666 | 657309926.2 | 0.064476019 | 701086767.3 | 394147.2233 | 495.3 |
| 1.68 | 33080 | 0.0672 | 658105700.9 | 0.065038396 | 702330404 | 394624.6881 | 495.9 |
| 1.695 | 33120 | 0.0678 | 658901475.6 | 0.065600457 | 703574995.7 | 395102.153 | 496.5 |
| 1.71 | 33160 | 0.0684 | 659697250.4 | 0.066162202 | 704820542.3 | 395579.6178 | 497.1 |
| 1.725 | 33200 | 0.069 | 660493025.1 | 0.066723632 | 706067043.8 | 396057.0826 | 497.7 |
| 1.74 | 33200 | 0.0696 | 660493025.1 | 0.067284747 | 706463339.6 | 396295.8151 | 498 |
| 1.755 | 33240 | 0.0702 | 661288799.8 | 0.067845547 | 707711273.6 | 396534.5475 | 498.3 |
| 1.77 | 33280 | 0.0708 | 662084574.6 | 0.068406033 | 708960162.4 | 397012.0123 | 498.9 |
| 1.785 | 33320 | 0.0714 | 662880349.3 | 0.068966204 | 710210006.2 | 397489.4772 | 499.5 |
| 1.8 | 33360 | 0.072 | 663676124 | 0.069526063 | 711460804.9 | 397966.942 | 500.1 |
| 1.815 | 33400 | 0.0726 | 664471898.7 | 0.070085608 | 712712558.6 | 398444.4068 | 500.7 |
| 1.83 | 33440 | 0.0732 | 665267673.5 | 0.07064484 | 713965267.2 | 398921.8717 | 501.3 |
| 1.845 | 33440 | 0.0738 | 665267673.5 | 0.071203759 | 714364427.8 | 399160.6041 | 501.6 |
| 1.86 | 33480 | 0.0744 | 666063448.2 | 0.071762366 | 715618568.7 | 399399.3365 | 501.9 |
| 1.875 | 33520 | 0.075 | 666859222.9 | 0.072320662 | 716873664.7 | 399876.8013 | 502.5 |
| 1.89 | 33560 | 0.0756 | 667654997.7 | 0.072878645 | 718129715.5 | 400354.2662 | 503.1 |
| 1.905 | 33560 | 0.0762 | 667654997.7 | 0.073436318 | 718530308.5 | 400592.9986 | 503.4 |
| 1.92 | 33600 | 0.0768 | 668450772.4 | 0.07399368 | 719787791.7 | 400831.731 | 503.7 |
| 1.935 | 33640 | 0.0774 | 669246547.1 | 0.074550731 | 721046229.9 | 401309.1959 | 504.3 |
| 1.95 | 33680 | 0.078 | 670042321.8 | 0.075107472 | 722305623 | 401786.6607 | 504.9 |
| 1.965 | 33680 | 0.0786 | 670042321.8 | 0.075663904 | 722707648.3 | 402025.3931 | 505.2 |
| 1.98 | 33720 | 0.0792 | 670838096.6 | 0.076220026 | 723968473.8 | 402264.1255 | 505.5 |
| 1.995 | 33760 | 0.0798 | 671633871.3 | 0.076775839 | 725230254.2 | 402741.5904 | 506.1 |
| 2.01 | 33760 | 0.0804 | 671633871.3 | 0.077331343 | 725633234.6 | 402980.3228 | 506.4 |
| 2.025 | 33800 | 0.081 | 672429646 | 0.077886539 | 726896447.4 | 403219.0552 | 506.7 |
| 2.04 | 33800 | 0.0816 | 672429646 | 0.078441426 | 727299905.2 | 403457.7876 | 507 |
| 2.055 | 33840 | 0.0822 | 673225420.8 | 0.078996006 | 728564550.3 | 403696.52 | 507.3 |
| 2.07 | 33840 | 0.0828 | 673225420.8 | 0.079550279 | 728968485.6 | 403935.2525 | 507.6 |
| 2.085 | 33880 | 0.0834 | 674021195.5 | 0.080104244 | 730234563.2 | 404173.9849 | 507.9 |
| 2.1 | 33920 | 0.084 | 674816970.2 | 0.080657903 | 731501595.7 | 404651.4497 | 508.5 |
| 2.115 | 33920 | 0.0846 | 674816970.2 | 0.081211255 | 731906485.9 | 404890.1821 | 508.8 |
| 2.13 | 33960 | 0.0852 | 675612744.9 | 0.081764302 | 733174950.8 | 405128.9146 | 509.1 |
| 2.145 | 33960 | 0.0858 | 675612744.9 | 0.082317042 | 733580318.5 | 405367.647 | 509.4 |
| 2.16 | 34000 | 0.0864 | 676408519.7 | 0.082869478 | 734850215.8 | 405606.3794 | 509.7 |
| 2.175 | 34000 | 0.087 | 676408519.7 | 0.083421608 | 735256060.9 | 405845.1118 | 510 |
| 2.19 | 34040 | 0.0876 | 677204294.4 | 0.083973434 | 736527390.6 | 406083.8442 | 510.3 |
| 2.205 | 34040 | 0.0882 | 677204294.4 | 0.084524955 | 736933713.2 | 406322.5766 | 510.6 |
| 2.22 | 34080 | 0.0888 | 678000069.1 | 0.085076172 | 738206475.3 | 406561.3091 | 510.9 |
| 2.235 | 34080 | 0.0894 | 678000069.1 | 0.085627086 | 738613275.3 | 406800.0415 | 511.2 |
| 2.25 | 34120 | 0.09 | 678795843.9 | 0.086177696 | 739887469.8 | 407038.7739 | 511.5 |
| 2.265 | 34120 | 0.0906 | 678795843.9 | 0.086728004 | 740294747.3 | 407277.5063 | 511.8 |
| 2.28 | 34160 | 0.0912 | 679591618.6 | 0.087278008 | 741570374.2 | 407516.2387 | 512.1 |
| 2.295 | 34160 | 0.0918 | 679591618.6 | 0.08782771 | 741978129.2 | 407754.9712 | 512.4 |
| 2.31 | 34160 | 0.0924 | 679591618.6 | 0.088377111 | 742385884.2 | 407754.9712 | 512.4 |
| 2.325 | 34200 | 0.093 | 680387393.3 | 0.088926209 | 743663420.9 | 407993.7036 | 512.7 |
| 2.34 | 34240 | 0.0936 | 681183168.1 | 0.089475006 | 744941912.6 | 408471.1684 | 513.3 |
| 2.355 | 34240 | 0.0942 | 681183168.1 | 0.090023503 | 745350622.5 | 408709.9008 | 513.6 |
| 2.37 | 34240 | 0.0948 | 681183168.1 | 0.090571698 | 745759332.4 | 408709.9008 | 513.6 |
| 2.385 | 34240 | 0.0954 | 681183168.1 | 0.091119593 | 746168042.3 | 408709.9008 | 513.6 |
| 2.4 | 34280 | 0.096 | 681978942.8 | 0.091667189 | 747448921.3 | 408948.6333 | 513.9 |
| 2.415 | 34320 | 0.0966 | 682774717.5 | 0.092214484 | 748730755.2 | 409426.0981 | 514.5 |
| 2.43 | 34320 | 0.0972 | 682774717.5 | 0.09276148 | 749140420.1 | 409664.8305 | 514.8 |
| 2.445 | 34320 | 0.0978 | 682774717.5 | 0.093308177 | 749550084.9 | 409664.8305 | 514.8 |
| 2.46 | 34320 | 0.0984 | 682774717.5 | 0.093854575 | 749959749.7 | 409664.8305 | 514.8 |
| 2.475 | 34360 | 0.099 | 683570492.2 | 0.094400675 | 751243971 | 409903.5629 | 515.1 |
| 2.49 | 34360 | 0.0996 | 683570492.2 | 0.094946477 | 751654113.3 | 410142.2953 | 515.4 |
| 2.505 | 34360 | 0.1002 | 683570492.2 | 0.095491981 | 752064255.6 | 410142.2953 | 515.4 |
| 2.52 | 34400 | 0.1008 | 684366267 | 0.096037188 | 753350386.7 | 410381.0278 | 515.7 |
| 2.535 | 34400 | 0.1014 | 684366267 | 0.096582098 | 753761006.4 | 410619.7602 | 516 |
| 2.55 | 34400 | 0.102 | 684366267 | 0.097126711 | 754171626.2 | 410619.7602 | 516 |
| 2.565 | 34400 | 0.1026 | 684366267 | 0.097671027 | 754582246 | 410619.7602 | 516 |
| 2.58 | 34400 | 0.1032 | 684366267 | 0.098215047 | 754992865.7 | 410619.7602 | 516 |
| 2.595 | 34400 | 0.1038 | 684366267 | 0.098758772 | 755403485.5 | 410619.7602 | 516 |
| 2.61 | 34440 | 0.1044 | 685162041.7 | 0.099302201 | 756692958.9 | 410858.4926 | 516.3 |
| 2.625 | 34440 | 0.105 | 685162041.7 | 0.099845335 | 757104056.1 | 411097.225 | 516.6 |
| 2.64 | 34440 | 0.1056 | 685162041.7 | 0.100388174 | 757515153.3 | 411097.225 | 516.6 |
| 2.655 | 34440 | 0.1062 | 685162041.7 | 0.100930719 | 757926250.5 | 411097.225 | 516.6 |
| 2.67 | 34440 | 0.1068 | 685162041.7 | 0.101472969 | 758337347.8 | 411097.225 | 516.6 |
| 2.685 | 34480 | 0.1074 | 685957816.4 | 0.102014925 | 759629685.9 | 411335.9574 | 516.9 |
| 2.7 | 34480 | 0.108 | 685957816.4 | 0.102556588 | 760041260.6 | 411574.6899 | 517.2 |
| 2.715 | 34480 | 0.1086 | 685957816.4 | 0.103097958 | 760452835.3 | 411574.6899 | 517.2 |
| 2.73 | 34480 | 0.1092 | 685957816.4 | 0.103639035 | 760864410 | 411574.6899 | 517.2 |
| 2.745 | 34480 | 0.1098 | 685957816.4 | 0.104179819 | 761275984.7 | 411574.6899 | 517.2 |
| 2.76 | 34480 | 0.1104 | 685957816.4 | 0.104720311 | 761687559.4 | 411574.6899 | 517.2 |
| 2.775 | 34480 | 0.111 | 685957816.4 | 0.105260511 | 762099134.1 | 411574.6899 | 517.2 |
| 2.79 | 34480 | 0.1116 | 685957816.4 | 0.105800419 | 762510708.7 | 411574.6899 | 517.2 |
| 2.805 | 34480 | 0.1122 | 685957816.4 | 0.106340036 | 762922283.4 | 411574.6899 | 517.2 |
| 2.82 | 34480 | 0.1128 | 685957816.4 | 0.106879362 | 763333858.1 | 411574.6899 | 517.2 |
| 2.835 | 34480 | 0.1134 | 685957816.4 | 0.107418397 | 763745432.8 | 411574.6899 | 517.2 |
| 2.85 | 34520 | 0.114 | 686753591.2 | 0.107957142 | 765043500.5 | 411813.4223 | 517.5 |
| 2.865 | 34520 | 0.1146 | 686753591.2 | 0.108495596 | 765455552.7 | 412052.1547 | 517.8 |
| 2.88 | 34520 | 0.1152 | 686753591.2 | 0.109033761 | 765867604.9 | 412052.1547 | 517.8 |
| 2.895 | 34520 | 0.1158 | 686753591.2 | 0.109571636 | 766279657 | 412052.1547 | 517.8 |
| 2.91 | 34520 | 0.1164 | 686753591.2 | 0.110109223 | 766691709.2 | 412052.1547 | 517.8 |
| 2.925 | 34520 | 0.117 | 686753591.2 | 0.11064652 | 767103761.3 | 412052.1547 | 517.8 |
| 2.94 | 34520 | 0.1176 | 686753591.2 | 0.111183529 | 767515813.5 | 412052.1547 | 517.8 |
| 2.955 | 34520 | 0.1182 | 686753591.2 | 0.11172025 | 767927865.6 | 412052.1547 | 517.8 |
| 2.97 | 34520 | 0.1188 | 686753591.2 | 0.112256682 | 768339917.8 | 412052.1547 | 517.8 |
| 2.985 | 34520 | 0.1194 | 686753591.2 | 0.112792827 | 768751969.9 | 412052.1547 | 517.8 |
| 3 | 34520 | 0.12 | 686753591.2 | 0.113328685 | 769164022.1 | 412052.1547 | 517.8 |
| 3.015 | 34520 | 0.1206 | 686753591.2 | 0.113864256 | 769576074.2 | 412052.1547 | 517.8 |
| 3.03 | 34520 | 0.1212 | 686753591.2 | 0.11439954 | 769988126.4 | 412052.1547 | 517.8 |
| 3.045 | 34520 | 0.1218 | 686753591.2 | 0.114934538 | 770400178.6 | 412052.1547 | 517.8 |
| 3.06 | 34520 | 0.1224 | 686753591.2 | 0.11546925 | 770812230.7 | 412052.1547 | 517.8 |
| 3.075 | 34520 | 0.123 | 686753591.2 | 0.116003676 | 771224282.9 | 412052.1547 | 517.8 |
| 3.09 | 34480 | 0.1236 | 685957816.4 | 0.116537816 | 770742202.5 | 411813.4223 | 517.5 |
| 3.105 | 34480 | 0.1242 | 685957816.4 | 0.117071672 | 771153777.2 | 411574.6899 | 517.2 |
| 3.12 | 34480 | 0.1248 | 685957816.4 | 0.117605242 | 771565351.9 | 411574.6899 | 517.2 |
| 3.135 | 34480 | 0.1254 | 685957816.4 | 0.118138528 | 771976926.6 | 411574.6899 | 517.2 |
| 3.15 | 34480 | 0.126 | 685957816.4 | 0.11867153 | 772388501.3 | 411574.6899 | 517.2 |
| 3.165 | 34480 | 0.1266 | 685957816.4 | 0.119204247 | 772800076 | 411574.6899 | 517.2 |
| 3.18 | 34480 | 0.1272 | 685957816.4 | 0.119736682 | 773211650.7 | 411574.6899 | 517.2 |
| 3.195 | 34480 | 0.1278 | 685957816.4 | 0.120268832 | 773623225.4 | 411574.6899 | 517.2 |
| 3.21 | 34480 | 0.1284 | 685957816.4 | 0.1208007 | 774034800.1 | 411574.6899 | 517.2 |
| 3.225 | 34480 | 0.129 | 685957816.4 | 0.121332285 | 774446374.7 | 411574.6899 | 517.2 |
| 3.24 | 34440 | 0.1296 | 685162041.7 | 0.121863588 | 773959042.3 | 411335.9574 | 516.9 |
| 3.255 | 34440 | 0.1302 | 685162041.7 | 0.122394608 | 774370139.5 | 411097.225 | 516.6 |
| 3.27 | 34440 | 0.1308 | 685162041.7 | 0.122925347 | 774781236.8 | 411097.225 | 516.6 |
| 3.285 | 34440 | 0.1314 | 685162041.7 | 0.123455804 | 775192334 | 411097.225 | 516.6 |
| 3.3 | 34440 | 0.132 | 685162041.7 | 0.12398598 | 775603431.2 | 411097.225 | 516.6 |
| 3.315 | 34440 | 0.1326 | 685162041.7 | 0.124515875 | 776014528.4 | 411097.225 | 516.6 |
| 3.33 | 34400 | 0.1332 | 684366267 | 0.125045489 | 775523853.7 | 410858.4926 | 516.3 |
| 3.345 | 34400 | 0.1338 | 684366267 | 0.125574823 | 775934473.5 | 410619.7602 | 516 |
| 3.36 | 34400 | 0.1344 | 684366267 | 0.126103877 | 776345093.2 | 410619.7602 | 516 |
| 3.375 | 34400 | 0.135 | 684366267 | 0.126632651 | 776755713 | 410619.7602 | 516 |
| 3.39 | 34400 | 0.1356 | 684366267 | 0.127161146 | 777166332.8 | 410619.7602 | 516 |
| 3.405 | 34360 | 0.1362 | 683570492.2 | 0.127689361 | 776672793.3 | 410381.0278 | 515.7 |
| 3.42 | 34320 | 0.1368 | 682774717.5 | 0.128217298 | 776178298.9 | 409903.5629 | 515.1 |
| 3.435 | 34320 | 0.1374 | 682774717.5 | 0.128744956 | 776587963.7 | 409664.8305 | 514.8 |
| 3.45 | 34320 | 0.138 | 682774717.5 | 0.129272336 | 776997628.5 | 409664.8305 | 514.8 |
| 3.465 | 34280 | 0.1386 | 681978942.8 | 0.129799438 | 776501224.3 | 409426.0981 | 514.5 |
| 3.48 | 34280 | 0.1392 | 681978942.8 | 0.130326262 | 776910411.6 | 409187.3657 | 514.2 |
| 3.495 | 34280 | 0.1398 | 681978942.8 | 0.130852808 | 777319599 | 409187.3657 | 514.2 |
| 3.51 | 34240 | 0.1404 | 681183168.1 | 0.131379078 | 776821284.8 | 408948.6333 | 513.9 |
| 3.525 | 34240 | 0.141 | 681183168.1 | 0.131905071 | 777229994.7 | 408709.9008 | 513.6 |
| 3.54 | 34240 | 0.1416 | 681183168.1 | 0.132430787 | 777638704.6 | 408709.9008 | 513.6 |
| 3.555 | 34200 | 0.1422 | 680387393.3 | 0.132956227 | 777138480.7 | 408471.1684 | 513.3 |
| 3.57 | 34160 | 0.1428 | 679591618.6 | 0.133481391 | 776637301.7 | 407993.7036 | 512.7 |
| 3.585 | 34160 | 0.1434 | 679591618.6 | 0.13400628 | 777045056.7 | 407754.9712 | 512.4 |
| 3.6 | 34160 | 0.144 | 679591618.6 | 0.134530893 | 777452811.7 | 407754.9712 | 512.4 |
| 3.615 | 34120 | 0.1446 | 678795843.9 | 0.135055231 | 776949722.9 | 407516.2387 | 512.1 |
| 3.63 | 34080 | 0.1452 | 678000069.1 | 0.135579294 | 776445679.2 | 407038.7739 | 511.5 |
| 3.645 | 34080 | 0.1458 | 678000069.1 | 0.136103083 | 776852479.2 | 406800.0415 | 511.2 |
| 3.66 | 34080 | 0.1464 | 678000069.1 | 0.136626598 | 777259279.3 | 406800.0415 | 511.2 |
| 3.675 | 34040 | 0.147 | 677204294.4 | 0.137149838 | 776753325.7 | 406561.3091 | 510.9 |
| 3.69 | 34000 | 0.1476 | 676408519.7 | 0.137672805 | 776246417.2 | 406083.8442 | 510.3 |
| 3.705 | 33960 | 0.1482 | 675612744.9 | 0.138195499 | 775738553.8 | 405606.3794 | 509.7 |
| 3.72 | 33920 | 0.1488 | 674816970.2 | 0.138717919 | 775229735.4 | 405128.9146 | 509.1 |
| 3.735 | 33920 | 0.1494 | 674816970.2 | 0.139240067 | 775634625.6 | 404890.1821 | 508.8 |
| 3.75 | 33920 | 0.15 | 674816970.2 | 0.139761942 | 776039515.8 | 404890.1821 | 508.8 |
| 3.765 | 33880 | 0.1506 | 674021195.5 | 0.140283545 | 775528787.5 | 404651.4497 | 508.5 |
| 3.78 | 33840 | 0.1512 | 673225420.8 | 0.140804877 | 775017104.4 | 404173.9849 | 507.9 |
| 3.795 | 33800 | 0.1518 | 672429646 | 0.141325936 | 774504466.3 | 403696.52 | 507.3 |
| 3.81 | 33760 | 0.1524 | 671633871.3 | 0.141846724 | 773990873.3 | 403219.0552 | 506.7 |
| 3.825 | 33760 | 0.153 | 671633871.3 | 0.142367241 | 774393853.6 | 402980.3228 | 506.4 |
| 3.84 | 33720 | 0.1536 | 670838096.6 | 0.142887488 | 773878828.2 | 402741.5904 | 506.1 |
| 3.855 | 33680 | 0.1542 | 670042321.8 | 0.143407463 | 773362847.9 | 402264.1255 | 505.5 |
| 3.87 | 33640 | 0.1548 | 669246547.1 | 0.143927169 | 772845912.6 | 401786.6607 | 504.9 |
| 3.885 | 33600 | 0.1554 | 668450772.4 | 0.144446604 | 772328022.4 | 401309.1959 | 504.3 |
| 3.9 | 33560 | 0.156 | 667654997.7 | 0.14496577 | 771809177.3 | 400831.731 | 503.7 |
| 3.915 | 33520 | 0.1566 | 666859222.9 | 0.145484667 | 771289377.2 | 400354.2662 | 503.1 |
| 3.93 | 33480 | 0.1572 | 666063448.2 | 0.146003294 | 770768622.3 | 399876.8013 | 502.5 |
| 3.945 | 33440 | 0.1578 | 665267673.5 | 0.146521653 | 770246912.3 | 399399.3365 | 501.9 |
| 3.96 | 33400 | 0.1584 | 664471898.7 | 0.147039743 | 769724247.5 | 398921.8717 | 501.3 |
| 3.975 | 33360 | 0.159 | 663676124 | 0.147557564 | 769200627.7 | 398444.4068 | 500.7 |
| 3.99 | 33280 | 0.1596 | 662084574.6 | 0.148075118 | 767753272.7 | 397728.2096 | 499.8 |
| 4.005 | 33240 | 0.1602 | 661288799.8 | 0.148592404 | 767227265.6 | 397012.0123 | 498.9 |
| 4.02 | 33160 | 0.1608 | 659697250.4 | 0.149109423 | 765776568.2 | 396295.8151 | 498 |
| **Total Sum:** | **100498708.8** | **126290.4** |

References: `MECH341 Lab lectures / (MOODLE)