

# GRADIENT DESCENT

En este proyecto se va a usar el algoritmo del Gradient Descent para ajustar la pendiente y la ordenada en el origen de una recta de regresión lineal. Los datos que se van a usar en este proyecto son:

In [5]:

```
import pandas as pd  
  
df = pd.read_csv('Salary_Data.csv', sep = ',')
```

Los datos han sido sacados de <https://www.kaggle.com/uditkhanna112/linear-regressionsalary-vs-experience>

In [6]:

```
df
```

Out[6]:

	YearsExperience	Salary
0	1.1	39343.0
1	1.3	46205.0
2	1.5	37731.0
3	2.0	43525.0
4	2.2	39891.0
5	2.9	56642.0
6	3.0	60150.0
7	3.2	54445.0
8	3.2	64445.0
9	3.7	57189.0
10	3.9	63218.0
11	4.0	55794.0
12	4.0	56957.0
13	4.1	57081.0
14	4.5	61111.0
15	4.9	67938.0
16	5.1	66029.0
17	5.3	83088.0
18	5.9	81363.0
19	6.0	93940.0
20	6.8	91738.0
21	7.1	98273.0
22	7.9	101302.0
23	8.2	113812.0

	YearsExperience	Salary
24	8.7	109431.0
25	9.0	105582.0
26	9.5	116969.0
27	9.6	112635.0
28	10.3	122391.0
29	10.5	121872.0

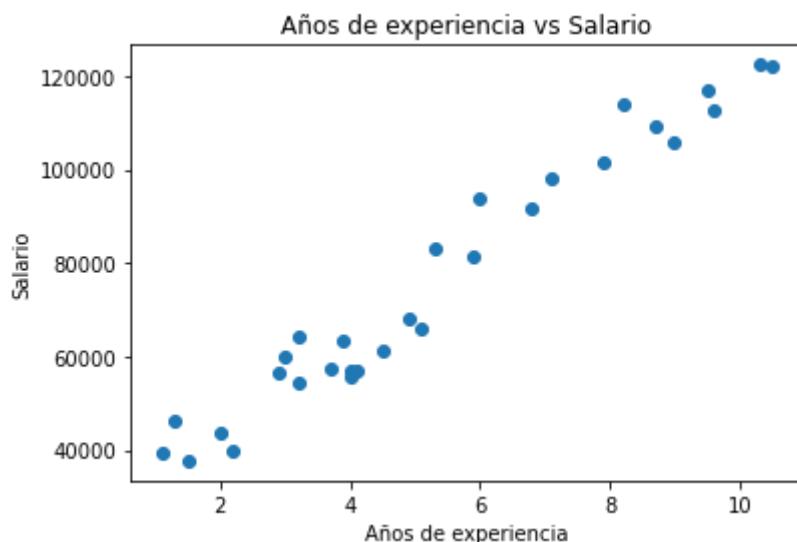
In [7]:

```
import matplotlib
from matplotlib import pyplot as plt
```

In [10]:

```
plt.scatter(df['YearsExperience'], df['Salary'])

plt.title('Años de experiencia vs Salario')
plt.xlabel('Años de experiencia')
plt.ylabel('Salario');
```



In [11]:

```
# para facilitar las operaciones con listas o vectores importamos numpy:
import numpy as np
```

In [18]:

```
experiencia = np.array(df['YearsExperience'])
salario = np.array(df['Salary'])

# la expresión que queremos optimizar es la media de los residuos al cuadrado:
# MRC = (1/n) * sum(salario - (b + m * experiencia))
# Cuyas derivadas son:
# con respecto a la ordenada en el origen (b):
# dMRC/db = (-2/n) * sum(salario - (b + m * experiencia))
# con respecto a la pendiente (m):
# dMRC/dm = (-2/n) * sum(experiencia * (salario - (b + m * experiencia)))
```

El algoritmo consiste en encontrar el óptimo de una función  $f(p)$  dando pequeños pasos en dirección hacia él, guiándose por la derivada de la función. Se elige un  $p_1$  discrecionalmente, y a partir de ahí:

- $p_2 = p_1 - \text{tasaAprendizaje} * f'(p_1)$
- $p_3 = p_2 - \text{tasaAprendizaje} * f'(p_2)$
- ...

In [71]:

```
#En nuestro caso:
n = len(experiencia)
b = m = 0
tasaAprendizaje = 0.026

for i in range(0, 400):
    #el algoritmo iterativo para b:
    b = b - tasaAprendizaje * (-2/n) * sum(salario - (b + m * experiencia))

    #el algoritmo iterativo para m:
    m = m - tasaAprendizaje * (-2/n) * sum(experiencia * (salario - (b + m * experiencia)))

    print('m = {}, b = {}, iteración = {}'.format(m, b, i))

x = np.array(range(11))
y = b + m * x

plt.scatter(df['YearsExperience'], df['Salary'])
plt.plot(x, y)

plt.title('Años de experiencia vs Salario')
plt.xlabel('Años de experiencia')
plt.ylabel('Salario');
```

```
m = 23732.778044906663, b = 3952.156, iteración = 0
m = 3793.7674073242015, b = 1141.5915327125886, iteración = 1
m = 20411.920978113878, b = 3986.1921301505727, iteración = 2
m = 6430.010288705787, b = 2091.3884526030656, iteración = 3
m = 18063.30138270915, b = 4158.223277033556, iteración = 4
m = 8255.693665403662, b = 2903.381916594491, iteración = 5
m = 16396.40998293884, b = 4423.568935138315, iteración = 6
m = 9513.919491393006, b = 3615.4805816250077, iteración = 7
m = 15207.679839098582, b = 4750.999062038563, iteración = 8
m = 10375.014631094464, b = 4254.32255580188, iteración = 9
m = 14354.463506768265, b = 5118.70640709299, iteración = 10
m = 10958.313750029223, b = 4838.647103427462, iteración = 11
m = 13736.799202613696, b = 5511.484420341159, iteración = 12
m = 11347.422265611338, b = 5381.657189462606, iteración = 13
m = 13284.634614624727, b = 5918.749893103908, iteración = 14
m = 11600.910870462898, b = 5892.674918872457, iteración = 15
m = 12948.874805044496, b = 6333.157488987994, iteración = 16
m = 11759.809024766466, b = 6378.301516758857, iteración = 17
m = 12695.10959989361, b = 6749.6290030712535, iteración = 18
m = 11852.855532622332, b = 6843.230146524943, iteración = 19
m = 12499.2184561412, b = 7164.67321427898, iteración = 20
m = 11900.177539714865, b = 7290.8154758277005, iteración = 21
m = 12344.29085044405, b = 7575.909351378375, iteración = 22
m = 11915.868348629434, b = 7723.472798401344, iteración = 23
m = 12218.468434950237, b = 7981.733227280486, iteración = 24
m = 11909.793651733527, b = 8142.957727341383, iteración = 25
m = 12113.433062076077, b = 8381.083338170003, iteración = 26
m = 11888.857127514082, b = 8550.562205753957, iteración = 27
m = 12023.347360449627, b = 8773.277005770127, iteración = 28
m = 11857.887220816488, b = 8947.251881426919, iteración = 29
m = 11944.112407025566, b = 9157.895597062596, iteración = 30
m = 11820.25849222946, b = 9333.762395370224, iteración = 31
```

m = 11872.847584011954, b = 9534.704131131253, iteración = 32  
m = 11778.326984014822, b = 9710.666881167152, iteración = 33  
m = 11807.526117588824, b = 9903.594979843057, iteración = 34  
m = 11733.735270223762, b = 10078.42329144221, iteración = 35  
m = 11746.719700711448, b = 10264.548450026192, iteración = 36  
m = 11687.62619650887, b = 10437.407588782928, iteración = 37  
m = 11689.419549656093, b = 10617.605193578791, iteración = 38  
m = 11640.792640226144, b = 10787.93703140638, iteración = 39  
m = 11634.911016683205, b = 10962.846904563034, iteración = 40  
m = 11593.782440976925, b = 11130.28651768963, iteración = 41  
m = 11582.685728794582, b = 11300.382822210784, iteración = 42  
m = 11546.971919820782, b = 11464.700066494739, iteración = 43  
m = 11532.380020576704, b = 11630.340301403328, iteración = 44  
m = 11500.617389117639, b = 11791.39888578482, iteración = 45  
m = 11483.731791022436, b = 11952.858232541792, iteración = 46  
m = 11454.891240813333, b = 12110.58706880206, iteración = 47  
m = 11436.550269858384, b = 12268.082457329234, iteración = 48  
m = 11409.90722915264, b = 12422.455573654708, iteración = 49  
m = 11390.694829464373, b = 12576.162582457982, iteración = 50  
m = 11365.738182171042, b = 12727.18508475469, iteración = 51  
m = 11346.060134994852, b = 12877.249772201469, iteración = 52  
m = 11322.428408226404, b = 13024.948009148815, iteración = 53  
m = 11302.565735670936, b = 13171.495226336176, iteración = 54  
m = 11280.002385505128, b = 13315.909912239053, iteración = 55  
m = 11260.148768018877, b = 13459.049137703458, iteración = 56  
m = 11238.470847143577, b = 13600.230545597717, iteración = 57  
m = 11218.758839684831, b = 13740.059985299846, iteración = 58  
m = 11197.835041574344, b = 13878.064590384933, iteración = 59  
m = 11178.354441226536, b = 14014.674061931535, iteración = 60  
m = 11158.08971435662, b = 14149.562200963144, iteración = 61  
m = 11138.900428613146, b = 14283.035165701089, iteración = 62  
m = 11119.225194244904, b = 14414.869407995011, iteración = 63  
m = 11100.36625602985, b = 14545.284405777365, iteración = 64  
m = 11081.228851684704, b = 14674.128422577602, iteración = 65  
m = 11062.724734483589, b = 14801.560087742095, iteración = 66  
m = 11044.086117649382, b = 14927.47787053992, iteración = 67  
m = 11025.951158901657, b = 15051.997654206105, iteración = 68  
m = 11007.78119448529, b = 15175.05297732392, iteración = 69  
m = 10990.022693498031, b = 15296.729663674754, iteración = 70  
m = 10972.297551020807, b = 15416.985717768117, iteración = 71  
m = 10954.917938172584, b = 15535.885795747467, iteración = 72  
m = 10937.618266579888, b = 15653.404940837767, iteración = 73  
m = 10920.616621824369, b = 15769.59287431329, iteración = 74  
m = 10903.726269191311, b = 15884.436476349738, iteración = 75  
m = 10887.099384657071, b = 15997.974902910453, iteración = 76  
m = 10870.604499727035, b = 16110.203228640925, iteración = 77  
m = 10854.34762290393, b = 16221.153108173681, iteración = 78  
m = 10838.23602420325, b = 16330.82526065778, iteración = 79  
m = 10822.343377351463, b = 16439.245988523046, iteración = 80  
m = 10806.604109821563, b = 16546.419870913487, iteración = 81  
m = 10791.069252613419, b = 16652.369366109688, iteración = 82  
m = 10775.69227566366, b = 16757.101665036582, iteración = 83  
m = 10760.508358010562, b = 16860.636440637314, iteración = 84  
m = 10745.484325685002, b = 16962.982623128242, iteración = 85  
m = 10730.644263647611, b = 17064.15784410098, iteración = 86  
m = 10715.964369363284, b = 17164.172163790317, iteración = 87  
m = 10701.460967195559, b = 17263.04169578061, iteración = 88  
m = 10687.11683375303, b = 17360.777205437, iteración = 89  
m = 10672.942868230693, b = 17457.39365703387, iteración = 90  
m = 10658.926469573627, b = 17552.902225328424, iteración = 91  
m = 10645.074747922883, b = 17647.31698557795, iteración = 92  
m = 10631.378353170363, b = 17740.64931664179, iteración = 93  
m = 10617.841752525128, b = 17832.91258905113, iteración = 94  
m = 10604.457885636304, b = 17924.118243809462, iteración = 95

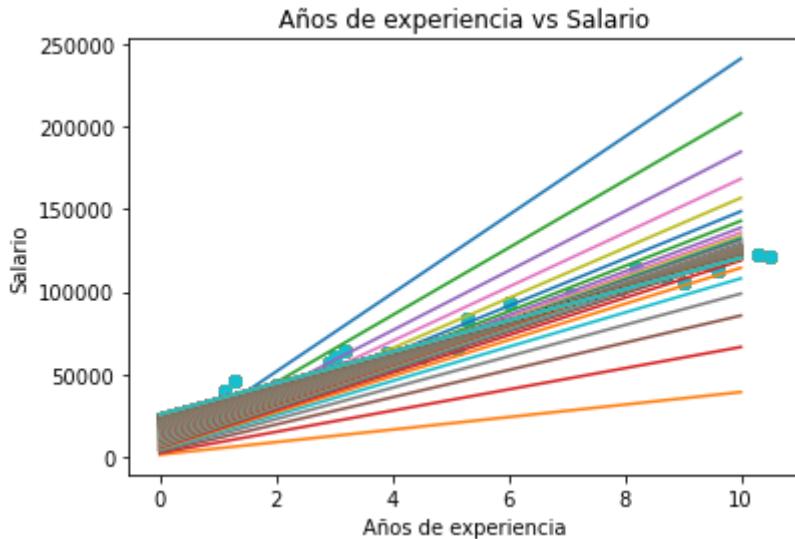
m = 10591.22937957852, b = 18014.279077715964, iteración = 96  
m = 10578.1507899961, b = 18103.406496293053, iteración = 97  
m = 10565.223466070598, b = 18191.51281621516, iteración = 98  
m = 10552.443107081985, b = 18278.60934091977, iteración = 99  
m = 10539.810178011952, b = 18364.707974325906, iteración = 100  
m = 10527.321190542416, b = 18449.819872877444, iteración = 101  
m = 10514.97600105509, b = 18533.956576682216, iteración = 102  
m = 10502.771701290852, b = 18617.129065443227, iteración = 103  
m = 10490.707731890878, b = 18699.348551451527, iteración = 104  
m = 10478.781601609058, b = 18780.625818506145, iteración = 105  
m = 10466.992470236115, b = 18860.971777963252, iteración = 106  
m = 10455.338149054063, b = 18940.397005932726, iteración = 107  
m = 10443.817611280514, b = 19018.912133294914, iteración = 108  
m = 10432.428890272247, b = 19096.527521817516, iteración = 109  
m = 10421.170838499762, b = 19173.253537826717, iteración = 110  
m = 10410.041654792007, b = 19249.1003256545, iteración = 111  
m = 10399.040116768241, b = 19324.077999779132, iteración = 112  
m = 10388.164548844114, b = 19398.196486461664, iteración = 113  
m = 10377.413685723937, b = 19471.465658750356, iteración = 114  
m = 10366.785949243163, b = 19543.895225887718, iteración = 115  
m = 10356.280053351253, b = 19615.494828272, iteración = 116  
m = 10345.8944973526, b = 19686.273960327926, iteración = 117  
m = 10335.627989756813, b = 19756.24203740233, iteración = 118  
m = 10325.479093148115, b = 19825.408342074203, iteración = 119  
m = 10315.446521119846, b = 19893.78207137681, iteración = 120  
m = 10305.528889388908, b = 19961.372299523275, iteración = 121  
m = 10295.724923803386, b = 20028.18801133584, iteración = 122  
m = 10286.033285902535, b = 20094.23807646566, iteración = 123  
m = 10276.452718615736, b = 20159.531273149812, iteración = 124  
m = 10266.981923986541, b = 20224.076270477286, iteración = 125  
m = 10257.619665213964, b = 20287.881645361147, iteración = 126  
m = 10248.364680928225, b = 20350.95587043485, iteración = 127  
m = 10239.215756642832, b = 20413.307326262973, iteración = 128  
m = 10230.171664642658, b = 20474.94429317526, iteración = 129  
m = 10221.231214003674, b = 20535.874960133813, iteración = 130  
m = 10212.393208428264, b = 20596.107419319065, iteración = 131  
m = 10203.656481248663, b = 20655.649672647134, iteración = 132  
m = 10195.019865838665, b = 20714.509628277017, iteración = 133  
m = 10186.482220096392, b = 20772.695105474493, iteración = 134  
m = 10178.042405669086, b = 20830.213832458652, iteración = 135  
m = 10169.699305065218, b = 20887.07345010047, iteración = 136  
m = 10161.451807055431, b = 20943.281510701094, iteración = 137  
m = 10153.29881862113, b = 20998.84548086727, iteración = 138  
m = 10145.23925468391, b = 21053.772740935943, iteración = 139  
m = 10137.272046437094, b = 21108.070587266473, iteración = 140  
m = 10129.396134109029, b = 21161.74623211169, iteración = 141  
m = 10121.610472761102, b = 21214.806805495118, iteración = 142  
m = 10113.91402717775, b = 21267.259355388633, iteración = 143  
m = 10106.305775890194, b = 21319.110849292727, iteración = 144  
m = 10098.784707557506, b = 21370.368174622883, iteración = 145  
m = 10091.349823747978, b = 21421.03814007574, iteración = 146  
m = 10084.000136365861, b = 21471.127476155725, iteración = 147  
m = 10076.734669563099, b = 21520.642836385316, iteración = 148  
m = 10069.552457899574, b = 21569.590797924124, iteración = 149  
m = 10062.452547646377, b = 21617.977862664135, iteración = 150  
m = 10055.433995460835, b = 21665.81045790789, iteración = 151  
m = 10048.495869264269, b = 21713.094937377486, iteración = 152  
m = 10041.637247278535, b = 21759.8375819286, iteración = 153  
m = 10034.85721860644, b = 21806.04460049357, iteración = 154  
m = 10028.154882522394, b = 21851.72213081507, iteración = 155  
m = 10021.529348845268, b = 21896.87624033763, iteración = 156  
m = 10014.97973740788, b = 21941.512926949785, iteración = 157  
m = 10008.50517828519, b = 21985.63811983418, iteración = 158  
m = 10002.104811389852, b = 22029.25768021046, iteración = 159

m = 9995.777786599803, b = 22072.377402151244, iteración = 160  
m = 9989.523263442907, b = 22115.00301332043, iteración = 161  
m = 9983.34041115475, b = 22157.14017576025, iteración = 162  
m = 9977.228408426476, b = 22198.794486621402, iteración = 163  
m = 9971.186443414383, b = 22239.971478924912, iteración = 164  
m = 9965.213713532745, b = 22280.676622281713, iteración = 165  
m = 9959.30942543034, b = 22320.915323632056, iteración = 166  
m = 9953.472794815489, b = 22360.692927952958, iteración = 167  
m = 9947.703046410119, b = 22400.01471897718, iteración = 168  
m = 9941.999413798021, b = 22438.88591988756, iteración = 169  
m = 9936.361139363868, b = 22477.311694017106, iteración = 170  
m = 9930.787474158407, b = 22515.297145529574, iteración = 171  
m = 9925.277677827578, b = 22552.847320101897, iteración = 172  
m = 9919.831018490231, b = 22589.967205590692, iteración = 173  
m = 9914.446772660944, b = 22626.661732697914, iteración = 174  
m = 9909.12422513716, b = 22662.93577562322, iteración = 175  
m = 9903.862668918198, b = 22698.794152713584, iteración = 176  
m = 9898.661405099636, b = 22734.241627101506, iteración = 177  
m = 9893.51974279025, b = 22769.28290733923, iteración = 178  
m = 9888.43699901207, b = 22803.92264802293, iteración = 179  
m = 9883.41249861649, b = 22838.16545041203, iteración = 180  
m = 9878.445574188885, b = 22872.015863039527, iteración = 181  
m = 9873.535565964716, b = 22905.47838231691, iteración = 182  
m = 9868.681821737908, b = 22938.55745313082, iteración = 183  
m = 9863.88369677756, b = 22971.25746943398, iteración = 184  
m = 9859.1405537395, b = 23003.582774828417, iteración = 185  
m = 9854.451762583978, b = 23035.537663142808, iteración = 186  
m = 9849.816700489999, b = 23067.12637900251, iteración = 187  
m = 9845.23475177425, b = 23098.353118393665, iteración = 188  
m = 9840.705307807939, b = 23129.222029220313, iteración = 189  
m = 9836.227766937094, b = 23159.737211855576, iteración = 190  
m = 9831.801534401691, b = 23189.902719686146, iteración = 191  
m = 9827.426022257447, b = 23219.722559650843, iteración = 192  
m = 9823.100649297057, b = 23249.20069277275, iteración = 193  
m = 9818.82484097355, b = 23278.34103468545, iteración = 194  
m = 9814.598029323497, b = 23307.14745615309, iteración = 195  
m = 9810.41965289197, b = 23335.623783584575, iteración = 196  
m = 9806.289156657624, b = 23363.77379954181, iteración = 197  
m = 9802.205991959256, b = 23391.601243242178, iteración = 198  
m = 9798.169616422689, b = 23419.10981105519, iteración = 199  
m = 9794.179493888922, b = 23446.30315699351, iteración = 200  
m = 9790.235094342755, b = 23473.184893198297, iteración = 201  
m = 9786.335893842506, b = 23499.758590419046, iteración = 202  
m = 9782.48137445033, b = 23526.027778487864, iteración = 203  
m = 9778.671024163476, b = 23551.995946788364, iteración = 204  
m = 9774.904336846235, b = 23577.666544719163, iteración = 205  
m = 9771.18081216275, b = 23603.042982152063, iteración = 206  
m = 9767.499955510515, b = 23628.128629885003, iteración = 207  
m = 9763.861277954711, b = 23652.926820089797, iteración = 208  
m = 9760.264296163235, b = 23677.440846754762, iteración = 209  
m = 9756.708532342513, b = 23701.673966122253, iteración = 210  
m = 9753.193514174025, b = 23725.629397121207, iteración = 211  
m = 9749.718774751564, b = 23749.310321794717, iteración = 212  
m = 9746.28385251924, b = 23772.7198857227, iteración = 213  
m = 9742.888291210129, b = 23795.86119843974, iteración = 214  
m = 9739.531639785708, b = 23818.737333848123, iteración = 215  
m = 9736.21345237591, b = 23841.351330626163, iteración = 216  
m = 9732.933288219925, b = 23863.70619263182, iteración = 217  
m = 9729.69071160763, b = 23885.804889301722, iteración = 218  
m = 9726.48529182173, b = 23907.65035604559, iteración = 219  
m = 9723.316603080535, b = 23929.245494636154, iteración = 220  
m = 9720.184224481405, b = 23950.59317359461, iteración = 221  
m = 9717.087739944844, b = 23971.696228571644, iteración = 222  
m = 9714.026738159231, b = 23992.55746272409, iteración = 223

m = 9711.000812526174, b = 24013.179647087294, iteración = 224  
m = 9708.009561106524, b = 24033.56552094319, iteración = 225  
m = 9705.052586566953, b = 24053.71779218415, iteración = 226  
m = 9702.12949612721, b = 24073.6391376727, iteración = 227  
m = 9699.239901507914, b = 24093.332203597078, iteración = 228  
m = 9696.38341887901, b = 24112.799605822736, iteración = 229  
m = 9693.559668808752, b = 24132.043930239808, iteración = 230  
m = 9690.768276213332, b = 24151.067733106607, iteración = 231  
m = 9688.00887030704, b = 24169.873541389163, iteración = 232  
m = 9685.281084553011, b = 24188.463853096895, iteración = 233  
m = 9682.584556614547, b = 24206.841137614425, iteración = 234  
m = 9679.91892830698, b = 24225.007836029585, iteración = 235  
m = 9677.283845550099, b = 24242.966361457682, iteración = 236  
m = 9674.678958321103, b = 24260.719099362028, iteración = 237  
m = 9672.103920608137, b = 24278.268407870804, iteración = 238  
m = 9669.558390364282, b = 24295.6166180903, iteración = 239  
m = 9667.042029462185, b = 24312.766034414555, iteración = 240  
m = 9664.554503649075, b = 24329.71893483146, iteración = 241  
m = 9662.095482502422, b = 24346.477571225343, iteración = 242  
m = 9659.664639386014, b = 24363.04416967609, iteración = 243  
m = 9657.26165140657, b = 24379.42093075484, iteración = 244  
m = 9654.886199370874, b = 24395.610029816296, iteración = 245  
m = 9652.537967743341, b = 24411.613617287672, iteración = 246  
m = 9650.216644604136, b = 24427.433818954345, iteración = 247  
m = 9647.921921607718, b = 24443.072736242226, iteración = 248  
m = 9645.653493941894, b = 24458.532446496894, iteración = 249  
m = 9643.41106028733, b = 24473.815003259537, iteración = 250  
m = 9641.194322777517, b = 24488.92243653972, iteración = 251  
m = 9639.002986959222, b = 24503.856753085045, iteración = 252  
m = 9636.836761753346, b = 24518.6199366477, iteración = 253  
m = 9634.6953594163, b = 24533.213948247983, iteración = 254  
m = 9632.578495501743, b = 24547.64072643476, iteración = 255  
m = 9630.485888822834, b = 24561.902187542993, iteración = 256  
m = 9628.417261414843, b = 24576.000225948268, iteración = 257  
m = 9626.372338498273, b = 24589.936714318446, iteración = 258  
m = 9624.350848442318, b = 24603.713503862404, iteración = 259  
m = 9622.352522728816, b = 24617.332424575936, iteración = 260  
m = 9620.377095916552, b = 24630.795285484834, iteración = 261  
m = 9618.424305606028, b = 24644.103874885186, iteración = 262  
m = 9616.493892404582, b = 24657.259960580916, iteración = 263  
m = 9614.58559989195, b = 24670.265290118605, iteración = 264  
m = 9612.699174586198, b = 24683.121591019622, iteración = 265  
m = 9610.834365910048, b = 24695.8305710096, iteración = 266  
m = 9608.990926157605, b = 24708.39391824526, iteración = 267  
m = 9607.168610461442, b = 24720.813301538667, iteración = 268  
m = 9605.367176760077, b = 24733.090370578895, iteración = 269  
m = 9603.58638576583, b = 24745.22675615116, iteración = 270  
m = 9601.826000933013, b = 24757.22407035344, iteración = 271  
m = 9600.085788426544, b = 24769.08390681061, iteración = 272  
m = 9598.365517090851, b = 24780.80784088613, iteración = 273  
m = 9596.664958419202, b = 24792.397429891294, iteración = 274  
m = 9594.983886523305, b = 24803.85421329211, iteración = 275  
m = 9593.322078103369, b = 24815.179712913774, iteración = 276  
m = 9591.679312418366, b = 24826.375433142817, iteración = 277  
m = 9590.055371256787, b = 24837.442861126947, iteración = 278  
m = 9588.450038907584, b = 24848.38346697257, iteración = 279  
m = 9586.863102131581, b = 24859.19870394009, iteración = 280  
m = 9585.294350133088, b = 24869.89000863693, iteración = 281  
m = 9583.743574531967, b = 24880.45880120837, iteración = 282  
m = 9582.210569335883, b = 24890.906485526182, iteración = 283  
m = 9580.695130913004, b = 24901.23444937511, iteración = 284  
m = 9579.197057964904, b = 24911.444064637217, iteración = 285  
m = 9577.716151499857, b = 24921.536687474098, iteración = 286  
m = 9576.252214806385, b = 24931.513658507043, iteración = 287

m = 9574.805053427139, b = 24941.376302995104, iteración = 288  
m = 9573.374475133061, b = 24951.12593101113, iteración = 289  
m = 9571.960289897865, b = 24960.76383761579, iteración = 290  
m = 9570.562309872763, b = 24970.291303029586, iteración = 291  
m = 9569.180349361563, b = 24979.709592802934, iteración = 292  
m = 9567.814224795944, b = 24989.019957984245, iteración = 293  
m = 9566.46375471113, b = 24998.22363528611, iteración = 294  
m = 9565.128759721734, b = 25007.32184724958, iteración = 295  
m = 9563.809062497976, b = 25016.315802406552, iteración = 296  
m = 9562.50448774208, b = 25025.206695440305, iteración = 297  
m = 9561.214862165045, b = 25033.99570734419, iteración = 298  
m = 9559.940014463567, b = 25042.684005578507, iteración = 299  
m = 9558.679775297336, b = 25051.27274422557, iteración = 300  
m = 9557.43397726651, b = 25059.763064143022, iteración = 301  
m = 9556.202454889484, b = 25068.156093115365, iteración = 302  
m = 9554.985044580933, b = 25076.452946003767, iteración = 303  
m = 9553.781584630035, b = 25084.654724894157, iteración = 304  
m = 9552.59191517905, b = 25092.762519243613, iteración = 305  
m = 9551.415878202026, b = 25100.777406025074, iteración = 306  
m = 9550.253317483865, b = 25108.700449870405, iteración = 307  
m = 9549.10407859952, b = 25116.5327032118, iteración = 308  
m = 9547.968008893522, b = 25124.275206421597, iteración = 309  
m = 9546.844957459683, b = 25131.928987950454, iteración = 310  
m = 9545.73477512106, b = 25139.49506446397, iteración = 311  
m = 9544.637314410125, b = 25146.974440977727, iteración = 312  
m = 9543.5524295492, b = 25154.368110990796, iteración = 313  
m = 9542.479976431065, b = 25161.677056617693, iteración = 314  
m = 9541.419812599846, b = 25168.902248718845, iteración = 315  
m = 9540.371797232065, b = 25176.044647029546, iteración = 316  
m = 9539.335791117956, b = 25183.10520028744, iteración = 317  
m = 9538.31165664295, b = 25190.084846358543, iteración = 318  
m = 9537.299257769433, b = 25196.98451236183, iteración = 319  
m = 9536.298460018621, b = 25203.805114792372, iteración = 320  
m = 9535.309130452759, b = 25210.54755964309, iteración = 321  
m = 9534.331137657402, b = 25217.21274252509, iteración = 322  
m = 9533.364351724022, b = 25223.801548786632, iteración = 323  
m = 9532.40864423268, b = 25230.314853630724, iteración = 324  
m = 9531.463888235048, b = 25236.753522231396, iteración = 325  
m = 9530.529958237463, b = 25243.11840984861, iteración = 326  
m = 9529.606730184338, b = 25249.410361941857, iteración = 327  
m = 9528.694081441608, b = 25255.630214282482, iteración = 328  
m = 9527.791890780514, b = 25261.77879306469, iteración = 329  
m = 9526.900038361428, b = 25267.856915015273, iteración = 330  
m = 9526.018405717998, b = 25273.865387502137, iteración = 331  
m = 9525.146875741357, b = 25279.805008641513, iteración = 332  
m = 9524.285332664622, b = 25285.67656740399, iteración = 333  
m = 9523.433662047457, b = 25291.4808437193, iteración = 334  
m = 9522.591750760932, b = 25297.21860857993, iteración = 335  
m = 9521.759486972445, b = 25302.890624143532, iteración = 336  
m = 9520.936760130899, b = 25308.497643834162, iteración = 337  
m = 9520.123460952005, b = 25314.04041244235, iteración = 338  
m = 9519.319481403763, b = 25319.51966622405, iteración = 339  
m = 9518.524714692128, b = 25324.936132998413, iteración = 340  
m = 9517.739055246793, b = 25330.290532244493, iteración = 341  
m = 9516.962398707208, b = 25335.583575196793, iteración = 342  
m = 9516.194641908682, b = 25340.81596493975, iteración = 343  
m = 9515.43568286869, b = 25345.988396501125, iteración = 344  
m = 9514.685420773343, b = 25351.101556944333, iteración = 345  
m = 9513.943755963965, b = 25356.156125459693, iteración = 346  
m = 9513.21058992389, b = 25361.15277345465, iteración = 347  
m = 9512.485825265345, b = 25366.09216464297, iteración = 348  
m = 9511.76936571654, b = 25370.97495513289, iteración = 349  
m = 9511.061116108853, b = 25375.80179351427, iteración = 350  
m = 9510.360982364222, b = 25380.57332094476, iteración = 351

```
m = 9509.668871482609, b = 25385.29017123495, iteración = 352
m = 9508.984691529688, b = 25389.95297093256, iteración = 353
m = 9508.30835162459, b = 25394.562339405693, iteración = 354
m = 9507.639761927881, b = 25399.118888925066, iteración = 355
m = 9506.97883362957, b = 25403.62322474537, iteración = 356
m = 9506.325478937375, b = 25408.07594518565, iteración = 357
m = 9505.679611065003, b = 25412.477641708792, iteración = 358
m = 9505.041144220666, b = 25416.82889900008, iteración = 359
m = 9504.409993595658, b = 25421.130295044866, iteración = 360
m = 9503.786075353108, b = 25425.382401205345, iteración = 361
m = 9503.169306616826, b = 25429.58578229644, iteración = 362
m = 9502.559605460314, b = 25433.74099666084, iteración = 363
m = 9501.956890895864, b = 25437.848596243162, iteración = 364
m = 9501.361082863816, b = 25441.909126663264, iteración = 365
m = 9500.77210222191, b = 25445.923127288723, iteración = 366
m = 9500.189870734797, b = 25449.89113130648, iteración = 367
m = 9499.614311063606, b = 25453.813665793656, iteración = 368
m = 9499.045346755716, b = 25457.691251787586, iteración = 369
m = 9498.48290223457, b = 25461.524404355005, iteración = 370
m = 9497.926902789646, b = 25465.31363266048, iteración = 371
m = 9497.377274566537, b = 25469.05944003404, iteración = 372
m = 9496.83394455714, b = 25472.762324038034, iteración = 373
m = 9496.296840589941, b = 25476.422776533214, iteración = 374
m = 9495.765891320461, b = 25480.04128374409, iteración = 375
m = 9495.24102622174, b = 25483.618326323496, iteración = 376
m = 9494.722175575016, b = 25487.15437941645, iteración = 377
m = 9494.209270460404, b = 25490.649912723256, iteración = 378
m = 9493.702242747811, b = 25494.10539056191, iteración = 379
m = 9493.201025087816, b = 25497.521271929752, iteración = 380
m = 9492.705550902789, b = 25500.898010564477, iteración = 381
m = 9492.215754377983, b = 25504.236055004356, iteración = 382
m = 9491.731570452861, b = 25507.535848647854, iteración = 383
m = 9491.252934812383, b = 25510.79782981251, iteración = 384
m = 9490.779783878526, b = 25514.022431793164, iteración = 385
m = 9490.312054801789, b = 25517.210082919508, iteración = 386
m = 9489.849685452888, b = 25520.36120661299, iteración = 387
m = 9489.39261441445, b = 25523.476221443052, iteración = 388
m = 9488.94078097293, b = 25526.55554118273, iteración = 389
m = 9488.494125110445, b = 25529.599574863616, iteración = 390
m = 9488.052587496926, b = 25532.608726830193, iteración = 391
m = 9487.616109482107, b = 25535.58339679354, iteración = 392
m = 9487.184633087849, b = 25538.523979884434, iteración = 393
m = 9486.758101000345, b = 25541.430866705825, iteración = 394
m = 9486.336456562587, b = 25544.30444338473, iteración = 395
m = 9485.919643766767, b = 25547.145091623526, iteración = 396
m = 9485.507607246904, b = 25549.95318875064, iteración = 397
m = 9485.100292271436, b = 25552.72910777067, iteración = 398
m = 9484.697644735981, b = 25555.473217413946, iteración = 399
```



En el gráfico de arriba se aprecia cómo se va ajustando la recta a la nube de puntos conforme las iteraciones avanzan

Vamos a comparar los valores de 'b' y 'm' con los que obtenemos al conseguir los coeficientes con el paquete de scikit learn:

```
In [41]: from sklearn import linear_model
```

```
In [43]: regresion = linear_model.LinearRegression()
regresion.fit(df[['YearsExperience']], df['Salary'])
```

```
Out[43]: LinearRegression()
```

```
In [44]: regresion.intercept_
```

```
Out[44]: 25792.200198668717
```

```
In [45]: regresion.coef_
```

```
Out[45]: array([9449.96232146])
```

Se ve que los valores del gradient descent convergen a los óptimos

```
In [ ]:
```