**AnalogGPT**

Developerha466920

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AI 생성 콘텐츠는 정확하지 않을 수 있습니다.

**How to use**

First, write your prompt (e.g., “The cat is”) on a blank paper and convert it into an array of token IDs using the tokenizer table (e.g., [70, 216, 18, 25]). Then, extract the positional embedding corresponding to the length of the token array (in this case, 4 → positions [0:4]) and add it to the token embeddings to obtain the **input embedding**. Next, apply **Layer Normalization** using the following formulas: compute the mean , the variance , and normalize each input dimension as . Then apply the learned scale and shift using . This gives the first hidden state **h₀** with shape [4 × 12]. Use this to compute Q, K, and V matrices by applying the corresponding weights (each resulting in [4 × 12]), and compute attention by taking the dot product Q and K^T, applying softmax, and multiplying the result by V to get the attention output. Then, pass this through the masked multi-head self-attention block, followed by a **residual connection** that adds the attention output back to the input of the block. Apply a second layer normalization (LayerNorm2) to the result. Pass this through the first MLP layer using weights and biases of shape [4 × 48], apply the **GELU activation function**, and then pass through a second MLP layer to reduce the shape back to [4 × 12]. Again, apply a residual connection by adding the MLP output to the block input. Repeat this entire process—multi-head attention, residual connection, layer normalization, MLP, and another residual connection—for layers 2, 3, and 4. The final output after all layers retains the shape [4 × 12]. For the output stage, select the last token embedding from xfinalx\_{\text{final}}xfinal​; if multiple tokens are needed, retain the others as well. Multiply the selected vector by the output layer weight and add bias to produce a [1 × 300] logits vector. Finally, apply the **softmax** function to obtain a probability distribution over the vocabulary, and choose the token corresponding to the highest probability.

**Tokenizer**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **0** | <pad> | **1** | <unk> | **2** | <s> | **3** | </s> | **4** | ▁t | **5** | he | **6** | ▁a | **7** | in | **8** | ▁the | **9** | er | **10** | on | **11** | ▁, |
| **12** | re | **13** | ▁s | **14** | ed | **15** | ▁o | **16** | ▁w | **17** | nd | **18** | at | **19** | ▁. | **20** | or | **21** | it | **22** | ▁c | **23** | en |
| **24** | ▁f | **25** | is | **26** | es | **27** | ar | **28** | ▁of | **29** | ▁b | **30** | an | **31** | ▁in | **32** | al | **33** | ing | **34** | ▁p | **35** | ▁and |
| **36** | as | **37** | ▁to | **38** | ro | **39** | ic | **40** | ▁m | **41** | ▁d | **42** | ▁h | **43** | ion | **44** | le | **45** | ou | **46** | ▁T | **47** | ▁re |
| **48** | ▁= | **49** | ▁" | **50** | ▁A | **51** | ▁S | **52** | ent | **53** | il | **54** | ▁th | **55** | ▁1 | **56** | st | **57** | ▁C | **58** | el | **59** | om |
| **60** | ▁l | **61** | am | **62** | ▁e | **63** | ▁n | **64** | ▁@ | **65** | ad | **66** | ac | **67** | ▁was | **68** | ▁M | **69** | ur | **70** | ▁The | **71** | ec |
| **72** | ▁on | **73** | ly | **74** | ▁B | **75** | ▁I | **76** | ▁g | **77** | ▁' | **78** | et | **79** | ol | **80** | id | **81** | iv | **82** | im | **83** | ▁for |
| **84** | ir | **85** | -@ | **86** | ▁@-@ | **87** | ig | **88** | ot | **89** | ter | **90** | ▁as | **91** | ▁H | **92** | us | **93** | ow | **94** | ▁st | **95** | ut |
| **96** | ith | **97** | ay | **98** | ▁2 | **99** | ▁P | **100** | ation | **101** | ver | **102** | ▁be | **103** | her | **104** | ▁that | **105** | ▁with | **106** | ▁R | **107** | ce |
| **108** | th | **109** | ▁D | **110** | ▁is | **111** | un | **112** | em | **113** | ▁F | **114** | ▁wh | **115** | ul | **116** | ▁by | **117** | ▁al | **118** | ch | **119** | ▁) |
| **120** | ▁( | **121** | ▁W | **122** | ▁con | **123** | ra | **124** | ▁G | **125** | os | **126** | ▁L | **127** | ▁N | **128** | ▁at | **129** | ers | **130** | ct | **131** | ▁it |
| **132** | ▁19 | **133** | rom | **134** | and | **135** | ▁an | **136** | um | **137** | est | **138** | ▁J | **139** | ag | **140** | ▁he | **141** | 00 | **142** | ist | **143** | ain |
| **144** | od | **145** | av | **146** | ri | **147** | ▁E | **148** | ▁O | **149** | ▁from | **150** | ▁com | **151** | ▁his | **152** | op | **153** | ▁pro | **154** | res | **155** | ies |
| **156** | if | **157** | ▁v | **158** | ort | **159** | ere | **160** | ill | **161** | ld | **162** | ▁de | **163** | pp | **164** | ▁su | **165** | ore | **166** | ▁In | **167** | ▁r |
| **168** | ▁se | **169** | ▁were | **170** | ew | **171** | ong | **172** | igh | **173** | ard | **174** | ate | **175** | all | **176** | art | **177** | ak | **178** | ich | **179** | ▁ch |
| **180** | ▁or | **181** | ab | **182** | ant | **183** | ud | **184** | oc | **185** | ber | **186** | ▁ex | **187** | gh | **188** | ity | **189** | ated | **190** | pt | **191** | ess |
| **192** | ear | **193** | ▁K | **194** | ▁pl | **195** | ame | **196** | qu | **197** | ive | **198** | rou | **199** | ▁are | **200** | ▁sh | **201** | ▁k | **202** | ack | **203** | ect |
| **204** | ▁ | **205** | e | **206** | t | **207** | a | **208** | n | **209** | i | **210** | o | **211** | r | **212** | s | **213** | h | **214** | l | **215** | d |
| **216** | c | **217** | u | **218** | m | **219** | f | **220** | g | **221** | p | **222** | w | **223** | y | **224** | b | **225** | , | **226** | . | **227** | v |
| **228** | k | **229** | @ | **230** | 1 | **231** | T | **232** | 0 | **233** | A | **234** | S | **235** | = | **236** | " | **237** | C | **238** | M | **239** | 2 |
| **240** | I | **241** | B | **242** | 9 | **243** | ' | **244** | - | **245** | H | **246** | P | **247** | x | **248** | R | **249** | D | **250** | F | **251** | N |
| **252** | W | **253** | L | **254** | ) | **255** | ( | **256** | G | **257** | 3 | **258** | 5 | **259** | 8 | **260** | J | **261** | E | **262** | O | **263** | 4 |
| **264** | 6 | **265** | 7 | **266** | z | **267** | j | **268** | K | **269** | q | **270** | U | **271** | V | **272** | ; | **273** | – | **274** |  | **275** | Y |
| **276** | Z | **277** | / | **278** | — | **279** | é | **280** | Q | **281** | % | **282** | $ | **283** | [ | **284** | ] | **285** | X | **286** | & | **287** | ! |
| **288** | á | **289** | ā | **290** | í | **291** | ’ | **292** | £ | **293** | ° | **294** | ó | **295** | ? | **296** | + | **297** | è | **298** | ō | **299** | ü |

**Token Embedding Weight (Embedding\_Dim = 12)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | -3.741246e-01 | -6.359636e-01 | -2.619245e-01 | 3.121038e-01 | 2.094382e-01 | 1.075720e+00 | -4.619952e-01 | 4.249024e-02 | -2.159138e-01 | -5.736234e-01 | 1.266070e-01 | -4.451426e-01 |
|  | -7.353153e-01 | -5.996881e-01 | 1.014305e+00 | 4.083213e-01 | -1.571335e-01 | 6.998475e-01 | 6.791546e-02 | 1.905314e-01 | -2.278671e-02 | -3.782676e-01 | 3.491611e-02 | 3.402570e-01 |
|  | 3.467283e-02 | 2.548601e-01 | 4.086047e-02 | 1.717503e-01 | -5.115746e-01 | 6.766837e-01 | 1.282385e-01 | 2.962483e-01 | -3.473595e-01 | -4.927135e-01 | -5.789226e-01 | 2.419079e-01 |
|  | 1.069627e-01 | 2.027459e-01 | 7.700051e-02 | -3.232928e-01 | 3.801017e-01 | 5.631875e-03 | 3.105607e-01 | 1.806552e-01 | 1.559680e-01 | 2.571816e-01 | -3.157049e-01 | -1.392332e-01 |
|  | 1.284529e-01 | -2.380871e-01 | 8.687333e-01 | 2.930850e-01 | 1.185499e+00 | -5.584015e-01 | -2.329724e-01 | -1.662668e-01 | 5.702108e-01 | 2.260734e-01 | -1.919873e-01 | 3.451475e-01 |
|  | -1.342812e-02 | 7.272981e-01 | 1.963617e-01 | 1.529339e-01 | 4.779461e-01 | -3.960828e-01 | 1.632019e-01 | 7.358618e-01 | 5.218012e-01 | 1.696179e-02 | 3.237548e-01 | -3.577949e-01 |
|  | 2.915032e-01 | -3.489269e-02 | 6.340353e-02 | -4.158981e-01 | 4.160497e-01 | -4.152122e-01 | 5.910597e-01 | 4.619655e-02 | -1.903221e-01 | -1.838506e-01 | -1.434972e-01 | -9.567142e-01 |
|  | -6.026332e-01 | 3.247442e-01 | 1.388659e-01 | 6.024736e-01 | 1.062524e-01 | 1.729565e-01 | -2.108377e-01 | -5.561347e-02 | -1.459196e-02 | 4.286093e-02 | -1.399781e-01 | -2.736831e-02 |
|  | 3.553801e-01 | 8.200578e-02 | 1.826134e-01 | 1.508268e-02 | 3.613860e-01 | 4.750213e-03 | 5.276601e-01 | 2.174844e-01 | 1.150251e-01 | 2.198538e-01 | -7.384960e-01 | -7.126193e-01 |
|  | -4.686502e-01 | 2.832316e-01 | -3.188397e-01 | -3.104689e-01 | 3.565649e-02 | -1.762012e-01 | 1.095651e-01 | 2.794001e-01 | 3.103457e-01 | -2.285425e-01 | -4.667726e-01 | -6.259897e-01 |
|  | -3.769045e-01 | 1.961696e-01 | -3.508306e-02 | 4.982104e-01 | -2.481366e-01 | 3.312525e-01 | -2.146422e-02 | -8.358729e-02 | -1.794412e-01 | 2.448799e-01 | -2.173516e-01 | -2.086928e-01 |
|  | 2.810138e-01 | -1.051151e-01 | -6.064624e-02 | 2.152081e-01 | -5.393874e-01 | 2.288370e-01 | -9.527911e-02 | -4.808075e-01 | -4.875821e-01 | 1.817241e-01 | -6.001818e-01 | -1.969526e-01 |
|  | -3.759269e-01 | 8.759813e-01 | 8.191445e-02 | 2.563907e-01 | 9.820316e-02 | -8.385955e-02 | 6.345936e-02 | 2.604657e-01 | 1.878369e-01 | -1.160676e-01 | 2.501043e-01 | 2.864914e-02 |
|  | -3.507758e-01 | -5.043256e-01 | 8.031011e-01 | 8.032272e-01 | 5.278075e-01 | -1.678835e-01 | 8.680293e-02 | -1.893068e-01 | 1.286397e-01 | 8.487370e-01 | 5.555109e-01 | 6.183923e-01 |
|  | 4.047858e-01 | 1.883234e-01 | -2.885724e-01 | -2.416733e-02 | -3.565985e-01 | 3.686874e-01 | -3.711023e-01 | -5.278273e-02 | 3.795477e-01 | 1.077237e-01 | -5.796869e-01 | 2.329091e-02 |
|  | -6.470322e-01 | -3.384739e-01 | 1.510402e-01 | 1.915626e-01 | 1.040492e+00 | -8.050457e-01 | 6.861634e-01 | -3.257445e-01 | -1.754623e-01 | 4.067573e-01 | 5.584681e-01 | -4.232318e-01 |
|  | 1.682435e-01 | -6.245732e-01 | 1.425062e+00 | 1.480113e-01 | 6.815319e-01 | -5.000867e-01 | 1.012095e-01 | 7.418559e-02 | 7.084013e-01 | 4.940264e-01 | 1.581442e-01 | 8.549743e-01 |
|  | -2.387830e-01 | 2.830384e-01 | 2.231746e-01 | -1.511972e-02 | -3.760754e-01 | -2.006596e-01 | -3.801146e-01 | -4.870207e-01 | -2.312145e-02 | 1.379384e-02 | -3.233887e-01 | 4.774582e-01 |
|  | -2.348181e-01 | -5.290049e-02 | -8.216100e-02 | 1.008585e-01 | -4.721082e-01 | -1.620399e-01 | -6.923155e-01 | -5.938687e-01 | -2.473466e-01 | -1.267873e-01 | 1.835161e-01 | 2.851944e-01 |
|  | 5.464725e-01 | 4.860434e-01 | 2.792165e-01 | 2.306858e-01 | 9.045330e-02 | 5.217069e-01 | 3.870041e-01 | -3.840479e-01 | -2.549053e-01 | 5.305757e-02 | -1.181685e-01 | 2.825569e-01 |
|  | -6.596212e-01 | 2.318089e-01 | 1.917708e-03 | 5.355712e-01 | 6.237117e-02 | 1.382089e-01 | -5.063785e-02 | 5.203236e-01 | 4.207487e-01 | 2.565870e-01 | -5.560579e-02 | -2.421822e-01 |
|  | -4.375865e-01 | 7.371452e-02 | -2.370981e-01 | -5.449254e-02 | -4.334641e-01 | -3.787960e-01 | -1.076010e+00 | -3.869490e-01 | -8.539812e-03 | -5.401996e-01 | -1.085428e-01 | -5.903808e-03 |
|  | 6.164281e-01 | -6.553172e-01 | 3.392923e-01 | 1.356256e-01 | 7.342450e-01 | -3.761473e-02 | -4.424805e-01 | 1.436273e-02 | 7.966507e-01 | 5.029292e-01 | 6.051508e-01 | 4.462536e-01 |
|  | -8.716955e-02 | 7.420007e-01 | -3.105992e-01 | -1.151167e-01 | -2.642896e-01 | -1.390395e-01 | 2.901450e-01 | 2.935485e-01 | 3.192998e-01 | 1.531366e-01 | 8.318524e-02 | -1.076350e-01 |
|  | 4.855952e-01 | -3.530156e-01 | 5.160901e-01 | -4.579481e-02 | 6.365767e-01 | -1.430010e-01 | -3.859461e-01 | 5.483787e-01 | 1.254073e+00 | 4.115719e-01 | -1.654300e-02 | 3.364155e-01 |
|  | 1.187748e-02 | 1.476845e-01 | -5.255827e-01 | -2.958370e-01 | -6.565349e-01 | 6.523562e-02 | 1.564404e-02 | -2.254566e-01 | -5.924476e-02 | 1.501635e-02 | 4.905788e-01 | -4.845830e-02 |
|  | 1.187731e-02 | 3.629892e-01 | -1.677346e-01 | -5.122992e-01 | -4.149582e-01 | 1.543900e-01 | 5.194840e-01 | 2.270150e-02 | -6.292372e-03 | -2.247434e-01 | 9.540474e-02 | -2.214405e-01 |
|  | -2.766705e-01 | 6.295751e-01 | -2.813250e-01 | 7.562449e-02 | 1.472348e-01 | -5.672444e-02 | -3.982165e-01 | 3.249701e-01 | 5.984972e-01 | -1.794218e-01 | -8.456100e-02 | -1.369748e-01 |
|  | 4.135862e-02 | 2.660182e-01 | -1.070185e-01 | 1.881003e-01 | -1.555656e-01 | 1.078080e-01 | 9.644274e-02 | -4.679268e-01 | -4.388032e-01 | -2.910905e-02 | -8.527181e-01 | -3.588705e-01 |
|  | -3.269448e-01 | -9.168607e-01 | 5.426850e-01 | -1.574035e-01 | 1.075410e+00 | -5.091579e-01 | -1.598323e-01 | -3.499114e-01 | 1.983279e-01 | -3.315790e-01 | 4.373586e-01 | -1.005001e-02 |
|  | -7.587793e-02 | 6.396311e-01 | -3.738569e-01 | 2.654343e-01 | -2.313420e-02 | 4.824351e-01 | 7.760686e-02 | 1.439420e-01 | 3.451670e-01 | 2.040722e-01 | 1.037700e-01 | -1.836074e-02 |
|  | 4.419639e-02 | 4.240375e-01 | 8.042527e-03 | 1.018647e-01 | -9.640117e-02 | -1.509566e-01 | 4.996216e-01 | -3.827031e-01 | -5.944813e-01 | 8.557582e-02 | -3.172722e-01 | -3.511923e-01 |
|  | -6.580539e-02 | 6.277527e-01 | -4.941296e-01 | -2.197353e-01 | -8.356217e-04 | 6.733745e-02 | -9.929182e-02 | -1.295157e-01 | 2.419459e-01 | -2.520447e-01 | -4.648413e-01 | -2.171812e-01 |
|  | 9.596699e-02 | 3.891764e-01 | -2.191116e-01 | 1.733603e-01 | -1.339736e-01 | 3.405188e-01 | -2.958721e-01 | -1.475393e-01 | 1.221352e-01 | -7.873219e-02 | -7.393892e-01 | -1.154481e-01 |
|  | 6.785265e-02 | -7.442403e-01 | -2.638059e-01 | -8.026627e-01 | 4.379361e-01 | -7.647990e-01 | -7.995994e-01 | -5.809360e-01 | 2.178549e-01 | -5.928018e-01 | -8.622745e-02 | -3.596630e-01 |
|  | 2.766337e-01 | -1.894154e-01 | -1.541874e-01 | 1.023968e-01 | -3.747013e-01 | 9.698736e-02 | -4.886083e-02 | -1.052799e-01 | -8.354484e-02 | 3.211825e-01 | -1.021455e+00 | -5.095027e-01 |
|  | -2.533658e-01 | 2.205839e-01 | 1.373449e-01 | 2.844949e-01 | -4.919519e-01 | 1.902598e-01 | -4.137455e-02 | -2.071862e-01 | -2.400187e-01 | 1.044110e-01 | 3.770865e-01 | 2.117995e-01 |
|  | 7.343245e-01 | 5.820661e-01 | -1.320540e-01 | 9.951511e-02 | 2.219942e-01 | -9.289251e-02 | 6.573648e-02 | -3.912631e-01 | -1.486294e-01 | 3.162678e-02 | -5.329723e-01 | -2.271891e-01 |
|  | -8.701636e-03 | 7.911878e-01 | -2.578035e-01 | 1.079105e-01 | 3.436117e-01 | -3.971726e-01 | -9.613451e-03 | 4.476804e-01 | 6.375737e-01 | 2.326715e-01 | 6.699937e-01 | 3.104901e-04 |
|  | -3.051059e-01 | 1.668366e-01 | -2.784700e-01 | 2.030129e-01 | -6.265243e-02 | 1.010338e-01 | -4.095863e-01 | 3.578996e-01 | 7.112590e-01 | 3.057080e-01 | -4.845263e-01 | -1.031866e-01 |
|  | 5.102268e-02 | -8.403216e-01 | 3.520824e-01 | -5.286848e-02 | 4.169939e-01 | 5.854640e-02 | -3.659338e-01 | 6.147039e-01 | 8.308720e-01 | -3.167620e-02 | 5.296530e-01 | -8.573918e-02 |
|  | -3.241666e-01 | -6.264162e-01 | 6.310352e-01 | 3.833021e-01 | 4.078305e-01 | -3.899396e-01 | -9.002727e-01 | -2.405254e-01 | 1.869247e-01 | -7.126293e-02 | 1.308406e-02 | 2.870940e-01 |
|  | -2.996103e-01 | -1.222547e-01 | 1.268053e+00 | 6.478647e-01 | 1.023386e+00 | -9.439889e-02 | 4.322594e-01 | 9.113930e-01 | 7.714936e-01 | 2.115714e-01 | 9.898560e-01 | 3.825802e-01 |
|  | -4.417183e-02 | 4.388018e-02 | -1.846232e-01 | -2.383762e-01 | -5.217836e-01 | 4.711094e-02 | 2.174854e-02 | 4.192283e-01 | 6.143690e-01 | 3.769628e-01 | -4.836476e-01 | -5.262929e-02 |
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|  | -9.213767e-02 | -3.717712e-01 | -1.803317e-01 | -8.999662e-01 | -8.947614e-02 | 1.126365e-01 | 1.304584e-01 | -4.964177e-01 | 1.518924e-01 | -3.836762e-01 | 2.942924e-01 | 1.922467e-01 |
|  | -9.939212e-02 | -1.380383e-01 | -3.605338e-02 | -6.366745e-01 | 9.567326e-02 | 4.732409e-02 | 4.081547e-01 | -4.832657e-01 | 1.612995e-01 | 1.807191e-01 | 2.283211e-01 | 3.606154e-01 |
|  | 2.545922e-01 | -7.557204e-03 | -1.788833e-01 | -6.395330e-01 | -6.982309e-02 | 1.158085e-01 | 2.305193e-01 | -5.521732e-01 | 1.573667e-01 | 6.661258e-03 | -8.056686e-02 | 2.459837e-01 |
|  | -2.166388e-01 | 1.089594e-02 | -2.747768e-01 | 1.409486e-01 | -4.647678e-01 | 2.627346e-01 | -1.116845e-01 | 8.749223e-02 | -2.203446e-01 | 2.740097e-01 | -2.089272e-01 | -1.731700e-02 |
|  | 2.382456e-01 | -3.144025e-01 | -6.638685e-02 | 1.754238e-01 | -6.309236e-02 | -3.342881e-02 | -2.283350e-01 | -3.357349e-01 | 3.709586e-02 | -3.187335e-01 | -7.022725e-02 | -2.905478e-01 |
|  | -5.680315e-02 | -4.038426e-01 | 1.446544e-02 | -8.395690e-01 | 1.503290e-01 | -1.746386e-01 | 2.882806e-01 | -6.354800e-01 | 7.023747e-02 | -6.038399e-02 | 2.635516e-01 | 2.933656e-01 |
|  | -8.406144e-02 | -7.074195e-01 | 1.878475e-01 | -7.913065e-01 | -1.656407e-01 | 3.701762e-01 | 8.660678e-01 | -1.384497e-01 | -4.097188e-02 | 1.184603e-01 | -5.108788e-03 | -1.180233e-01 |
|  | 2.070236e-01 | -7.353954e-01 | 7.879264e-02 | -6.394629e-01 | -5.149372e-01 | 4.865505e-01 | 5.038449e-01 | -3.675363e-01 | -5.711872e-02 | 3.009256e-01 | -1.221550e-01 | 1.281247e-01 |
|  | -5.495062e-01 | -4.487907e-01 | 4.942105e-01 | -5.624031e-01 | 1.019276e-01 | 1.345012e-01 | 9.032378e-01 | -3.365785e-01 | -3.933935e-01 | -2.625959e-01 | 1.751132e-01 | -9.536000e-02 |
|  | -3.982677e-02 | -1.361877e-01 | 3.684328e-01 | -1.376203e-01 | -4.394701e-01 | 8.814669e-02 | 1.909332e-01 | 7.555869e-02 | -1.076183e-01 | 1.819543e-03 | 2.147141e-01 | 1.314439e-01 |
|  | 6.852964e-02 | -6.086726e-02 | 2.865503e-02 | -7.165644e-01 | 1.403774e-01 | 1.415662e-01 | 5.975283e-01 | -2.979994e-01 | 2.846068e-01 | 3.094795e-02 | 4.636577e-01 | 3.336635e-01 |
|  | 1.051061e-01 | -1.372562e-01 | -3.196674e-02 | -9.163283e-01 | -9.620377e-02 | -1.277029e-01 | 6.835454e-01 | -1.890562e-01 | 1.138882e-01 | 2.684786e-02 | 2.916265e-01 | -9.416956e-02 |
|  | -5.508981e-02 | -2.719910e-01 | 2.089750e-01 | -8.067035e-01 | 1.596466e-01 | 1.859512e-01 | 9.180800e-01 | -2.926562e-01 | -8.659443e-02 | -4.988430e-02 | 2.363351e-01 | -3.980241e-02 |
|  | 2.027156e-01 | -3.209140e-01 | 3.289877e-01 | -8.013664e-01 | -5.147161e-02 | 3.620581e-02 | 7.200685e-01 | -5.741836e-01 | -2.175483e-01 | 5.310633e-02 | 6.790610e-02 | 1.856833e-01 |
|  | -1.607512e-01 | -3.042467e-01 | 4.731424e-01 | -4.290371e-01 | -8.376533e-02 | 2.924149e-01 | 8.132012e-01 | -5.988560e-01 | -3.748098e-01 | 1.487346e-01 | -2.122295e-01 | 2.256414e-01 |
|  | -3.344741e-01 | 3.618769e-01 | -3.071159e-01 | -2.909506e-01 | -2.159233e-01 | 2.935967e-01 | 8.624532e-02 | -2.553036e-01 | 2.378291e-01 | -7.079770e-02 | 2.146323e-01 | 3.609682e-01 |
|  | -5.126418e-01 | -5.959853e-01 | 3.403503e-02 | -5.878620e-01 | -1.130625e-01 | -3.433430e-01 | -2.726727e-01 | -2.540574e-01 | -1.486211e-01 | -6.542152e-01 | 7.641029e-01 | -3.246931e-02 |
|  | -2.073780e-01 | -8.959429e-02 | 8.888227e-02 | -3.087818e-01 | -4.923387e-01 | 2.178590e-01 | 3.128878e-01 | -3.372521e-01 | -5.709623e-02 | -2.773498e-02 | -3.247585e-01 | 7.397561e-02 |
|  | 4.375582e-01 | 1.313614e-01 | 1.233972e-01 | -2.659019e-01 | -2.604285e-01 | -1.265916e-01 | -6.305210e-02 | 3.314416e-01 | 2.788277e-01 | -5.175605e-02 | 1.834948e-01 | 1.079875e-02 |
|  | -3.325821e-01 | 6.542624e-01 | -4.297495e-01 | 6.262978e-01 | 7.803748e-01 | -4.850442e-01 | -1.935791e-01 | 1.131233e-01 | 3.831939e-01 | 5.388260e-01 | 4.140843e-01 | -4.393057e-02 |
|  | -1.192955e-01 | -7.197066e-01 | -4.099779e-01 | -3.045922e-01 | -4.041434e-01 | -2.229591e-02 | -3.136253e-01 | 1.696321e-02 | 1.743909e-01 | 1.648768e-01 | 8.502321e-01 | -9.327128e-02 |
|  | -2.093254e-01 | -6.863382e-02 | 1.695600e-01 | -1.193746e-03 | -5.629036e-01 | 6.629219e-02 | 4.345133e-02 | -5.068138e-01 | -3.240725e-01 | 2.180823e-01 | -6.043562e-01 | 2.296314e-01 |
|  | -2.820079e-01 | -1.580416e-01 | 4.268381e-01 | 1.133615e-01 | -4.560921e-01 | 3.178661e-01 | 8.105762e-01 | -6.723571e-02 | -4.451484e-01 | 4.432733e-01 | -6.337276e-02 | -1.801113e-01 |
|  | -2.100960e-01 | -1.422240e-01 | 6.505042e-01 | 2.295100e-01 | -4.479628e-01 | 3.702907e-01 | 2.556932e-01 | -1.954666e-01 | -3.598484e-01 | 1.555279e-01 | -1.113983e-02 | 3.102835e-01 |
|  | 2.391839e-01 | -5.563434e-01 | 5.393048e-01 | -8.380885e-01 | 4.718707e-01 | 3.121273e-01 | 7.225879e-01 | 4.165531e-01 | 1.014501e+00 | 2.414501e-01 | 5.993811e-01 | 2.754730e-01 |
|  | 3.356513e-01 | 1.171465e-01 | -2.358650e-01 | 3.645311e-02 | 1.860038e-01 | -8.374611e-02 | -2.422651e-01 | -3.624384e-01 | 3.099860e-01 | 3.265952e-01 | 9.146994e-01 | 5.605565e-01 |
|  | 1.167819e+00 | 4.391063e-03 | -1.486406e-01 | 4.720518e-02 | 6.780334e-03 | 3.075036e-02 | 1.338453e-01 | -2.348328e-02 | 1.507194e-01 | 5.868043e-01 | -2.541174e-01 | -3.085813e-01 |
|  | 2.553682e-03 | -9.179857e-02 | -1.410834e-01 | -2.610018e-01 | -6.630446e-01 | -1.343717e-02 | -8.222422e-02 | -7.144253e-01 | -4.644573e-01 | -4.946750e-02 | -3.611400e-01 | 4.509773e-02 |
|  | -4.050934e-01 | 2.287357e-01 | -1.832415e-01 | 5.803510e-02 | -6.535933e-01 | -1.526425e-01 | 1.077487e-01 | 2.925863e-02 | -1.619491e-02 | 4.420232e-01 | 2.510409e-01 | -4.630393e-03 |
|  | 4.039099e-03 | -1.175355e+00 | 3.367595e-01 | -1.089257e-01 | -1.659111e-01 | 4.807706e-03 | -8.144126e-01 | -8.025408e-02 | -2.530111e-01 | -5.636504e-01 | -2.306505e-01 | -1.081266e+00 |
|  | -8.287553e-02 | -1.543109e-01 | -5.100740e-03 | -7.253329e-01 | -5.809653e-01 | 9.376544e-02 | 2.293872e-01 | -3.132501e-01 | 2.360530e-01 | -1.064602e-01 | -7.075334e-01 | 9.853959e-02 |
|  | 4.982769e-01 | 3.471265e-01 | 3.311645e-01 | 1.340794e-01 | -6.152963e-01 | 3.560473e-01 | 5.868309e-01 | 1.423913e-01 | 6.384512e-02 | 7.068230e-01 | -3.526845e-01 | 3.033530e-01 |
|  | -2.531409e-01 | -9.366035e-02 | 3.731954e-02 | -3.485151e-01 | -4.062453e-01 | 2.467309e-01 | 3.299522e-01 | -3.601970e-01 | -5.891673e-02 | 1.073158e-01 | -5.350974e-01 | 2.074591e-01 |
|  | -2.075657e-01 | 1.548031e-01 | 7.103022e-02 | -1.446610e-01 | -2.432630e-01 | 2.020084e-01 | 2.652580e-01 | -4.760306e-01 | 1.921748e-02 | 1.693061e-01 | -4.824643e-01 | 3.577197e-01 |
|  | -1.154943e-01 | -3.541656e-01 | 3.955598e-02 | -6.626788e-01 | 5.157729e-01 | 1.306875e-01 | 3.876941e-01 | -3.630072e-01 | 5.786601e-01 | 4.373355e-02 | 1.897352e-02 | 2.475503e-01 |
|  | 3.056628e-01 | 3.522507e-01 | -2.123971e-01 | 1.501647e-01 | -2.071363e-01 | 2.249484e-01 | 2.323422e-01 | -6.422454e-01 | -4.566983e-01 | 1.570413e-01 | -4.044821e-02 | 3.284443e-01 |
|  | -2.540950e-02 | -4.552643e-01 | 4.305748e-01 | -1.309771e-01 | -5.286442e-01 | 1.639881e-01 | 1.749044e-03 | -3.519807e-01 | -4.949574e-01 | -8.400055e-02 | -6.710657e-02 | 2.683542e-01 |
|  | 2.583350e-01 | 5.954139e-01 | -2.470778e-01 | 2.778443e-01 | 5.488597e-01 | -7.122327e-01 | -1.391896e-01 | 2.619358e-01 | 3.639340e-02 | 8.925541e-02 | -1.062619e-01 | -6.346368e-01 |
|  | 1.422091e-01 | 3.386254e-01 | -2.899026e-01 | 5.485386e-01 | 1.378479e-01 | -7.415763e-02 | 1.347991e-01 | -1.131074e-01 | -1.875212e-01 | 4.743709e-01 | 3.260773e-01 | -5.062473e-01 |
|  | -8.900293e-02 | 4.474229e-01 | 1.473677e-01 | 4.180120e-01 | -2.871110e-01 | 1.810173e-01 | -2.755482e-02 | 3.867316e-01 | 5.033816e-01 | 3.810863e-01 | 4.586178e-01 | 1.940933e-01 |
|  | 9.111744e-01 | 1.149496e-01 | -5.631255e-01 | -2.717085e-01 | 3.532301e-01 | 2.692820e-03 | 6.157816e-01 | -2.368872e-01 | -1.177194e-01 | 1.901424e-01 | -2.301240e-01 | -4.665569e-01 |
|  | 2.918453e-01 | 2.573083e-01 | -1.868911e-02 | 8.623160e-02 | -6.959422e-01 | 1.504938e-02 | 3.022178e-01 | -1.137321e-01 | -2.409868e-01 | 2.123312e-01 | -3.761650e-01 | 1.940859e-01 |
|  | 3.958156e-01 | -5.031124e-02 | -9.620537e-02 | -2.076774e-01 | -2.866128e-01 | 1.875570e-01 | 3.140207e-01 | -1.808033e-01 | -8.384368e-02 | 3.675947e-01 | 7.038303e-02 | 2.196888e-01 |
|  | 2.975872e-01 | 1.559666e-01 | -3.889752e-02 | 2.068284e-01 | 5.962304e-01 | -7.892438e-01 | 3.517267e-02 | 6.899758e-01 | 3.094399e-01 | 6.755128e-01 | 2.606190e-01 | -3.603687e-01 |
|  | 3.208597e-01 | 4.423501e-01 | -5.895792e-02 | -7.815803e-02 | -5.457492e-01 | 3.602433e-01 | -5.234259e-02 | -8.352362e-02 | -1.682400e-02 | -1.684690e-01 | -5.706356e-02 | 5.797814e-01 |
|  | 1.842674e-01 | -9.545047e-02 | 8.898836e-01 | -7.223459e-02 | 1.851526e-01 | 2.776459e-01 | 2.916809e-01 | 2.425955e-01 | -1.390975e-01 | -1.333441e-01 | -1.449635e-01 | -1.356655e-01 |
|  | -6.166648e-02 | 1.799634e-01 | -3.281756e-01 | 1.693758e-01 | -1.383593e-01 | -4.138112e-01 | -2.425962e-01 | -1.839180e-01 | -1.561672e-01 | 2.512324e-01 | 2.514745e-01 | -4.381279e-01 |
|  | -3.250572e-01 | 1.959741e-01 | -3.171201e-01 | -1.433174e-01 | -4.128444e-01 | -1.944620e-01 | -4.793541e-02 | -1.796019e-01 | -4.306974e-02 | 1.572072e-01 | -2.491567e-02 | -2.058508e-01 |
|  | -2.760527e-01 | 4.517871e-02 | 1.892694e-01 | 3.743668e-01 | -8.706779e-02 | -6.224164e-01 | -1.408158e-02 | -1.023868e-01 | -1.540416e-01 | 5.133468e-01 | 1.664241e-02 | -1.738682e-02 |

**Position Embedding Weight (Embedding\_Dim = 12, Max\_Seq\_Len = 16)**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |
| 4.158500e-01 | -1.949988e-01 | -2.365078e-01 | -5.049745e-01 | 6.539327e-01 | -1.880279e-01 | -3.662106e-01 | 7.947314e-01 | -7.564061e-01 | -8.355716e-02 | -5.895474e-01 | 1.046270e+00 |
| 1.674122e-01 | 1.569716e-02 | -1.178682e-01 | -5.914081e-01 | 6.567027e-01 | 5.364657e-03 | -4.999004e-01 | 6.732099e-01 | -1.132163e+00 | 1.209195e-01 | -6.322204e-02 | 3.590975e-01 |
| 4.786139e-03 | 1.575054e-01 | -5.974528e-02 | -7.253161e-01 | 6.457813e-01 | 2.146142e-01 | -5.515308e-01 | 3.551483e-01 | -9.411322e-01 | 4.297113e-01 | 1.211590e-01 | 2.546982e-03 |
| -1.250602e-01 | 2.967361e-01 | 5.686091e-02 | -6.833055e-01 | 4.947201e-01 | 3.590525e-01 | -5.146986e-01 | 9.919457e-02 | -5.672447e-01 | 5.692165e-01 | 2.819290e-01 | -1.820414e-01 |
| -2.192527e-01 | 3.536757e-01 | 1.804120e-01 | -5.881378e-01 | 3.160569e-01 | 4.051244e-01 | -4.289742e-01 | -1.023577e-01 | -2.142949e-01 | 5.657954e-01 | 3.705807e-01 | -3.119287e-01 |
| -2.885894e-01 | 3.463786e-01 | 2.332268e-01 | -4.749943e-01 | 9.062239e-02 | 3.183042e-01 | -3.532475e-01 | -2.845000e-01 | 4.701203e-02 | 4.558106e-01 | 3.607281e-01 | -4.430472e-01 |
| -3.017989e-01 | 3.069823e-01 | 2.691520e-01 | -3.146965e-01 | -1.182940e-01 | 2.086618e-01 | -2.276500e-01 | -4.526762e-01 | 2.926774e-01 | 3.068767e-01 | 3.329665e-01 | -5.411173e-01 |
| -2.936891e-01 | 2.442140e-01 | 2.877829e-01 | -1.415950e-01 | -2.879260e-01 | 1.106215e-01 | -7.082754e-02 | -5.692025e-01 | 5.513123e-01 | 1.509377e-01 | 2.755358e-01 | -5.384153e-01 |
| -2.508033e-01 | 1.803741e-01 | 2.541365e-01 | 6.244984e-02 | -4.179104e-01 | -7.482575e-03 | 9.093513e-02 | -6.318926e-01 | 7.656417e-01 | -2.201265e-02 | 2.160273e-01 | -5.210577e-01 |
| -1.592364e-01 | 1.155828e-01 | 2.215285e-01 | 2.887821e-01 | -4.953842e-01 | -9.287743e-02 | 2.494547e-01 | -6.165589e-01 | 9.002618e-01 | -2.093817e-01 | 1.480190e-01 | -4.178449e-01 |
| -3.176242e-02 | 6.278335e-02 | 1.588431e-01 | 4.983150e-01 | -5.260979e-01 | -1.993727e-01 | 3.947840e-01 | -5.139300e-01 | 9.664299e-01 | -3.867995e-01 | 5.838409e-02 | -2.620399e-01 |
| 1.094573e-01 | -1.215952e-02 | 7.999105e-02 | 6.715674e-01 | -4.905423e-01 | -2.928883e-01 | 4.987429e-01 | -3.846574e-01 | 9.110691e-01 | -5.497895e-01 | -4.477762e-02 | -8.966552e-02 |
| 2.351709e-01 | -8.194827e-02 | -4.140887e-02 | 8.269899e-01 | -4.204212e-01 | -3.872293e-01 | 5.650887e-01 | -2.370369e-01 | 7.920983e-01 | -6.879665e-01 | -1.331920e-01 | 8.711663e-02 |
| 4.036961e-01 | -9.087127e-02 | -5.352523e-02 | 8.628485e-01 | -3.711848e-01 | -4.469160e-01 | 5.679197e-01 | 3.800835e-02 | 5.588811e-01 | -7.940201e-01 | -2.215289e-01 | 2.592809e-01 |
| 5.080879e-01 | -7.730159e-01 | -1.019610e+00 | 1.384328e+00 | 1.404163e-01 | -1.174958e+00 | 1.200360e+00 | 2.330894e-01 | 2.409616e-01 | -1.201913e+00 | -4.999893e-01 | 1.060508e+00 |
| 2.333611e-01 | -8.761143e-02 | 2.447063e-01 | 7.846642e-02 | -1.016171e-01 | 1.668976e-01 | -1.676541e-01 | -1.728621e-01 | 2.888685e-01 | -2.045751e-01 | -8.318471e-02 | -1.571816e-01 |

**Layer 1**

**1. Calculate LayerNorm 1**

**, ,**

**\*** In this case, h1 has shape of (n \* 12)

**Masked MSA block Weight (γ₁)**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |
| 6.175187e-01 | 1.020044e+00 | 1.007808e+00 | 8.669566e-01 | 7.341702e-01 | 1.133420e+00 | 8.829391e-01 | 1.102555e+00 | 9.235978e-01 | 1.039975e+00 | 7.770612e-01 | 9.110500e-01 |

**Masked MSA block Bias (β₁)**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |
| 5.107012e-02 | 2.985823e-01 | 3.019372e-02 | 3.707277e-01 | 1.328427e-01 | 9.781763e-02 | 7.925928e-02 | 4.113878e-01 | -1.374485e-01 | 2.032842e-01 | -2.752136e-02 | 3.073651e-01 |

**2. Calculate Q,K,V, Multihead attention**

**, ,** \*Perform a single 12×12 multiplication. (You can also compute by splitting into n\*12)

**Masked MSA Multihead Attention block *in* Q, K, V weight (3 heads)**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Query Weight** | | | | | | | | | | | |
| -2.792495e-01 | 3.953977e-02 | 3.542362e-02 | 6.315130e-03 | -1.026617e-01 | -2.668245e-01 | -5.189547e-01 | -2.565697e-01 | 5.204406e-01 | -1.021446e-01 | 7.447452e-01 | -5.499777e-01 |
| 1.331214e-01 | -1.706550e-01 | 1.224960e-01 | 3.754453e-01 | -1.954252e-01 | -1.099524e-02 | 2.956457e-01 | -6.418976e-01 | 1.635166e-01 | -1.864894e-01 | -9.323798e-02 | -3.868453e-01 |
| -1.411523e-01 | -4.861955e-01 | -1.484299e-01 | -2.628005e-01 | 3.561212e-01 | -4.165637e-01 | -1.246645e-01 | -1.331307e-01 | 9.420021e-02 | 7.773160e-01 | -1.914929e-01 | -1.826165e-01 |
| 7.832651e-02 | -3.660667e-01 | 4.445374e-02 | -4.951328e-01 | -1.872689e-01 | -1.628078e-01 | 3.260820e-01 | -5.164062e-01 | -4.193489e-02 | -1.586417e-01 | 2.338347e-01 | 1.090866e-01 |
| 1.729054e-01 | -2.158219e-01 | -1.979380e-01 | 3.485445e-01 | -6.498058e-02 | -4.169164e-01 | 1.962307e-01 | 3.627300e-02 | -8.858197e-02 | -9.346192e-02 | -5.862533e-02 | 5.172705e-02 |
| 1.103347e-01 | -4.045927e-01 | -1.976134e-01 | -1.863195e-01 | 8.715877e-02 | -2.712499e-02 | 2.647068e-02 | -1.769116e-01 | -2.207567e-01 | -2.643707e-01 | 2.605434e-01 | 1.753810e-02 |
| -2.410164e-01 | -2.876242e-01 | -3.390498e-01 | 3.006831e-01 | -2.714058e-01 | -4.627088e-02 | 2.295026e-01 | -5.067369e-03 | 3.500806e-01 | -3.360635e-01 | -6.319542e-03 | 3.214221e-02 |
| 5.754248e-02 | -8.645325e-03 | 2.289879e-01 | 1.074458e-01 | -2.436539e-01 | 1.759983e-02 | 2.078451e-01 | -5.085326e-01 | 2.499482e-01 | -1.311746e-01 | 1.556632e-01 | -4.525951e-01 |
| -1.291546e-01 | 1.583614e-01 | 2.222372e-01 | -1.217829e-01 | 1.233119e-02 | -1.475831e-01 | 3.290968e-02 | -2.722454e-01 | -2.101508e-01 | 1.802560e-01 | 8.568320e-02 | -1.887693e-01 |
| 1.825411e-02 | -1.910424e-01 | -3.104821e-01 | 2.241029e-02 | -7.294647e-02 | -3.353969e-01 | 1.521154e-01 | 1.256861e-01 | -9.248365e-02 | -1.575136e-01 | -2.661091e-02 | 3.113283e-01 |
| 1.243564e-01 | 1.954755e-01 | -5.468297e-02 | -3.325458e-01 | 3.234053e-01 | 2.088389e-01 | -1.999294e-01 | 5.582091e-01 | -4.011239e-01 | 4.179322e-01 | -1.356594e-01 | 3.355571e-01 |
| -1.461634e-01 | -1.536093e-01 | 2.298509e-01 | -2.634102e-01 | -2.240231e-01 | 7.712372e-02 | -4.240536e-01 | -1.070358e-01 | 2.424098e-02 | -6.747273e-02 | -9.508153e-02 | -4.966296e-01 |
| **Key Weight** | | | | | | | | | | | |
| -7.032716e-01 | 1.093499e-01 | 1.896074e-01 | 1.572291e-01 | -9.936372e-02 | -2.249519e-01 | -1.039722e-01 | -5.712576e-01 | 6.758159e-01 | 1.684140e-02 | 5.759029e-02 | 2.550745e-01 |
| 2.152955e-01 | -4.537740e-01 | -4.698764e-02 | 4.539201e-01 | -2.128524e-01 | -4.583617e-01 | 6.789792e-01 | -1.546418e-01 | 3.982602e-01 | -3.084548e-01 | -2.645471e-02 | 1.820333e-02 |
| 3.437873e-03 | -3.250760e-01 | 3.627523e-01 | -9.012647e-02 | 5.036770e-01 | 5.314283e-02 | -3.153650e-01 | -5.859272e-01 | -1.809361e-01 | -3.195641e-01 | 6.763883e-01 | -8.823578e-02 |
| 2.682933e-01 | -4.704495e-01 | -5.198516e-01 | -1.592912e-01 | 4.246598e-01 | -2.452989e-01 | -9.135675e-02 | -1.163367e-01 | 3.423918e-01 | 5.793197e-02 | 4.187952e-01 | 3.055103e-01 |
| 2.120039e-01 | -1.722056e-01 | -2.604557e-01 | 3.062814e-01 | -2.449265e-01 | -1.618424e-01 | 4.062946e-01 | 5.649540e-02 | 6.853672e-02 | -2.761923e-01 | -1.995293e-01 | 1.974432e-01 |
| -7.448874e-02 | 2.933140e-01 | 4.356859e-02 | -2.304727e-01 | -4.279252e-01 | -4.410567e-01 | 3.364206e-01 | -3.124151e-02 | 4.714936e-02 | 2.621034e-01 | -2.944664e-01 | 3.300493e-01 |
| -1.388859e-01 | -1.517586e-01 | -8.341229e-02 | 3.166132e-01 | -1.960111e-01 | -3.040619e-01 | 2.132628e-01 | -1.432710e-01 | 4.513142e-01 | -2.260285e-01 | 1.092601e-01 | 1.090887e-01 |
| -1.162943e-01 | 8.464699e-02 | 1.964041e-01 | 3.160956e-01 | -2.842618e-01 | 1.685001e-01 | 1.343239e-01 | -4.987705e-01 | 4.270934e-01 | 1.458530e-01 | 9.217408e-02 | -6.692948e-01 |
| 2.035015e-01 | 3.150247e-01 | 4.465348e-01 | -4.592846e-01 | 1.922341e-01 | -2.009263e-01 | -3.179545e-01 | -6.629802e-02 | -1.895987e-01 | -2.728598e-01 | 3.462494e-01 | 1.416076e-01 |
| 1.681152e-01 | 7.429418e-02 | -3.285249e-01 | 1.915191e-01 | 1.580143e-01 | -5.093717e-01 | 2.923319e-01 | 8.335689e-02 | -2.546118e-01 | -2.491655e-01 | 3.010071e-02 | 2.247480e-01 |
| 1.852761e-01 | -2.676605e-01 | -1.480981e-01 | 6.496824e-02 | 7.861305e-02 | 9.052855e-01 | -2.647865e-01 | 3.378736e-01 | -5.535348e-01 | -2.289393e-01 | -1.401489e-01 | 7.166484e-02 |
| -7.280927e-02 | 3.991065e-01 | 3.540847e-02 | -4.231727e-01 | 2.387370e-01 | -1.508976e-01 | -1.956227e-01 | -1.033321e-01 | 6.274411e-02 | 2.709376e-01 | 7.193717e-02 | -8.705443e-02 |
| Value Weight | | | | | | | | | | | |
| -4.760642e-02 | 1.153213e-01 | 2.888625e-01 | -1.532473e-01 | 1.596577e-01 | 1.338508e-01 | -1.650820e-02 | -7.358602e-02 | -5.258554e-02 | -1.553292e-01 | 6.665179e-02 | 1.039752e-01 |
| -3.108766e-02 | -1.044388e-01 | 4.171821e-02 | 1.026634e-01 | 1.794530e-01 | -1.026676e-01 | 2.323950e-02 | -1.219923e-01 | 1.005323e-01 | 9.940047e-03 | 1.536721e-01 | 2.925911e-02 |
| -3.769203e-01 | 2.933545e-01 | 4.533527e-01 | -3.314814e-02 | 1.134705e-01 | 1.887563e-01 | -1.306248e-01 | -3.535120e-01 | -1.680150e-01 | -8.878160e-02 | 4.180366e-01 | -3.910843e-02 |
| 1.791872e-02 | 1.356270e-01 | 4.511670e-01 | -1.391735e-01 | 5.269162e-02 | -2.949315e-03 | -2.769011e-01 | -2.182507e-01 | -8.016232e-04 | -1.167188e-01 | 2.962922e-01 | 2.228689e-02 |
| -7.002337e-02 | -3.489582e-01 | -6.743068e-02 | -1.019152e-01 | 2.113149e-01 | -1.670513e-01 | -5.437221e-02 | 1.103952e-01 | -1.152873e-01 | -9.282544e-03 | -2.018562e-01 | -3.190120e-02 |
| 7.436498e-02 | 3.393827e-01 | -1.131088e-01 | -9.822752e-02 | -1.813683e-01 | 9.692207e-02 | -1.065122e-01 | -8.921663e-02 | -1.515985e-01 | 1.967913e-02 | 5.358198e-02 | 1.833280e-01 |
| -6.869946e-02 | -2.391681e-02 | 1.122617e-01 | -1.346641e-01 | 7.441692e-02 | 7.294011e-02 | -1.414108e-01 | 1.083032e-01 | -5.647025e-02 | -4.571600e-03 | 1.289537e-01 | -4.711917e-02 |
| -9.999207e-02 | -1.704070e-02 | 7.774289e-02 | -9.631440e-02 | 4.171303e-02 | 1.958076e-01 | -9.364770e-02 | -1.285449e-01 | -2.437167e-02 | 1.350189e-01 | -5.160280e-02 | -2.946573e-01 |
| 2.538922e-02 | 1.281845e-01 | 1.491838e-01 | -3.899211e-02 | 4.511770e-02 | 8.468506e-02 | 7.884675e-02 | -1.338072e-01 | 1.579389e-01 | 1.853745e-01 | -4.679220e-02 | -6.851358e-02 |
| 2.418706e-02 | -1.254606e-01 | -5.347631e-02 | 1.187408e-01 | 2.143664e-02 | -1.267350e-01 | -3.065812e-02 | -1.201589e-01 | 8.379860e-03 | -1.217897e-01 | -1.588612e-01 | -4.209636e-02 |
| -8.204520e-02 | -9.613573e-02 | -2.129527e-01 | 4.803011e-02 | -2.823481e-01 | 6.728744e-02 | 1.634807e-01 | 6.039409e-03 | -9.135426e-03 | -1.686017e-01 | -1.132802e-01 | 9.978408e-03 |
| -1.102383e-01 | -5.171299e-03 | 1.004393e-01 | 9.367552e-02 | -1.836075e-01 | -7.221987e-02 | 1.689304e-01 | 4.228823e-02 | 1.230265e-01 | -6.336271e-02 | 2.144309e-01 | 7.796630e-02 |

**Masked MSA Multihead Attention block *in* Q, K, V bias**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Query Bias** | | | | | | | | | | | |
| -2.613653e-01 | -8.790769e-02 | -4.019997e-01 | -8.936365e-01 | -2.178935e-01 | -5.322961e-01 | -1.492995e-01 | -3.010020e-02 | -2.744495e-01 | -3.917830e-01 | 6.259365e-01 | -6.141562e-01 |
| **Key Bias** | | | | | | | | | | | |
| -5.541956e-03 | -1.078536e-01 | -6.014297e-02 | -5.414705e-02 | 1.955501e-02 | 2.172704e-01 | -6.367262e-03 | -3.093931e-02 | 2.994608e-02 | -8.932211e-02 | 1.152926e-02 | 2.426405e-02 |
| **Value Bais** | | | | | | | | | | | |
| 9.739690e-02 | 1.016206e-01 | 3.195527e-02 | 8.656941e-02 | -1.825441e-01 | -1.237254e-01 | -4.931368e-02 | -1.112436e-01 | 7.801253e-02 | -5.483798e-03 | -5.830943e-02 | 8.546195e-02 |

**⇒ Casual Mask(Upper triangle) ⇒ ⇒**

\*In this case, Multihead(Q,K,V) has shape of (n \* 12)

If you calculate with 3 divided heads, you need to concat each heads.

**3. Calculate attn\_out score**

**Masked MSA Multihead Attention block *out* weight (**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |
| 2.296920e-01 | 6.337877e-02 | 1.988660e-01 | 1.199686e-01 | 6.091955e-03 | -2.289907e-02 | 4.795380e-02 | -5.835060e-02 | -3.241669e-02 | -5.748540e-03 | 2.022160e-01 | -8.187824e-02 |
| 2.224511e-01 | 1.179493e-01 | 1.249893e-01 | 1.687535e-01 | -2.020105e-02 | -5.463995e-02 | 3.164335e-01 | 4.339921e-04 | -2.958499e-02 | -1.810687e-01 | -1.212703e-01 | -2.558562e-02 |
| -9.392462e-02 | 1.927584e-01 | 1.922287e-01 | 1.957741e-01 | -5.997881e-02 | -1.180053e-01 | 3.956347e-02 | 2.104219e-02 | -1.355107e-01 | -1.365213e-01 | -3.404369e-03 | 1.645151e-01 |
| 2.258604e-01 | -6.877765e-02 | 1.588061e-01 | 1.089525e-01 | 2.567744e-02 | -1.991557e-01 | -6.356298e-02 | -1.287074e-01 | 1.506761e-01 | 2.260825e-01 | 1.429993e-01 | 3.667868e-02 |
| 1.698860e-01 | -2.087757e-01 | 2.226186e-01 | 4.569338e-02 | 2.910604e-01 | -1.258384e-01 | 2.480363e-02 | 1.703122e-01 | -4.338131e-02 | 1.424514e-01 | 1.140026e-01 | -3.250392e-01 |
| 1.535334e-03 | 9.692797e-02 | 1.956073e-01 | 1.145139e-01 | 6.508366e-02 | -6.817421e-02 | 1.412480e-01 | 2.320696e-01 | -5.574000e-03 | -1.311437e-01 | -1.104528e-01 | -1.698209e-01 |
| 5.627479e-02 | 2.054298e-02 | 1.961335e-01 | 3.335799e-02 | 1.277968e-02 | -2.502251e-01 | -6.837761e-02 | -8.888113e-02 | -9.257112e-02 | -2.723962e-02 | 1.321969e-01 | 1.746046e-01 |
| 1.336287e-01 | 2.301398e-02 | 2.115751e-01 | 4.563403e-02 | 3.851434e-02 | -7.542416e-02 | 1.090383e-01 | -2.539386e-01 | -2.188720e-01 | 9.637687e-02 | 2.056393e-01 | -1.507020e-02 |
| 5.354102e-02 | 3.044952e-01 | 1.869746e-01 | 2.930542e-02 | -6.189694e-02 | -3.378853e-01 | -7.500225e-02 | 1.221219e-01 | 1.197681e-01 | 9.214049e-02 | -1.094512e-01 | 2.967557e-02 |
| 1.301843e-01 | -1.171548e-01 | 1.505906e-01 | 2.119444e-01 | 2.735528e-01 | -5.948799e-02 | 1.365253e-01 | 1.652365e-01 | 3.995057e-04 | -1.394250e-01 | -2.518052e-02 | -1.761882e-01 |
| 1.640473e-01 | -4.663282e-02 | 1.737370e-01 | 9.680154e-02 | 1.034575e-01 | -7.983501e-02 | 1.790202e-01 | 1.707492e-01 | 9.976751e-02 | -4.113890e-02 | -7.733175e-02 | -1.301939e-01 |
| 9.537873e-02 | 2.494660e-02 | 1.235056e-01 | 1.608102e-01 | 1.520736e-01 | -1.373051e-01 | -4.109162e-02 | -2.258032e-01 | -2.315932e-01 | 3.257933e-01 | 6.243302e-03 | -2.326884e-02 |

**Masked MSA Multihead Attention block *out* bias (**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |
| 3.860737e-02 | 7.282480e-02 | 7.049787e-02 | 6.551839e-02 | -2.906172e-02 | 4.279015e-02 | -6.398575e-02 | -1.357106e-02 | 1.069346e-01 | -4.720674e-02 | -6.364526e-02 | -7.774815e-02 |

**4. Residual Connection**

**input\_x2 = attn\_out + input\_x**(in this case, input\_x is position embedded matrix)

**5. Calculate LayerNorm 2**

**, ,**

**\*** In this case, h1 has shape of (n \* 12)

**MLP block Layer Norm weight(**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |
| 9.946589e-01 | 1.202689e+00 | 1.260670e+00 | 1.052192e+00 | 1.181151e+00 | 1.176190e+00 | 1.104370e+00 | 9.938747e-01 | 9.886096e-01 | 9.084116e-01 | 1.228172e+00 | 1.021777e+00 |

**MLP block Layer Norm bias()**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |
| 5.375889e-01 | -5.733227e-02 | 7.314308e-01 | 2.938749e-01 | 7.507070e-02 | -2.391119e-01 | -7.325138e-01 | -1.814895e-01 | 3.447169e-01 | -7.763035e-01 | -1.837611e-01 | -2.451412e-01 |

**6. Calculate First MLP Layer**

\*In this case, h3 has shape of (n \* 48)

**First MLP Layer Bias (, MLP\_Dim = 48)**

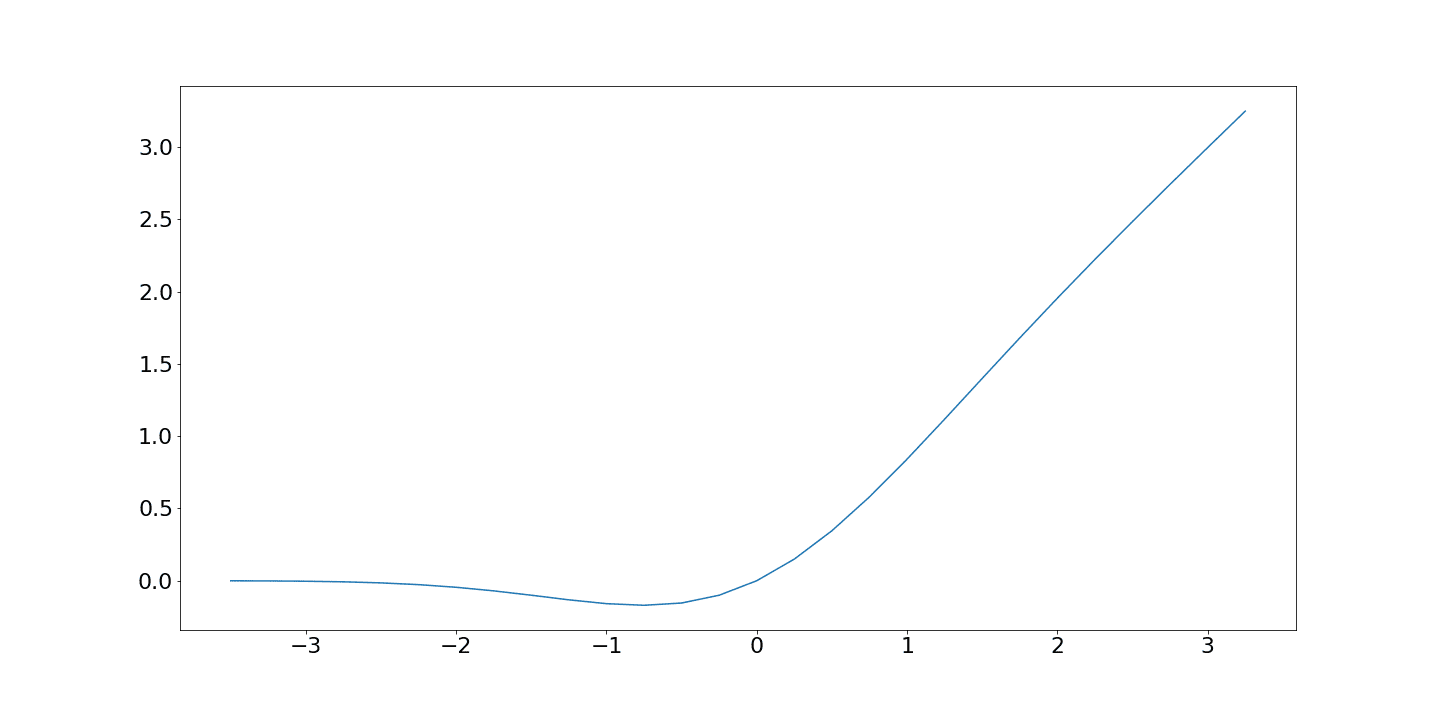
|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |
| -1.939433e-01 | -6.600589e-02 | 4.450232e-02 | -2.548952e-01 | -1.247528e-01 | -1.722536e-01 | -3.477310e-01 | -1.982095e-01 | -3.977574e-01 | -6.903913e-02 | -5.716963e-02 | -3.044240e-02 |
| -2.085882e-01 | -6.547067e-02 | -1.435132e-01 | -5.728777e-01 | -2.649985e-01 | -3.262985e-01 | -1.308431e-01 | 4.957111e-03 | -5.522528e-01 | -1.875569e-02 | -2.766736e-01 | -5.985761e-02 |
| -2.865958e-01 | -1.954991e-01 | -2.674843e-01 | -3.395607e-01 | -1.938981e-01 | -1.505516e-01 | -1.464152e-01 | -4.963903e-01 | -1.783533e-01 | -3.756034e-01 | -4.926806e-01 | -2.536334e-01 |
| -3.457421e-01 | -3.486527e-01 | -1.775814e-01 | -1.570985e-01 | -4.541936e-01 | -3.809987e-01 | -4.883842e-01 | -9.827219e-02 | -2.235727e-01 | -2.040592e-01 | -1.881442e-01 | -3.684056e-01 |

**First MLP Layer Weight (, MLP\_Dim = 48)**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |
| 8.436242e-02 | 3.309907e-01 | -1.265323e-01 | -2.651952e-01 | -3.214999e-01 | -3.440635e-02 | 1.452881e-01 | 2.584947e-01 | -3.219152e-02 | 3.791124e-02 | -2.535067e-01 | -5.427764e-02 |
| -4.236160e-01 | -1.756311e-02 | -2.493714e-01 | 1.163731e-01 | -1.731601e-02 | 6.124616e-02 | -1.197602e-01 | 7.832584e-02 | -1.788122e-01 | 3.760832e-01 | 3.047084e-01 | 4.465086e-02 |
| -2.900081e-02 | -5.756255e-01 | -5.350589e-02 | -6.699180e-02 | -1.349073e-01 | 5.446093e-01 | 5.149246e-01 | -2.345226e-01 | -1.800599e-01 | 1.063341e-01 | 1.473295e-01 | 1.730854e-01 |
| 3.898960e-01 | 2.742361e-01 | -4.173667e-01 | -2.260616e-01 | -4.995226e-01 | 2.614065e-01 | 3.599948e-01 | -2.474554e-01 | -1.013411e-01 | 4.085613e-01 | -3.885469e-01 | 1.321718e-01 |
| -1.324084e-01 | -7.414284e-02 | -1.979880e-01 | 4.842538e-02 | 2.852807e-01 | 2.340987e-01 | -7.818210e-02 | -3.062958e-02 | -3.729198e-01 | -7.393245e-02 | 2.877381e-01 | 1.664144e-01 |
| -4.665755e-02 | 5.150911e-02 | -3.290243e-01 | -4.857787e-01 | 1.371431e-01 | -3.366507e-01 | 2.897084e-01 | 4.581787e-02 | 2.329867e-01 | 8.467928e-02 | -2.547471e-01 | 4.186167e-01 |
| -5.484579e-02 | -8.798543e-02 | 2.961327e-02 | 1.997106e-01 | 6.723101e-02 | -7.130204e-02 | 1.645843e-01 | -2.271231e-01 | 8.125836e-02 | 1.507227e-01 | 1.442054e-01 | -1.410967e-01 |
| -3.327148e-01 | 4.385493e-02 | 1.186493e-02 | -2.641042e-02 | 8.634736e-02 | -4.637570e-02 | 2.633547e-01 | 1.044967e-01 | -3.190723e-01 | 1.597306e-02 | 4.701901e-01 | -1.922013e-01 |
| -1.998999e-01 | -2.227454e-03 | -5.759092e-01 | 3.131253e-01 | -3.590923e-01 | 2.813629e-01 | 3.118961e-01 | 5.652592e-03 | 1.310062e-01 | 2.597118e-01 | -2.959660e-02 | -1.362516e-01 |
| -5.675757e-01 | 4.498365e-01 | -5.833562e-01 | 9.857069e-02 | 1.513211e-01 | 2.417411e-01 | 4.561372e-01 | 2.072976e-02 | -1.520061e-01 | -1.479705e-01 | -6.437214e-02 | 1.546058e-01 |
| 1.393756e-01 | -2.216481e-01 | -2.565475e-01 | 5.613055e-02 | -6.856796e-02 | 3.502362e-02 | 1.574306e-01 | 6.347455e-02 | 6.152899e-03 | -9.735055e-02 | 1.611977e-01 | 1.149917e-01 |
| -7.343953e-01 | -3.287280e-01 | 5.186075e-02 | 1.892108e-05 | 2.081991e-01 | 2.396640e-01 | 2.150088e-01 | 8.327222e-02 | 2.074582e-02 | 2.672257e-03 | 2.853460e-01 | -4.333633e-02 |
| -6.064786e-01 | -1.668649e-01 | 2.134058e-01 | -2.062263e-01 | 1.315666e-01 | -4.273135e-01 | 1.263544e-01 | 5.349827e-02 | 2.869838e-01 | 6.223165e-01 | -2.495210e-01 | 1.313756e-01 |
| -1.315151e-01 | 3.338518e-01 | 4.980007e-02 | -1.324761e-01 | -1.530018e-01 | -3.176527e-01 | 3.691591e-01 | -3.230503e-01 | -3.084138e-01 | 3.051152e-02 | 5.165936e-01 | 4.568247e-01 |
| -4.368032e-01 | -3.844838e-01 | -6.961854e-02 | 5.416688e-02 | -1.371919e-01 | -1.582561e-01 | -1.258470e-01 | 4.193279e-01 | 1.998897e-01 | 1.820073e-01 | 3.419287e-01 | -4.240986e-02 |
| -1.813686e-02 | -4.012248e-01 | -1.861254e-02 | -1.426992e-01 | 1.305710e-01 | -3.882874e-01 | 5.469626e-01 | -2.056633e-01 | 1.891843e-01 | 1.058144e-01 | 2.249481e-01 | 3.290791e-01 |
| 1.045914e-01 | 4.562384e-02 | -5.551332e-01 | 7.419242e-02 | 3.591939e-02 | -1.996097e-01 | 1.212227e-01 | 2.791586e-01 | 2.484992e-01 | 4.041847e-01 | -3.765473e-01 | -2.993769e-01 |
| -2.940661e-01 | 1.794049e-01 | -1.825147e-02 | -2.881805e-01 | 3.746618e-01 | -9.625448e-02 | 1.297163e-02 | -3.504250e-01 | 7.191411e-02 | 5.565679e-01 | -7.489312e-02 | 1.592441e-01 |
| -5.556252e-01 | -3.279289e-01 | 4.043823e-01 | -1.646459e-01 | -1.450002e-01 | 1.133863e-01 | 8.272319e-02 | -2.617103e-02 | -2.524227e-01 | 6.365429e-01 | -2.736633e-01 | 2.060419e-01 |
| -3.921773e-02 | -3.201829e-01 | -1.674886e-01 | -1.276855e-01 | 2.407494e-01 | 1.808373e-01 | 1.944759e-01 | -9.357739e-02 | -1.724226e-01 | 1.555841e-01 | 3.581393e-01 | -8.495566e-02 |
| -1.668880e-01 | -3.012202e-01 | -6.258541e-01 | 2.280522e-01 | -2.164889e-01 | 4.510711e-02 | 4.815871e-01 | 4.540892e-01 | -5.490097e-01 | 1.618315e-01 | 2.239391e-01 | 1.159388e-01 |
| 1.283136e-01 | -2.799305e-01 | -3.528995e-01 | -1.188580e-01 | 1.278552e-01 | -9.804433e-02 | 1.572390e-01 | 3.374718e-02 | -3.273756e-01 | 1.676381e-01 | 1.030858e-01 | 4.547871e-01 |
| 1.515785e-01 | 1.390864e-01 | 1.687809e-01 | -1.559472e-01 | -2.032881e-01 | -2.518319e-01 | 1.572952e-01 | 1.419582e-01 | -6.441288e-02 | 2.346644e-01 | -2.714113e-01 | -2.405868e-01 |
| 9.742393e-02 | 1.423411e-01 | -2.831687e-01 | 7.605757e-02 | 1.981246e-01 | -1.621979e-01 | 5.578078e-02 | -1.617742e-01 | 6.618115e-02 | 9.570550e-03 | 1.634017e-01 | -3.963638e-02 |
| -5.031434e-01 | 5.474340e-02 | 7.623224e-02 | 1.073860e-01 | 1.705824e-01 | -4.008250e-01 | 1.362696e-01 | 5.402452e-02 | -1.550738e-01 | 1.036302e-01 | -3.362033e-01 | 4.887702e-01 |
| 2.402918e-01 | -2.831787e-02 | -4.302533e-01 | -6.529351e-01 | -1.488736e-01 | -3.935062e-01 | 5.067838e-01 | -4.981291e-01 | 2.212420e-01 | 6.276122e-01 | -2.664607e-01 | 4.270675e-01 |
| -8.451793e-02 | -2.836623e-01 | -2.211105e-01 | 2.555338e-01 | -3.626899e-02 | -1.811786e-01 | 3.030118e-01 | 4.407173e-02 | -1.119238e-01 | 1.513394e-01 | 4.947774e-02 | 1.139735e-01 |
| -3.310524e-01 | -1.120889e-01 | -4.039589e-01 | 9.325964e-02 | 1.597526e-01 | 6.918777e-02 | 3.420039e-01 | 1.739441e-01 | -2.137030e-01 | 5.610002e-01 | -3.278339e-01 | -6.197254e-02 |
| -1.046591e-01 | -5.591857e-01 | -2.915517e-01 | 7.990949e-03 | -4.935871e-01 | 1.145130e-01 | 2.145667e-01 | 4.465586e-01 | -2.617370e-02 | 3.684376e-01 | 3.502481e-01 | -3.702616e-01 |
| -1.223959e-01 | -1.559641e-01 | -1.924631e-01 | 4.737774e-02 | 7.968221e-02 | -1.238088e-01 | 8.226332e-02 | -3.473532e-01 | 2.176723e-01 | 8.794463e-02 | 1.304451e-01 | 5.465212e-02 |
| 1.149821e-01 | 1.312566e-01 | -1.179414e-01 | -4.557660e-01 | -9.455644e-02 | -2.476642e-01 | -3.457024e-02 | -1.286415e-01 | 6.290696e-02 | 3.010890e-01 | 2.839037e-01 | 2.382153e-01 |
| -5.715172e-01 | -6.342787e-02 | 1.378344e-01 | -4.307114e-01 | 4.782599e-01 | -1.264658e-01 | 2.545918e-01 | 2.228056e-02 | 1.933319e-01 | 5.975672e-02 | -1.612204e-01 | -3.095476e-02 |
| -2.394171e-01 | 1.355426e-02 | 3.026398e-01 | -2.596408e-01 | -1.155191e-01 | -1.978993e-02 | 3.461849e-02 | 9.761143e-02 | 1.070790e-01 | 4.647217e-02 | -1.671818e-01 | 1.354898e-01 |
| 3.035323e-01 | 2.117587e-01 | -6.510899e-01 | -4.610320e-01 | -1.454162e-01 | 3.444099e-02 | 3.396882e-01 | 4.192800e-02 | -6.470449e-02 | 5.821052e-01 | -1.316472e-01 | 3.122640e-03 |
| -4.008213e-01 | -3.051759e-01 | -4.384631e-02 | -2.719060e-01 | 4.931313e-01 | -3.663092e-01 | 2.745726e-01 | 8.088339e-02 | -1.736562e-01 | 2.618106e-01 | 1.062870e-01 | 1.222070e-01 |
| 1.643039e-01 | -3.724553e-01 | -1.107644e-01 | -1.929343e-01 | 2.682650e-01 | -2.773132e-01 | 3.199480e-01 | -1.897439e-02 | -6.125842e-02 | 2.492445e-01 | -2.471695e-01 | 3.721015e-01 |
| -2.082109e-01 | -6.961525e-03 | 4.622136e-02 | -4.262011e-01 | -2.824389e-02 | 1.563046e-01 | -1.533788e-02 | 1.671271e-01 | -2.772513e-01 | 1.783076e-01 | 2.585746e-01 | 1.895407e-01 |
| -2.328182e-01 | 2.664538e-02 | -8.120240e-01 | 2.781328e-01 | -1.059401e-01 | 1.421564e-01 | 1.194517e-02 | -3.724723e-03 | -9.860758e-02 | 4.200060e-02 | -1.065772e-01 | 3.949641e-01 |
| 2.124165e-01 | 3.685976e-02 | -2.170440e-02 | 9.126296e-02 | -1.956812e-02 | 5.587420e-02 | 3.666870e-02 | -1.176983e-01 | -1.141773e-01 | -6.363793e-02 | 6.362675e-02 | -6.592344e-02 |
| 8.796211e-02 | 2.110506e-01 | -5.623729e-01 | 2.130861e-01 | -6.119412e-01 | 1.247668e-01 | -4.163024e-02 | 1.496015e-01 | 1.906191e-02 | 6.597185e-01 | -3.538654e-01 | 7.067129e-02 |
| -3.085080e-01 | 2.017810e-01 | -1.896604e-01 | -7.997660e-02 | -8.013204e-02 | 3.245280e-01 | -1.394667e-01 | 7.840837e-02 | -1.596369e-01 | 4.205556e-01 | 2.405025e-02 | 1.153224e-01 |
| 3.113872e-02 | 5.161632e-01 | -1.110522e-01 | 1.374907e-01 | -2.208991e-01 | 1.207914e-01 | 1.990836e-01 | -2.339947e-01 | -3.320372e-01 | -1.298524e-01 | -8.654768e-02 | 1.301954e-01 |
| -1.781198e-01 | -6.202097e-01 | -6.190566e-01 | -2.829090e-01 | -1.314551e-01 | 5.573395e-01 | 3.757187e-01 | 2.282092e-01 | -1.193636e-01 | 1.328459e-01 | 1.013410e-01 | 4.039651e-01 |
| 2.272227e-01 | -5.370199e-02 | -3.482796e-01 | 2.088702e-01 | -1.610741e-01 | -7.535093e-02 | -2.137721e-01 | -4.376637e-02 | -1.427649e-02 | 1.271417e-01 | 3.263238e-01 | -4.873639e-02 |
| 1.060271e-01 | -3.304012e-02 | 1.253234e-01 | -1.949458e-01 | 6.114651e-02 | -6.888904e-02 | 5.752788e-02 | -1.463081e-01 | 6.645042e-02 | 3.378450e-02 | 5.673198e-02 | 5.444355e-02 |
| -3.274714e-01 | 2.569616e-01 | -6.314697e-01 | 2.964568e-01 | -3.315138e-02 | 3.178645e-01 | -3.132708e-02 | -1.447907e-01 | 1.065161e-02 | 1.798558e-02 | -9.071746e-02 | 1.105964e-01 |
| 8.087170e-02 | 4.283916e-02 | -1.692761e-01 | -1.527408e-02 | -3.880201e-01 | 3.599030e-01 | 3.163265e-02 | -1.571790e-02 | -5.573195e-02 | -1.948499e-02 | 5.800559e-03 | 7.443554e-02 |
| -3.322576e-02 | -7.668363e-02 | 4.391302e-03 | 4.457314e-02 | 6.902912e-02 | -1.865077e-01 | 2.451347e-01 | -2.352315e-01 | 1.630179e-01 | 1.006368e-01 | 1.530121e-01 | -4.634706e-02 |

**7. GELU Activation Function**

\*In this case, h3 has shape of (n \* 48)



**8. Calculate Second MLP Layer**

**Second MLP Layer Weight (, MLP\_Dim = 48)**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |
| -1.213444e-02 | -2.560442e-02 | -1.296355e-01 | -4.750964e-02 | 3.313500e-02 | 7.362746e-02 | 1.061464e-02 | -1.556941e-02 | -6.097750e-03 | -5.830389e-02 | 6.252193e-03 | 1.966351e-02 |
| -4.637607e-04 | -5.889318e-03 | 6.976106e-03 | 1.471722e-02 | -4.720849e-02 | 5.601250e-02 | 1.497123e-03 | 1.796211e-02 | -2.439483e-02 | 9.334974e-03 | -4.527332e-02 | 8.215222e-02 |
| 2.132443e-02 | 2.836684e-02 | -1.825298e-03 | -7.288171e-02 | -1.198584e-01 | 1.304639e-01 | 3.324714e-02 | 1.239136e-02 | 1.433019e-02 | 5.437090e-03 | 4.850045e-02 | -1.141646e-02 |
| 2.963030e-02 | 2.235129e-02 | -7.192482e-02 | -9.468318e-02 | 1.767868e-02 | -1.958123e-02 | -2.233563e-01 | 3.614733e-02 | -2.498970e-02 | -4.164165e-03 | -2.758539e-02 | 5.424226e-02 |
| -1.011985e-02 | -1.609649e-02 | -6.444969e-02 | -1.773528e-02 | 2.599816e-02 | 1.937222e-02 | -3.847656e-02 | -2.368219e-03 | -3.848630e-03 | 1.021726e-01 | -2.176211e-02 | 1.048156e-02 |
| 6.443524e-02 | -4.622979e-03 | 1.181081e-02 | -3.460309e-02 | 4.945514e-02 | 3.928671e-02 | 7.688870e-03 | -5.173412e-02 | 1.224990e-01 | 1.932821e-02 | -1.831774e-02 | -2.752065e-02 |
| -3.072220e-02 | 5.305245e-02 | -4.997607e-02 | 1.280877e-01 | -7.324868e-02 | 7.455754e-02 | 2.207023e-02 | -6.917061e-04 | 9.177978e-02 | 2.599231e-03 | -1.788883e-03 | -1.527644e-02 |
| -4.246535e-02 | 4.900618e-02 | -9.267459e-02 | -8.310817e-02 | -1.590522e-03 | -4.825322e-02 | -9.543427e-02 | -8.565620e-02 | 5.905624e-02 | 2.401935e-02 | -6.965755e-02 | 1.549458e-03 |
| 2.354755e-03 | 2.081824e-02 | 1.242643e-02 | 8.642969e-02 | -2.080328e-03 | 4.747489e-02 | 5.063703e-02 | 3.204806e-02 | -8.325088e-02 | -9.098602e-02 | -3.326432e-02 | 2.429927e-02 |
| 5.935346e-03 | 7.564881e-02 | 3.348223e-02 | -1.510638e-02 | 1.027500e-01 | 4.790459e-02 | 1.060797e-02 | 4.192135e-02 | 1.773575e-01 | 7.807672e-03 | -2.540824e-02 | 2.002003e-01 |
| -3.367737e-02 | 8.217344e-02 | -3.966207e-02 | -5.742734e-02 | 2.622062e-02 | 9.817603e-02 | -1.055496e-02 | 1.168178e-02 | -1.289250e-01 | -5.676615e-02 | 4.886152e-02 | -1.141741e-01 |
| -3.248290e-02 | -1.618647e-02 | 4.203472e-02 | 3.782574e-02 | -4.514301e-02 | 9.900612e-02 | 1.659463e-01 | 7.524665e-02 | 6.933031e-03 | 1.167240e-02 | -2.732407e-02 | 8.144605e-02 |
| -9.073242e-02 | -2.223555e-02 | -1.978372e-02 | -1.910037e-02 | 7.574432e-02 | 9.017090e-02 | -2.300122e-02 | -1.503695e-02 | 2.792281e-02 | 7.670284e-02 | -6.244530e-03 | -6.038661e-02 |
| 2.092080e-02 | -4.125335e-02 | -1.391687e-02 | 5.681013e-02 | 1.971407e-02 | -2.477131e-02 | -4.943774e-02 | -7.979786e-02 | -3.886707e-02 | -3.575992e-02 | -3.947770e-02 | -9.063906e-02 |
| 1.777359e-02 | 4.833169e-02 | -3.018437e-03 | -9.014110e-02 | -1.763904e-02 | -3.198446e-03 | -5.991722e-02 | -3.123188e-02 | 7.082096e-02 | -2.622858e-02 | -7.380892e-02 | 3.483795e-02 |
| 7.965795e-02 | 4.174212e-02 | -1.080820e-02 | -1.075109e-01 | 2.854828e-03 | -2.884857e-02 | -1.706638e-01 | -3.632495e-02 | -2.726148e-02 | 7.912206e-03 | 5.253421e-02 | 2.275384e-02 |
| 2.658343e-03 | -4.567225e-02 | 7.746952e-02 | -2.192625e-06 | -4.175438e-02 | 3.501082e-02 | -1.141600e-01 | 3.096087e-02 | -5.327808e-02 | -1.824977e-02 | 4.625499e-02 | 1.544971e-02 |
| 1.918781e-03 | 1.307161e-02 | 4.342364e-02 | -3.265312e-02 | 1.171634e-02 | -1.330958e-03 | 6.351086e-02 | -1.094283e-02 | 6.618196e-02 | -1.403272e-01 | 5.925931e-02 | -3.983191e-02 |
| 5.423132e-02 | 1.789970e-01 | 9.366560e-02 | -1.654957e-01 | 6.325032e-02 | -7.844118e-02 | 2.668956e-02 | 4.082812e-02 | 2.905945e-02 | 6.629589e-02 | 8.699793e-02 | 6.655171e-02 |
| 4.730103e-03 | 1.831435e-02 | 2.846360e-02 | -4.063052e-02 | -8.855050e-03 | 2.424954e-02 | 5.723594e-03 | -1.564537e-02 | 2.250986e-02 | -4.701614e-02 | 4.022622e-02 | -8.163828e-02 |
| 4.844698e-03 | -2.033100e-02 | -2.753379e-02 | -3.638111e-02 | 1.062591e-02 | 5.614243e-02 | -7.820335e-03 | 2.134311e-02 | -3.015246e-02 | -2.358981e-02 | -1.110693e-02 | -2.097776e-02 |
| 1.228057e-01 | 7.341467e-02 | -2.326784e-02 | -8.406099e-02 | -3.211554e-02 | -3.537943e-03 | 2.170110e-02 | 3.745036e-03 | -3.876034e-02 | -4.741478e-02 | 5.882233e-02 | -1.069095e-01 |
| 3.112249e-02 | 7.709707e-02 | -6.704995e-02 | 4.238695e-02 | -9.418500e-02 | -6.434751e-02 | -2.444241e-02 | 5.776973e-02 | -1.976160e-03 | 1.216823e-02 | -5.071141e-02 | -5.600825e-02 |
| -7.123835e-02 | -8.951021e-03 | -3.860366e-02 | 1.070519e-03 | 7.829637e-02 | -4.814175e-02 | 9.276747e-02 | 1.448413e-02 | -4.472699e-02 | 6.549937e-02 | 1.825712e-02 | -1.985794e-02 |
| 3.271933e-02 | -7.679545e-03 | -5.309027e-02 | -3.700291e-02 | 3.474604e-02 | 2.238809e-02 | 5.445282e-03 | -8.820000e-03 | 3.246049e-02 | 8.295700e-02 | -7.759536e-03 | -1.863241e-02 |
| -9.899961e-02 | -6.531850e-03 | 4.731641e-02 | 1.793095e-02 | 2.511272e-02 | 1.740705e-03 | -6.982790e-02 | -1.599638e-02 | -1.237118e-02 | 4.218160e-02 | -2.152085e-02 | -9.388201e-03 |
| -1.747783e-02 | -9.384271e-02 | -2.365964e-02 | 6.013965e-02 | -7.329135e-03 | 4.584548e-02 | -1.872214e-02 | -7.906935e-02 | -3.182860e-02 | -3.509295e-02 | -1.490903e-02 | 5.633005e-02 |
| 5.494574e-02 | 7.559900e-03 | -4.261676e-02 | 3.361271e-02 | 3.634698e-03 | 5.545684e-02 | 8.660595e-02 | -1.890665e-02 | -2.068094e-02 | 6.133835e-02 | -4.723006e-03 | -6.172762e-03 |
| 3.612503e-02 | 2.632738e-02 | 3.839540e-03 | 1.922637e-02 | 6.119780e-03 | 5.956573e-02 | -2.859851e-02 | 9.337675e-03 | 1.066858e-02 | -1.023852e-01 | 1.706653e-02 | 2.012831e-02 |
| -7.185896e-02 | -2.024756e-02 | -1.281168e-02 | 3.411029e-02 | 2.888985e-02 | 3.890721e-02 | 9.970040e-03 | 4.654614e-02 | -3.098518e-02 | -1.000798e-02 | 2.086258e-03 | 7.157440e-02 |
| 1.571435e-02 | 3.568165e-02 | 2.366008e-04 | -4.248291e-02 | -1.312593e-02 | 6.612428e-02 | 9.136707e-03 | 1.036584e-02 | -7.098516e-02 | -4.345572e-03 | 1.214915e-01 | 9.094986e-03 |
| 2.959426e-02 | -7.274782e-02 | -4.241582e-02 | 5.109688e-02 | -1.347847e-02 | -1.969832e-02 | -1.728416e-02 | 4.862119e-03 | -2.889409e-02 | -2.012919e-02 | -1.323378e-02 | 1.407501e-02 |
| 4.458323e-02 | -2.136544e-02 | 1.288103e-01 | 2.522084e-02 | 1.706086e-02 | -8.727577e-02 | 7.779646e-02 | -6.109295e-02 | -1.885750e-02 | 4.865851e-02 | -3.538574e-02 | 4.597635e-02 |
| -2.509869e-03 | -1.072410e-02 | 8.119407e-02 | 8.559725e-02 | -1.617793e-02 | -5.445666e-02 | -5.051105e-02 | 4.274982e-04 | 9.685905e-02 | 8.709245e-02 | 8.182213e-02 | 6.728643e-02 |
| 1.438739e-02 | -2.233846e-02 | -2.605897e-02 | 2.594756e-02 | 3.286041e-02 | 4.594444e-02 | -2.321246e-02 | -5.704705e-02 | -3.016325e-02 | -7.248077e-02 | -1.353056e-01 | -5.320462e-02 |
| -3.195918e-02 | -3.965003e-02 | 4.285590e-02 | 1.059754e-01 | -3.939741e-02 | -1.640744e-02 | 2.433119e-01 | 6.457496e-02 | 1.546999e-02 | 3.157043e-02 | -3.454338e-03 | 1.132732e-01 |
| 5.739271e-02 | 8.422936e-03 | -3.838286e-02 | 5.732361e-02 | -5.389544e-02 | -6.645302e-03 | -8.540145e-02 | 3.206751e-03 | -5.207982e-02 | 1.186258e-01 | -8.646697e-04 | 8.280651e-02 |
| -2.521329e-04 | -4.142531e-02 | 8.681374e-02 | -9.775551e-02 | 2.498619e-03 | -2.139306e-02 | 8.109511e-02 | -7.091404e-02 | 3.915010e-01 | -3.996553e-02 | 1.985057e-03 | -4.003773e-02 |
| -6.280466e-02 | -2.209283e-01 | 5.578937e-02 | 7.145371e-02 | -4.086122e-02 | -6.439392e-02 | 1.130992e-02 | 3.432087e-02 | 4.980001e-02 | 3.328142e-02 | 5.717958e-02 | -1.332640e-02 |
| 1.180190e-03 | 4.199089e-02 | -4.340132e-02 | -4.537983e-03 | -8.873415e-03 | 2.432784e-02 | -3.083320e-01 | 3.133499e-02 | 2.633942e-02 | 2.137781e-02 | 4.647779e-02 | -9.506039e-02 |
| 4.793591e-02 | -3.920952e-02 | -1.147242e-03 | 1.250534e-03 | 7.458529e-03 | 5.401741e-02 | -1.674846e-03 | 1.894429e-02 | 5.525671e-02 | 7.109375e-02 | 1.372296e-02 | 4.894758e-02 |
| -6.331684e-02 | 5.312894e-03 | -6.614771e-02 | -2.866394e-02 | 5.962365e-02 | -1.522241e-02 | 1.657922e-02 | -3.656345e-02 | 1.162610e-01 | -3.441234e-02 | 1.528947e-02 | -1.176724e-01 |
| -2.791927e-02 | 6.115990e-02 | 3.803758e-02 | -5.213379e-02 | 1.700226e-02 | -2.541423e-02 | 2.040650e-02 | 1.312876e-03 | 6.506786e-02 | -6.530667e-03 | -2.843723e-02 | -3.926858e-03 |
| 6.180457e-02 | -5.598215e-02 | -1.810292e-02 | 8.989854e-03 | -8.630250e-03 | -3.243024e-03 | 6.280518e-02 | -8.989531e-02 | 4.168596e-02 | -2.942334e-02 | 2.947448e-02 | -1.739253e-02 |
| -3.778056e-02 | 1.542021e-02 | -1.430069e-03 | -7.699469e-03 | 1.830936e-02 | 5.124546e-02 | 6.334582e-03 | 8.592394e-04 | 1.901453e-02 | -4.213338e-02 | 1.151159e-02 | -4.662337e-02 |
| -3.184187e-02 | -1.703876e-02 | -3.997327e-02 | 6.063098e-02 | -2.418158e-02 | 3.319186e-02 | 3.848450e-03 | 1.984473e-02 | -2.164936e-01 | 4.501395e-02 | 1.543440e-02 | 4.994651e-02 |
| 7.067930e-02 | -7.402973e-02 | 4.140399e-02 | -4.048699e-02 | -3.547501e-02 | -1.582017e-02 | -4.690566e-03 | -2.894699e-03 | -6.278580e-02 | 2.617482e-02 | 6.944713e-02 | 8.357466e-02 |
| 1.415232e-02 | 7.870832e-03 | -8.519700e-03 | -7.050515e-02 | 1.453790e-02 | -9.937067e-02 | -1.135923e-02 | 6.632666e-02 | 2.923285e-02 | -3.901720e-02 | 4.396728e-03 | 3.008035e-02 |

**Second MLP Layer Weight (, MLP\_Dim = 48)**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |
| -2.808428e-02 | -7.007735e-03 | 3.117389e-02 | -3.099765e-02 | 3.991134e-02 | 8.091213e-03 | 4.337511e-03 | 2.958847e-03 | 2.385014e-02 | 1.061317e-03 | 1.416043e-02 | -1.741107e-02 |

**9. Residual Connection**

**input\_x3 = input\_x2 + h4**(in this case, input\_x2 is value before LayerNorm2)

**Layer 2**

From now on, this is the repeat of layer 1.   
However, the input is the result of Layer 1, which is **input\_x3**

**1. Calculate LayerNorm 1**

**, ,**

**\*** In this case, h1 has shape of (n \* 12)

**Masked MSA block Weight ()**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |
| 1.172357e+00 | 9.122452e-01 | 1.039936e+00 | 1.119288e+00 | 8.580945e-01 | 1.116191e+00 | 9.693699e-01 | 9.974678e-01 | 1.044559e+00 | 1.111009e+00 | 1.054808e+00 | 1.060566e+00 |

**Masked MSA block Bias()**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |
| 7.259727e-02 | -8.546419e-03 | -3.731542e-02 | 3.104292e-01 | 1.149615e-01 | 1.175100e-01 | -5.597764e-02 | 1.627964e-01 | -4.860411e-03 | 2.608685e-01 | -1.026048e-01 | 3.019810e-01 |

**2. Calculate Q,K,V, Multihead attention**

**, ,** \*Perform a single 12×12 multiplication. (You can also compute by splitting into n\*12)

**Masked MSA Multihead Attention block *in* Q, K, V weight**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Query Weight** | | | | | | | | | | | |
| 1.624145e-01 | -9.438099e-03 | 8.071346e-02 | -3.860031e-02 | 3.133897e-01 | -1.708488e-01 | 9.024177e-03 | 1.547996e-01 | -2.072956e-01 | 2.649908e-01 | 1.835885e-01 | 4.927286e-02 |
| 1.522439e-01 | 1.334333e-02 | 1.248620e-01 | 2.038397e-01 | -2.574865e-01 | -3.784092e-01 | 3.612407e-01 | -3.897077e-01 | 4.717741e-01 | -7.037898e-02 | 1.175003e-01 | -1.600395e-03 |
| -2.810110e-01 | 4.755688e-02 | 1.632130e-01 | 1.204995e-01 | -5.161890e-02 | 1.898713e-01 | -4.105132e-01 | -3.674321e-01 | 3.090789e-01 | 2.710271e-01 | 6.405523e-01 | -7.350649e-01 |
| -3.291817e-02 | -4.992740e-01 | -4.781748e-02 | 3.827656e-01 | 2.872331e-01 | -5.615429e-01 | -7.355303e-02 | -3.533024e-02 | 4.101382e-02 | -1.950525e-01 | 2.971037e-01 | 4.596902e-02 |
| -5.738714e-01 | 1.906117e-01 | -6.178911e-01 | 1.733912e-01 | -5.620744e-01 | -1.756225e-01 | 3.664021e-01 | -2.568397e-01 | -3.887776e-02 | 3.587635e-01 | 5.929713e-02 | -1.162686e-01 |
| 4.730597e-01 | 9.556873e-02 | -6.691730e-02 | 2.382826e-01 | -6.725737e-01 | 1.446220e-02 | 9.553326e-01 | 2.196742e-01 | -1.483462e-01 | -3.634938e-01 | -7.956273e-01 | 2.519892e-01 |
| -7.289357e-02 | -8.510776e-02 | -1.914573e-01 | -4.158179e-02 | 2.455456e-01 | -1.118770e-02 | -1.440557e-01 | 6.212415e-01 | -8.115252e-01 | -2.189289e-01 | -1.660463e-01 | 7.433470e-01 |
| -2.148486e-01 | -2.449109e-01 | 6.285263e-02 | 1.980509e-01 | -3.114553e-01 | -3.998583e-01 | -1.641098e-01 | -1.376100e-01 | 4.601088e-01 | -7.459058e-01 | 2.415552e-01 | 1.354724e-01 |
| 1.750237e-01 | -2.005721e-01 | -2.705749e-01 | 3.336974e-01 | -5.552911e-02 | -2.487135e-01 | 1.773397e-01 | 2.595645e-01 | -5.758085e-02 | -2.010282e-01 | -6.796796e-02 | 2.519740e-01 |
| -4.805664e-02 | -6.027530e-02 | 8.092668e-02 | -2.139272e-01 | -9.389076e-03 | -3.668600e-01 | -1.730429e-01 | 3.454478e-01 | -4.695682e-01 | 5.591838e-01 | 1.591225e-01 | 9.440363e-02 |
| -8.296639e-02 | -1.289035e-01 | -2.828962e-02 | -1.548353e-01 | 1.110915e-01 | 1.982315e-01 | -1.115429e-01 | 4.612693e-01 | -8.987720e-02 | -1.691555e-02 | -3.084761e-02 | 1.896942e-01 |
| -2.049356e-01 | 1.378499e-01 | -2.498730e-01 | -3.173443e-01 | 2.408590e-01 | 1.681240e-01 | -7.310084e-02 | -1.136446e-01 | -1.723071e-01 | 4.838990e-02 | -1.117007e-01 | 1.426453e-01 |
| **Key Weight** | | | | | | | | | | | |
| 4.544555e-02 | -2.773947e-01 | 2.261954e-01 | -2.281647e-01 | 5.903457e-01 | 7.827238e-01 | -5.773841e-01 | -2.344534e-02 | -4.875675e-01 | -2.896473e-01 | 2.931242e-01 | -4.826008e-01 |
| 2.907512e-01 | -4.999436e-01 | -1.161166e-01 | 5.601895e-01 | -1.505883e-01 | 4.079412e-01 | 2.218659e-01 | -1.798275e-01 | -2.618463e-02 | -6.500468e-01 | -2.119785e-01 | -9.692355e-02 |
| -2.484820e-01 | 1.217504e-01 | 4.961333e-02 | -4.069815e-02 | -1.908873e-01 | 3.651659e-01 | 2.963961e-02 | -3.221190e-01 | 5.433864e-01 | -2.467273e-01 | 1.692747e-01 | -2.458006e-01 |
| -2.463119e-01 | -2.378412e-01 | -9.360334e-02 | -5.512526e-02 | 2.422812e-01 | -2.250700e-02 | -2.710463e-02 | 4.013341e-01 | 1.441922e-01 | -5.133580e-01 | 4.671274e-02 | 3.900554e-01 |
| 6.778052e-01 | 3.035733e-01 | 5.906389e-01 | 3.829136e-01 | -2.128232e-01 | 4.796351e-01 | 5.373897e-02 | -6.438479e-01 | -1.147043e-01 | -9.842188e-01 | -1.752238e-01 | -1.963121e-01 |
| 4.924527e-01 | -7.439625e-01 | 3.628948e-02 | 3.314215e-01 | 3.887130e-01 | -1.943265e-01 | -9.524753e-03 | 3.708252e-01 | -2.942561e-01 | -4.049636e-01 | -2.038472e-01 | 2.623623e-01 |
| 1.439334e-01 | 1.443626e-01 | -3.343692e-01 | -3.789839e-01 | 4.084055e-01 | 3.362020e-01 | -2.313766e-01 | 4.158210e-01 | -1.049860e+00 | 5.963162e-02 | -3.206121e-01 | 2.596034e-01 |
| -6.197649e-03 | 3.328919e-01 | -4.667248e-01 | 4.832133e-01 | -7.959691e-01 | -1.403155e-01 | 7.278005e-01 | 2.219661e-01 | 2.709127e-01 | -4.567651e-01 | -4.171980e-01 | 4.255459e-01 |
| 1.679604e-01 | -4.348453e-01 | -1.933397e-01 | 5.044978e-01 | -2.299653e-01 | -8.862887e-02 | 2.905832e-01 | -2.174807e-02 | 1.464142e-01 | -5.095354e-01 | 1.001545e-02 | 4.027172e-02 |
| 6.558786e-02 | 3.533208e-03 | -9.301282e-02 | -1.437988e-02 | 2.566876e-03 | -4.161351e-02 | -2.118174e-01 | 4.159030e-01 | -2.971629e-01 | -1.095113e-01 | 1.102619e-01 | -2.322358e-02 |
| 3.470794e-01 | 8.272670e-03 | -6.135744e-02 | 2.397752e-01 | 1.546178e-01 | 3.970676e-02 | -1.087745e-01 | -6.315371e-02 | -3.958032e-01 | -1.144713e-01 | -2.285767e-01 | 2.057930e-01 |
| -9.225377e-02 | -2.848696e-01 | 3.003165e-02 | -1.654892e-01 | 1.505771e-01 | -1.353193e-01 | -5.085415e-02 | 2.283275e-01 | -8.436627e-02 | 1.238024e-01 | -4.481592e-02 | 3.012312e-01 |
| **Value Weight** | | | | | | | | | | | |
| -3.278750e-01 | -1.345084e-01 | 3.705600e-02 | 4.868884e-02 | 2.431773e-01 | 2.190796e-02 | 9.552821e-02 | -6.722442e-03 | 7.785143e-02 | 1.036691e-01 | -4.547167e-02 | 1.422558e-01 |
| 3.570159e-01 | -2.728993e-04 | -2.445555e-01 | 1.210045e-01 | 2.218061e-01 | -6.616599e-02 | 4.117461e-02 | -1.864199e-01 | -4.820843e-02 | 1.264363e-01 | -3.039345e-02 | 1.183976e-01 |
| 2.376896e-01 | -6.775007e-02 | 9.085254e-02 | -5.521126e-02 | 2.103750e-01 | -7.513210e-02 | -1.155620e-02 | -1.932190e-01 | -1.658856e-02 | 2.843453e-03 | -2.660478e-02 | -2.296168e-01 |
| -6.504632e-02 | 1.616480e-01 | 1.033420e-01 | -7.904159e-02 | -1.553880e-01 | -1.701832e-01 | -1.179596e-01 | 2.868271e-01 | 6.914174e-02 | 9.968871e-02 | 2.401392e-01 | 8.703052e-02 |
| -3.083404e-01 | 2.179920e-01 | -2.030982e-01 | -4.401673e-01 | 1.487084e-01 | -4.264757e-01 | 4.494936e-02 | 2.060948e-01 | 1.354002e-01 | 2.883945e-01 | -1.863678e-01 | 5.590668e-01 |
| 3.117070e-01 | 1.124799e-01 | 2.193698e-01 | -3.422341e-02 | -1.517230e-01 | -3.296185e-02 | 2.331339e-01 | 2.358012e-02 | -1.536311e-01 | -3.605675e-02 | 1.759435e-01 | -9.406453e-02 |
| -6.695753e-01 | -1.950615e-02 | -3.345039e-01 | -3.123473e-01 | -9.762790e-02 | -2.329478e-01 | -1.406784e-01 | 5.538306e-01 | 2.652375e-01 | 1.892644e-01 | -1.722331e-01 | 5.158924e-01 |
| 2.953189e-01 | 6.561383e-02 | 1.043632e-01 | 5.269924e-02 | 1.899503e-01 | 2.835465e-01 | -1.395685e-02 | -1.292054e-02 | -1.357009e-01 | -1.885305e-01 | -8.766425e-02 | 9.516513e-02 |
| -1.677247e-01 | 6.818361e-02 | 2.155989e-01 | -2.873662e-01 | -1.803548e-02 | 6.529157e-02 | -1.022243e-02 | 7.492451e-02 | -7.419596e-02 | 6.870912e-02 | -1.584983e-01 | -1.951259e-02 |
| 1.667253e-01 | -3.511966e-02 | -9.375440e-02 | 3.248343e-01 | -8.082359e-03 | 1.828896e-01 | 2.639313e-01 | 2.868272e-01 | -1.389248e-01 | -3.747522e-02 | -2.694026e-01 | 2.643350e-02 |
| 1.107320e-01 | -1.241600e-01 | 5.468424e-03 | 1.385256e-01 | 1.722506e-01 | 2.299881e-01 | 2.437823e-02 | -8.835125e-02 | 3.000176e-02 | -3.450254e-01 | -1.023940e-01 | -1.810675e-02 |
| 3.258447e-02 | 1.295040e-01 | -1.344221e-01 | 2.197458e-02 | -2.187490e-01 | 2.427430e-02 | 8.965177e-02 | -5.200688e-02 | -3.423892e-02 | -9.113051e-02 | -1.097563e-01 | -1.491315e-01 |

**Masked MSA Multihead Attention block *in* Q, K, V bias**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Query Bias** | | | | | | | | | | | |
| 7.260851e-01 | 5.990345e-01 | 3.626682e-01 | -2.791425e-01 | -2.342048e-01 | -6.482888e-02 | -2.866837e-01 | -7.981344e-01 | -7.203748e-02 | -1.746933e-01 | 4.118584e-02 | -4.116932e-01 |
| **Key Bias** | | | | | | | | | | | |
| 1.936006e-03 | 1.055229e-02 | -2.981336e-02 | 1.102254e-01 | -1.526059e-02 | -5.130705e-02 | -1.143592e-01 | 5.408736e-02 | -3.033875e-02 | -2.302156e-02 | -3.102210e-02 | 2.874614e-02 |
| **Value Bais** | | | | | | | | | | | |
| 1.034705e-01 | 1.928400e-01 | -1.021686e-01 | 2.931870e-01 | 1.250891e-01 | 1.215772e-01 | 1.545540e-01 | 2.522532e-01 | -1.264551e-01 | 1.853869e-01 | 1.602221e-01 | -4.739623e-02 |

**⇒ Casual Mask(Upper triangle) ⇒ ⇒**

\*In this case, Multihead(Q,K,V) has shape of (n \* 12)

If you calculate with 3 divided heads, you need to concat each heads.

**3. Calculate attn\_out score**

**Masked MSA Multihead Attention block *out* weight()**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |
| 7.397891e-02 | -6.217564e-02 | -4.629865e-02 | 1.038022e-01 | -2.627777e-01 | 1.342518e-01 | -1.545438e-01 | -1.617938e-02 | -1.110505e-01 | 4.414389e-02 | 2.130805e-02 | -1.655514e-02 |
| 9.095367e-02 | -1.248511e-01 | 2.165619e-01 | -8.530050e-02 | -2.068749e-01 | -2.437384e-02 | -2.811618e-01 | -3.790256e-02 | 1.031749e-01 | -8.392612e-03 | 1.457031e-01 | -1.648869e-01 |
| -6.294671e-02 | -5.728995e-02 | 1.802934e-01 | -3.822100e-01 | -2.362082e-01 | -7.465045e-02 | -3.023837e-01 | -2.677619e-02 | -1.263888e-01 | -1.381983e-01 | 9.754778e-02 | -1.083756e-01 |
| -2.080604e-02 | 5.614285e-02 | 1.078515e-02 | 1.388195e-01 | -1.726483e-01 | 2.322315e-01 | -1.117159e-01 | 1.942724e-01 | -1.280641e-01 | 1.908764e-01 | 1.786769e-01 | 1.505349e-01 |
| -3.071793e-01 | 3.457892e-03 | 5.993846e-02 | 1.884029e-01 | -2.316388e-02 | 4.109500e-01 | -2.418783e-01 | 9.037685e-02 | 9.728067e-02 | 3.500312e-01 | 1.238391e-01 | 8.400109e-02 |
| -1.308550e-01 | -8.707072e-02 | 2.194309e-01 | -9.976751e-02 | -1.936342e-01 | 1.726964e-01 | -2.909880e-01 | -2.573030e-02 | 1.199559e-01 | 8.757388e-03 | 6.352377e-02 | -1.568427e-01 |
| 7.736985e-02 | 2.178557e-01 | 4.032985e-05 | 4.806525e-02 | -9.883817e-02 | 1.499279e-01 | -2.390819e-01 | 2.691319e-01 | -1.768326e-01 | 1.743374e-01 | 1.093614e-01 | 1.466413e-01 |
| 2.365263e-01 | 1.715996e-01 | 1.526950e-01 | -9.954670e-02 | -2.141500e-01 | -1.139666e-01 | -2.696219e-01 | 1.646579e-01 | -1.712021e-01 | 1.037849e-01 | 2.391602e-01 | -2.362848e-01 |
| -2.055707e-01 | 4.123328e-03 | 5.612574e-02 | -2.926222e-01 | -1.580002e-01 | 2.558701e-01 | -2.452114e-01 | 9.987704e-02 | -6.138575e-02 | -4.764600e-02 | 1.460021e-01 | 3.190892e-01 |
| -2.793332e-01 | -2.095648e-01 | 1.358126e-01 | 8.101501e-02 | -1.604020e-02 | 3.546096e-02 | -3.889802e-01 | -1.447582e-02 | -7.468336e-03 | 2.764913e-01 | -1.389737e-01 | 1.467789e-02 |
| -6.648651e-02 | -1.541877e-01 | 1.141514e-01 | -1.250690e-03 | -2.083939e-01 | 1.378028e-01 | -2.003497e-01 | 2.712687e-02 | 1.839674e-01 | 1.552211e-01 | 4.124226e-02 | -4.980779e-04 |
| -2.602478e-03 | 2.990674e-01 | 2.734167e-01 | -6.372160e-02 | -5.683573e-02 | 1.519060e-01 | -2.998567e-01 | 3.575199e-01 | -2.588527e-01 | 2.322959e-01 | 2.425177e-01 | -8.178751e-02 |

**Masked MSA Multihead Attention block *out* bias()**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |
| -2.452131e-03 | -8.009599e-03 | -1.399106e-01 | -9.819391e-02 | 1.763125e-02 | 1.103114e-01 | 5.715930e-02 | 4.713771e-03 | -2.487050e-01 | 2.211257e-01 | 7.350094e-02 | 2.107744e-01 |

**4. Residual Connection**

**input\_x2 = attn\_out + input\_x**(in this case, input\_x is position embedded matrix)

**5. Calculate LayerNorm 2**

**, ,**

**\*** In this case, h1 has shape of (n \* 12)

**MLP block Layer Norm weight(**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |
| 1.228373e+00 | 1.182670e+00 | 1.181346e+00 | 9.882852e-01 | 9.761013e-01 | 1.087607e+00 | 1.137451e+00 | 1.103013e+00 | 8.528818e-01 | 9.310936e-01 | 1.172479e+00 | 9.126095e-01 |

**MLP block Layer Norm bias()**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |
| -4.924535e-01 | 6.655191e-01 | 3.126464e-01 | -3.493734e-01 | -7.790722e-01 | 6.260208e-01 | 2.665403e-02 | -7.936532e-01 | 7.441322e-01 | 5.249609e-01 | 1.318179e-01 | -6.665556e-01 |

**6. Calculate First MLP Layer**

\*In this case, h3 has shape of (n \* 48)

**First MLP Layer Bias (, MLP\_Dim = 48)**

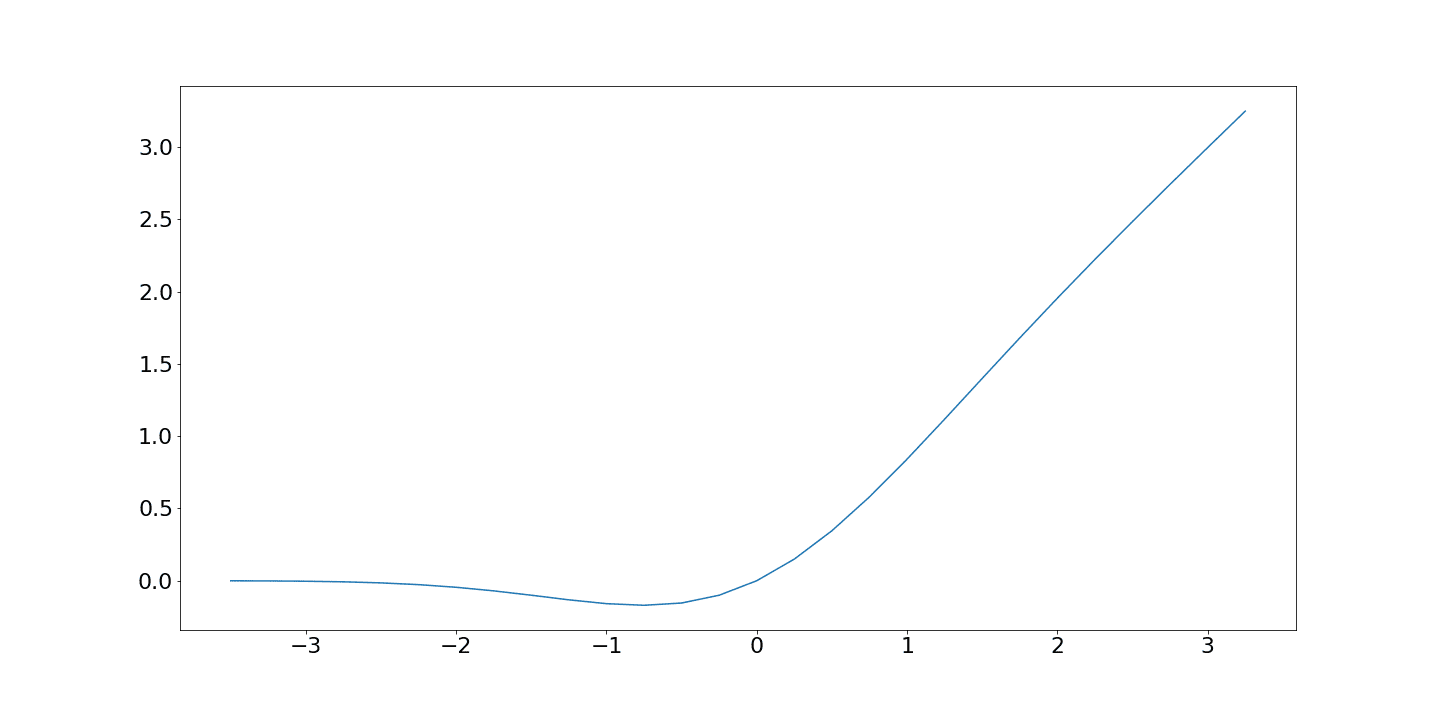
|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |
| -1.460735e-01 | -4.003490e-01 | -3.266484e-01 | -1.693635e-01 | -2.623611e-01 | -4.225815e-01 | -7.956621e-01 | -4.284546e-01 | -4.818350e-01 | -3.325710e-01 | -2.320900e-01 | -1.085248e-01 |
| -3.310618e-01 | -9.150692e-01 | -4.610535e-01 | -3.380509e-01 | -1.757553e-01 | -2.866957e-01 | -6.014673e-01 | -2.233477e-01 | -3.279175e-01 | -3.459518e-01 | 9.577810e-04 | -2.375534e-01 |
| -3.913757e-01 | -2.336717e-01 | -3.112995e-01 | -4.421872e-02 | -3.109154e-01 | -4.172139e-01 | -6.220463e-02 | -5.799634e-01 | -2.389141e-01 | -3.557474e-01 | -3.218636e-01 | -4.493155e-01 |
| -4.451885e-01 | -3.293109e-01 | -2.015561e-01 | -2.340078e-01 | -1.630465e-01 | -3.977982e-01 | -1.256536e-01 | 2.219219e-01 | 3.336828e-02 | -5.347942e-01 | -3.477111e-01 | -1.447282e-01 |

**First MLP Layer Weight (, MLP\_Dim = 48)**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |
| 6.911775e-02 | 1.843837e-01 | 8.591122e-02 | -4.056628e-02 | -2.676218e-01 | -4.883251e-01 | -3.219152e-01 | 1.710352e-01 | 8.127057e-02 | 1.082544e-02 | 2.538148e-01 | 3.343522e-01 |
| 6.062622e-03 | -7.184843e-03 | 4.060288e-03 | -1.067601e-01 | 2.652220e-01 | 3.561476e-02 | -2.020598e-01 | 2.443257e-02 | -2.674464e-01 | -1.641853e-02 | 8.525694e-02 | -7.954220e-02 |
| -8.878003e-02 | -2.900914e-01 | 8.194791e-02 | 5.282148e-02 | -1.422569e-01 | -4.736072e-01 | -1.012733e-01 | 4.426857e-01 | -1.690067e-01 | 1.872829e-01 | 1.038096e-01 | 6.205328e-01 |
| -2.645462e-01 | 2.407733e-02 | -1.000806e-01 | 3.615150e-02 | 4.324024e-01 | -2.877426e-01 | -2.327647e-03 | 6.465413e-02 | 2.304419e-01 | -1.652264e-01 | 2.108473e-01 | -2.688895e-01 |
| 1.724388e-01 | -1.079371e-01 | -2.500668e-02 | 1.952271e-01 | -5.878562e-05 | -1.331380e-01 | 1.904294e-01 | -1.698550e-02 | -8.793338e-02 | -3.166698e-01 | 2.367592e-01 | 2.918372e-02 |
| 2.816044e-02 | -9.512892e-02 | -2.418162e-01 | -2.171976e-03 | 2.417744e-01 | -5.658461e-01 | 1.896327e-01 | -7.933733e-02 | 1.471939e-01 | 1.045936e-03 | 4.493658e-02 | -7.705207e-03 |
| 7.102754e-02 | -3.366105e-01 | -2.414279e-01 | 1.244783e-01 | 5.543936e-01 | 1.064853e-01 | 2.841399e-01 | 4.236528e-01 | -3.807603e-01 | -3.477368e-01 | -1.247706e-01 | 2.932599e-01 |
| -4.693987e-01 | -2.517998e-01 | 1.195733e-01 | -1.885137e-01 | 3.592320e-01 | -2.283584e-01 | -2.050130e-01 | 3.622801e-02 | 8.538508e-02 | -9.303895e-02 | 4.245929e-01 | 1.101667e-01 |
| -1.808362e-01 | -4.766238e-01 | 4.303973e-01 | -9.471455e-02 | 1.115912e-01 | 1.648158e-01 | 2.697206e-01 | -1.037831e-01 | -2.807420e-01 | -1.594548e-01 | 5.697530e-02 | -2.113059e-01 |
| 2.479831e-01 | -5.556040e-01 | 2.739016e-02 | 5.699001e-02 | 2.396876e-01 | -8.385596e-01 | 2.256556e-01 | 2.556401e-01 | -2.928690e-01 | 2.264532e-01 | -7.409031e-02 | 2.026577e-01 |
| -1.480195e-01 | 1.019552e-01 | -1.859834e-01 | -2.001313e-01 | 3.221724e-02 | 5.888860e-02 | -9.259263e-02 | -1.167181e-01 | 1.175357e-01 | -3.232361e-01 | 4.969642e-02 | 3.188808e-01 |
| -1.168943e-01 | -3.858544e-01 | 1.816737e-01 | -1.577002e-01 | 1.113976e-01 | -1.470803e-01 | -3.878587e-02 | -1.055703e-01 | 9.292533e-02 | -1.363752e-01 | 3.338148e-01 | 2.710562e-01 |
| 4.092898e-01 | 2.541498e-01 | -1.193482e-01 | -2.384429e-01 | -1.816814e-01 | -1.447409e-01 | 3.946416e-01 | -1.386067e-02 | -1.855159e-01 | 3.299367e-02 | 7.582243e-02 | -7.977816e-02 |
| 5.012834e-01 | -2.832069e-01 | -8.966436e-02 | 3.731627e-01 | 2.370299e-01 | -2.893164e-01 | -1.085483e-01 | 9.730385e-01 | -6.460624e-01 | -1.485755e-01 | -1.221703e-01 | 6.205085e-02 |
| 1.495447e-01 | -2.895350e-02 | -7.231198e-02 | 2.731936e-01 | 6.474168e-03 | 5.916114e-02 | 2.742833e-03 | 2.272793e-01 | 4.157181e-02 | -4.063222e-01 | -2.128650e-01 | 1.366687e-01 |
| 1.941143e-01 | -1.914245e-01 | -2.148696e-01 | 3.045203e-01 | 1.839744e-02 | 3.379154e-02 | 2.282492e-02 | 2.199262e-01 | 9.527658e-02 | -2.969663e-01 | 5.131260e-02 | -1.070706e-02 |
| -4.808914e-02 | -1.973774e-01 | -2.977222e-01 | 8.629739e-02 | 1.919896e-01 | -3.006602e-02 | 8.817330e-03 | -1.483953e-01 | 2.071484e-01 | 2.423469e-01 | -5.499581e-02 | -2.050193e-01 |
| -4.742007e-02 | -4.716052e-01 | 2.301870e-01 | -5.385605e-01 | 1.244621e-01 | -1.836153e-01 | 4.321837e-01 | 4.195324e-03 | -1.138270e-01 | 1.738522e-01 | 7.468598e-02 | 1.806767e-01 |
| 2.873714e-01 | 1.076620e-01 | -4.980731e-01 | -9.473652e-02 | -8.658504e-02 | 2.183601e-01 | 4.231475e-01 | 8.050553e-02 | -3.908499e-01 | -1.117265e-01 | -4.702952e-02 | 2.358804e-01 |
| 3.886508e-01 | 3.022639e-02 | -1.371266e-01 | 5.043661e-02 | 1.178134e-01 | 4.285172e-01 | 2.399983e-01 | -1.523992e-01 | -1.476015e-01 | -3.889247e-02 | -3.362105e-01 | -1.128013e-01 |
| 2.340006e-01 | -4.066448e-01 | 3.782067e-01 | 1.264189e-01 | 5.729287e-01 | -6.195212e-01 | -6.018603e-01 | -2.698098e-02 | 2.000335e-01 | -1.798481e-01 | 2.108676e-01 | -2.026688e-02 |
| 3.190358e-01 | -5.274184e-01 | -1.478018e-01 | 1.459737e-01 | 2.810901e-01 | -1.714696e-01 | 1.232586e-02 | 1.090640e+00 | -1.834159e-01 | -2.287140e-01 | -2.398178e-01 | 1.388507e-01 |
| -1.391845e-01 | -3.208580e-02 | -9.442683e-02 | -2.660229e-01 | 2.835402e-01 | 1.107642e-01 | 3.028451e-01 | 1.691954e-01 | 5.491670e-02 | -4.932127e-01 | 1.954819e-01 | -1.081313e-01 |
| 1.786934e-01 | -3.077064e-01 | -3.368082e-02 | 7.203368e-03 | -5.529697e-02 | -8.896737e-02 | -8.129343e-02 | -2.653190e-02 | -1.178955e-01 | -3.014231e-01 | 7.174466e-01 | 2.321682e-01 |
| 6.765670e-01 | -3.503734e-02 | -2.926368e-01 | 1.659088e-01 | -2.229387e-02 | -4.356470e-02 | 4.540753e-03 | 2.212451e-01 | -2.932433e-01 | -1.103267e-01 | -2.749178e-01 | 5.735178e-01 |
| -1.515214e-02 | 1.264513e-01 | -1.976111e-01 | 2.391709e-01 | -8.162221e-02 | -1.062197e-01 | -7.583345e-02 | -5.099814e-03 | 2.731159e-02 | 1.149239e-01 | 9.936719e-02 | -1.939027e-02 |
| -1.780776e-01 | 8.021633e-02 | -1.206801e-01 | -2.709275e-01 | -1.132045e-01 | -4.004577e-01 | 1.189896e-01 | 2.311017e-01 | 2.042031e-01 | 4.133911e-01 | -1.774705e-01 | 3.681663e-02 |
| -2.686013e-01 | -5.924163e-01 | 3.461178e-02 | 8.954684e-02 | -6.160764e-03 | 1.429614e-01 | -2.827331e-01 | 1.825264e-01 | 1.196436e-01 | 2.562626e-01 | -1.174548e-01 | 3.738781e-02 |
| 8.339261e-02 | -4.238895e-01 | 2.806526e-01 | 2.901022e-01 | 2.077127e-01 | 3.852810e-01 | -3.175797e-01 | -1.851386e-01 | -3.801116e-01 | 5.252100e-02 | -3.164604e-01 | 1.310185e-01 |
| 1.322366e-01 | -1.653986e-01 | 5.399252e-01 | -2.671957e-01 | 5.959595e-01 | -3.842081e-01 | 1.258449e-02 | 1.192976e-01 | -3.706736e-02 | -1.248360e-01 | -2.138305e-02 | -3.947032e-01 |
| 1.348458e-01 | -1.021357e-01 | -1.800024e-01 | 1.061740e-01 | 1.935453e-01 | -9.460095e-02 | -4.808237e-02 | -4.365038e-01 | 8.100404e-02 | 6.850351e-02 | 2.287480e-01 | 1.664430e-01 |
| 6.613149e-02 | 1.050985e-01 | -6.272864e-02 | -1.472739e-01 | 2.650899e-01 | -8.385604e-02 | -2.169645e-01 | 1.512930e-01 | -3.033875e-01 | 6.577106e-02 | 7.749699e-02 | 2.392772e-02 |
| 5.554162e-01 | 6.220041e-02 | 4.465340e-01 | -1.756833e-01 | 5.782017e-03 | -3.156301e-01 | -1.772954e-01 | -2.190545e-01 | -2.328668e-01 | -3.610477e-01 | 3.442444e-01 | 5.259137e-01 |
| 2.871677e-02 | 3.535694e-01 | 1.986066e-01 | 1.912476e-01 | 2.173560e-02 | -1.002797e-01 | -3.292443e-02 | -2.266429e-01 | -3.085351e-01 | 1.434321e-01 | -5.141833e-01 | 1.229946e-01 |
| -1.087980e-01 | 1.663366e-01 | 5.066839e-01 | -2.078192e-01 | -1.249738e-01 | -2.838343e-01 | 1.318664e-01 | 1.527453e-01 | -2.207895e-01 | -5.508792e-02 | -1.388687e-01 | 3.741400e-02 |
| 1.062036e-02 | -3.453961e-02 | 1.010512e-01 | -2.747152e-01 | 9.010043e-02 | 8.310009e-02 | -2.168696e-01 | 1.510475e-01 | -2.023785e-01 | 1.600615e-02 | -9.955123e-03 | -2.132519e-02 |
| 3.305688e-01 | -1.354156e-01 | 1.761997e-01 | -1.364726e-01 | 4.407424e-01 | -7.588930e-03 | -2.605478e-01 | 2.884372e-01 | -3.489092e-01 | -1.546427e-01 | 7.649530e-02 | 3.168139e-01 |
| -1.495923e-01 | -4.043329e-01 | 1.748380e-01 | 1.461780e-01 | 6.092191e-01 | -3.558883e-01 | 1.012171e-01 | -4.775739e-02 | 1.526335e-02 | -3.369631e-01 | 1.216353e-01 | 7.361339e-02 |
| -3.966698e-01 | -2.054695e-02 | 4.353288e-01 | -8.773441e-03 | 3.825736e-01 | 7.182840e-02 | -9.565526e-02 | 4.901680e-02 | 1.815300e-02 | -3.517292e-01 | -1.114326e-01 | 1.446739e-01 |
| 6.998955e-02 | -3.631848e-01 | -1.044226e-01 | 1.310712e-01 | 3.004791e-01 | -2.485364e-02 | -2.674485e-02 | 6.772159e-01 | -2.413749e-02 | -5.387827e-01 | -1.135544e-01 | -4.158718e-02 |
| 2.091623e-01 | -5.928998e-02 | 1.332631e-01 | -5.604968e-02 | -1.563626e-02 | -8.857167e-02 | 1.272855e-01 | -6.438626e-02 | 6.382309e-04 | -2.050525e-02 | 1.056910e-01 | -9.010646e-02 |
| 2.194384e-01 | 3.855797e-01 | -5.539037e-02 | 5.047749e-01 | 2.726832e-01 | -5.964614e-01 | -5.291317e-01 | 8.473531e-02 | 6.025128e-02 | -9.271245e-03 | -3.670653e-02 | -3.047142e-01 |
| -9.512211e-02 | -3.126647e-01 | -7.687338e-02 | -4.590636e-02 | -2.723436e-01 | 1.882223e-01 | 1.145077e-01 | 2.445154e-01 | -1.197581e-01 | -5.372212e-02 | 4.477701e-01 | 2.225369e-02 |
| 1.939057e-01 | 1.624009e-01 | -1.162887e-01 | 1.575252e-01 | 3.895137e-02 | 1.161256e-01 | -2.118452e-01 | 1.121270e-01 | -2.495289e-02 | -2.401346e-01 | 3.577313e-02 | 8.057560e-02 |
| -5.385280e-02 | -1.798985e-01 | -3.772156e-01 | 4.015246e-02 | 2.910159e-01 | 4.841631e-02 | -2.331502e-01 | 1.067937e-01 | 7.221774e-02 | -2.581961e-01 | -2.056146e-02 | 4.517883e-01 |
| -3.872576e-03 | -2.266365e-01 | -5.399941e-02 | 1.140557e-01 | -1.085780e-01 | -2.070497e-01 | 1.120036e-01 | -4.179348e-02 | 1.956143e-01 | -2.952590e-02 | 1.413199e-01 | -2.506842e-02 |
| 3.835225e-01 | -5.712838e-01 | -3.774336e-01 | 6.423384e-01 | 1.337960e-01 | 2.204406e-01 | -2.202918e-02 | 1.057689e-01 | -2.954580e-01 | -1.962430e-01 | 2.054457e-01 | -1.690480e-01 |
| -7.516514e-02 | 3.984958e-02 | -1.596664e-01 | 1.892912e-01 | 1.026179e-01 | -1.985448e-01 | 3.327379e-01 | -3.099835e-01 | -2.057117e-01 | 9.003332e-02 | 4.491915e-01 | 2.308423e-02 |

**7. GELU Activation Function**

\*In this case, h3 has shape of (n \* 48)



**8. Calculate Second MLP Layer**

**Second MLP Layer Weight (, MLP\_Dim = 48)**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |
| 1.203009e-02 | 8.711203e-03 | -4.908540e-02 | 3.788391e-02 | -2.777771e-02 | 9.075329e-02 | -1.264138e-01 | 2.280317e-02 | -4.429399e-02 | 1.378133e-02 | 8.544517e-02 | 3.009379e-02 |
| -2.293634e-02 | 2.742513e-01 | -3.029029e-02 | -1.896934e-02 | 6.157659e-02 | -3.491247e-02 | 5.603504e-02 | -5.571539e-02 | 1.025958e-02 | -2.214243e-02 | -5.074319e-02 | -1.029453e-01 |
| 1.964789e-02 | 6.731129e-02 | 7.088151e-02 | 2.427800e-02 | 3.889890e-02 | -4.050056e-03 | 4.139636e-02 | 1.183085e-02 | -8.113328e-02 | -7.082480e-02 | -6.543521e-04 | 6.177840e-02 |
| 5.418724e-02 | 3.508852e-02 | 1.918876e-02 | -7.630088e-02 | -8.930616e-02 | -4.065796e-02 | 2.784786e-03 | -9.072121e-04 | 1.890805e-02 | 5.126539e-02 | 8.117689e-03 | 1.710665e-02 |
| -4.508667e-03 | -3.650137e-02 | 1.836753e-02 | -2.544714e-02 | -6.276906e-02 | 4.648552e-02 | -3.120883e-02 | 4.323812e-02 | -2.754857e-03 | -3.912506e-02 | 2.756311e-02 | 6.585758e-02 |
| -6.317411e-02 | 2.114956e-01 | 4.690688e-03 | 2.811406e-02 | 6.232024e-02 | -1.746013e-02 | 2.676605e-02 | -3.868850e-02 | 1.599793e-01 | 5.583537e-03 | -5.247173e-02 | -8.598469e-02 |
| -3.978328e-02 | -1.209138e-01 | 2.533970e-02 | 5.494362e-02 | -5.748544e-03 | 3.972846e-02 | 3.546355e-02 | 2.272408e-03 | -4.953817e-02 | -8.480011e-03 | 3.209021e-02 | -3.677373e-02 |
| -6.554723e-02 | -1.474854e-01 | 7.411908e-02 | -9.034722e-02 | -2.688486e-02 | 2.738139e-03 | -5.903943e-02 | -2.993549e-02 | -1.122630e-02 | 2.217251e-02 | -1.024425e-03 | 2.503700e-02 |
| 2.511182e-02 | -4.589464e-02 | 1.670061e-03 | 1.088676e-01 | -8.048607e-02 | 1.762518e-02 | 7.843176e-02 | 3.756904e-02 | 6.403409e-03 | -1.601276e-01 | 1.578257e-01 | 2.481684e-02 |
| 9.448264e-02 | 3.149436e-01 | -3.256433e-02 | 4.048313e-03 | 1.222148e-01 | 2.707105e-03 | -4.291253e-02 | 3.804821e-02 | -8.654760e-02 | 6.754476e-02 | 3.606501e-02 | 1.747528e-02 |
| -5.038130e-02 | 1.391966e-01 | 6.777822e-02 | 2.103239e-02 | -1.188749e-02 | -6.440823e-03 | 1.391542e-01 | -3.671828e-02 | 4.017859e-02 | 1.423988e-01 | -9.963267e-02 | -5.440525e-02 |
| 2.218749e-02 | -6.719983e-02 | 2.714911e-02 | 9.111822e-02 | -9.418263e-03 | 9.494998e-02 | -2.723619e-02 | 1.142559e-02 | -2.211182e-02 | -1.883870e-02 | -1.446471e-02 | 1.091197e-01 |
| -8.716792e-02 | 6.580375e-02 | 4.484093e-02 | -2.759805e-02 | -4.656988e-02 | 1.030495e-01 | -3.243396e-01 | -3.604169e-02 | -3.135937e-02 | 1.490002e-01 | 1.496743e-03 | 9.515096e-03 |
| -1.233888e-01 | -8.129000e-02 | -1.150198e-01 | -8.481218e-02 | -7.794497e-02 | -4.415477e-02 | 8.650485e-02 | -5.332040e-02 | 3.653499e-02 | 1.105928e-01 | 2.406982e-02 | -1.113626e-01 |
| 4.105748e-02 | -8.594457e-02 | -1.270222e-02 | -4.819016e-02 | -1.238062e-02 | -7.472146e-02 | -3.698082e-02 | 9.688221e-02 | -7.366606e-02 | 4.274289e-03 | 4.718580e-02 | 5.758873e-02 |
| 8.605767e-02 | 4.070453e-02 | 1.488722e-02 | 4.319933e-03 | 4.879565e-02 | -1.867243e-02 | 4.242617e-03 | 3.620454e-02 | 5.747314e-02 | 7.511279e-02 | -9.829653e-02 | -1.003331e-01 |
| 1.374577e-02 | 3.441375e-02 | 4.697135e-04 | -7.233359e-02 | 1.499947e-02 | -2.645178e-02 | -2.461716e-01 | 4.000528e-02 | -4.130180e-02 | 5.837404e-02 | -4.941732e-02 | -7.805152e-03 |
| 6.502528e-02 | -1.876532e-01 | 1.036637e-01 | 8.368732e-02 | -1.237500e-01 | 5.712693e-02 | -3.443987e-02 | -1.928356e-02 | -1.059284e-01 | 1.206369e-01 | -5.645555e-02 | -1.554050e-02 |
| -4.379853e-03 | -3.201143e-02 | 4.281104e-02 | -2.658923e-02 | -1.137526e-02 | 2.405100e-02 | -6.269916e-02 | -7.850745e-02 | -7.178057e-03 | 7.862454e-03 | 2.817306e-02 | 6.798995e-02 |
| -3.901285e-02 | 1.625706e-02 | -7.504817e-02 | 1.554302e-01 | -1.907808e-03 | 9.949576e-04 | 5.411354e-02 | -5.654742e-03 | -2.748012e-02 | 4.471076e-02 | 1.861120e-01 | -1.774321e-01 |
| 5.335834e-02 | -7.041389e-02 | -6.797093e-02 | 4.127354e-02 | -6.168522e-02 | -3.025672e-03 | 8.754379e-02 | -1.015148e-02 | 9.639790e-03 | -1.477885e-01 | -2.753987e-02 | -5.906272e-03 |
| -5.528888e-02 | 5.650583e-02 | 5.162130e-02 | 2.474027e-02 | -2.853787e-02 | 6.974214e-02 | -5.704793e-02 | 2.872057e-02 | 3.730102e-02 | 1.260917e-01 | -3.024733e-02 | -2.712753e-02 |
| -3.380751e-02 | 6.124196e-02 | 9.023251e-02 | 6.269438e-02 | 7.848097e-02 | 1.419435e-01 | -1.637977e-02 | -8.968484e-02 | -1.896361e-02 | 7.130758e-02 | 1.145027e-01 | -7.982509e-02 |
| -1.560777e-01 | -1.104099e-01 | 3.211924e-03 | 1.403275e-01 | -3.962782e-02 | 4.163025e-02 | -1.588148e-02 | 5.020566e-02 | 1.067797e-02 | -5.854756e-02 | -4.064786e-02 | -2.429811e-02 |
| 1.525321e-02 | 3.060989e-02 | 3.838035e-02 | -7.129011e-02 | -3.673587e-02 | 4.097010e-02 | -7.089333e-02 | -2.403882e-02 | -3.306573e-02 | 1.312525e-01 | -6.232062e-05 | 6.189564e-02 |
| -1.853942e-02 | -1.488450e-01 | -6.669381e-02 | -8.098210e-02 | -6.374207e-02 | -4.605162e-02 | 5.931106e-02 | -6.857958e-02 | 9.764548e-02 | 9.561365e-02 | -6.071608e-02 | -6.272243e-03 |
| -3.456000e-03 | 3.591146e-02 | -3.251653e-02 | 1.672023e-02 | -7.489149e-03 | -1.177189e-01 | -3.699128e-02 | 6.937984e-02 | 3.489500e-02 | -4.269299e-02 | -7.598850e-02 | 2.710705e-02 |
| 2.517114e-02 | 4.949595e-02 | -6.355862e-02 | -9.025263e-03 | 7.606383e-04 | 2.234613e-02 | 2.471935e-02 | -2.377089e-02 | 4.450289e-03 | 6.557740e-02 | -1.272182e-01 | -5.162885e-02 |
| -2.644886e-02 | 2.975726e-02 | 4.902284e-02 | -2.249357e-02 | 4.282946e-02 | 6.175473e-02 | -3.253509e-02 | 2.419047e-02 | -4.768481e-02 | 1.217370e-02 | 5.819328e-02 | 3.967244e-02 |
| 1.480749e-02 | 2.230016e-01 | 1.283482e-02 | 2.852399e-02 | 2.739893e-02 | 7.943054e-02 | -3.627796e-02 | 3.757189e-02 | 4.526583e-02 | -4.684272e-02 | 3.833983e-02 | 6.400721e-03 |
| 5.078221e-02 | 8.686792e-03 | 3.183815e-02 | -4.756654e-02 | -3.012258e-02 | 1.537382e-02 | 5.016672e-02 | 2.600693e-02 | -5.709336e-03 | 5.274877e-02 | -9.278062e-02 | 4.253828e-02 |
| -8.431355e-03 | -8.102131e-03 | -2.010091e-03 | 1.197067e-02 | -1.713173e-02 | 6.346150e-03 | 4.124056e-02 | 1.779575e-02 | -1.718605e-02 | 1.851398e-02 | -1.012589e-01 | -6.268752e-03 |
| 2.477618e-02 | -4.979134e-02 | 1.980375e-02 | 6.178940e-02 | -9.734300e-02 | -7.818473e-03 | 2.452493e-01 | -4.266696e-02 | 1.050905e-01 | -6.846540e-05 | -1.233276e-02 | 8.529090e-02 |
| 8.848231e-02 | -1.529587e-01 | -8.561627e-02 | -1.376968e-01 | 6.355746e-02 | -1.264677e-02 | 2.040046e-02 | 6.998052e-02 | -1.406075e-01 | 1.070029e-01 | -4.059391e-03 | 1.083923e-02 |
| -1.376874e-02 | 1.074604e-01 | 2.841028e-02 | 1.411755e-02 | 7.303095e-03 | -5.688302e-02 | 2.631511e-02 | 1.093917e-01 | 1.302875e-02 | 1.844951e-02 | 2.692457e-02 | -9.961666e-02 |
| 1.000284e-01 | 1.035063e-01 | 8.147851e-03 | -1.829459e-02 | 8.076475e-02 | 7.106320e-02 | 4.346574e-02 | 4.316854e-02 | 6.280061e-02 | 9.448913e-03 | 3.389051e-02 | 4.815015e-02 |
| 6.209474e-02 | -8.705387e-02 | 8.630420e-02 | -4.122757e-02 | 1.247126e-03 | -1.685515e-02 | -3.439866e-01 | 6.135345e-02 | 5.447454e-02 | -3.713467e-02 | 7.053195e-02 | 2.021516e-02 |
| 2.461625e-02 | 2.138194e-01 | 6.097676e-02 | 4.594697e-02 | 5.813807e-02 | -5.968021e-02 | 1.495886e-02 | 1.116322e-02 | 1.524795e-02 | -1.836950e-02 | 5.331650e-02 | -3.319474e-02 |
| -4.868073e-02 | -7.966968e-02 | -1.227750e-02 | 6.544768e-02 | 2.617106e-02 | 6.489465e-02 | -9.086533e-02 | -1.083310e-01 | 4.721278e-02 | -7.473481e-02 | -1.932366e-02 | -1.797787e-03 |
| -7.497769e-02 | -1.068491e-01 | 5.285514e-02 | -2.774955e-02 | -3.759483e-02 | 3.796098e-02 | 8.009918e-02 | -4.213737e-02 | -4.613210e-02 | -1.600582e-03 | 8.029904e-02 | -1.026428e-01 |
| -9.838394e-02 | 5.986496e-03 | -3.717999e-02 | -5.492974e-02 | -3.471651e-02 | -1.363913e-02 | -2.066695e-01 | 5.663643e-02 | -1.327350e-02 | -1.991537e-02 | 5.212422e-03 | 1.341130e-03 |
| -2.759451e-02 | 9.817190e-03 | 6.101592e-02 | 3.965614e-02 | 9.503770e-03 | -7.611816e-02 | -1.260445e-03 | -1.898231e-02 | 5.018329e-02 | 1.140667e-01 | 2.687895e-02 | -1.307656e-02 |
| -6.896446e-02 | -9.038033e-02 | 2.551706e-02 | -8.055238e-02 | -4.226598e-02 | -9.167382e-03 | -8.424299e-03 | -4.962463e-02 | 9.816603e-03 | 1.791038e-02 | 3.041770e-02 | -1.383809e-03 |
| 3.433970e-02 | -1.018433e-01 | 4.894012e-02 | 1.022584e-03 | -5.584127e-02 | 1.698894e-03 | 4.752786e-02 | -4.382009e-02 | -5.992562e-04 | -7.439802e-03 | 1.565364e-01 | -5.521530e-02 |
| -3.229127e-02 | 5.435386e-02 | 1.396288e-01 | -1.856896e-02 | 4.899584e-02 | 8.634371e-02 | -1.184036e-01 | -2.847103e-02 | 2.588561e-03 | 1.806365e-01 | -8.906235e-02 | -3.326091e-02 |
| 1.012223e-02 | -3.171287e-01 | 2.814401e-02 | 1.969164e-02 | -4.775022e-02 | 1.569173e-02 | -7.606544e-02 | -7.220425e-02 | -1.321761e-01 | -4.817657e-02 | -9.110251e-03 | -1.042227e-02 |
| -3.480501e-02 | -5.259216e-02 | -6.573295e-02 | -5.069616e-02 | 1.146034e-01 | -2.189316e-02 | 5.917747e-03 | 4.956196e-02 | -3.754982e-02 | -1.033714e-01 | -6.220735e-03 | 6.946164e-02 |
| -2.394829e-02 | 3.017544e-02 | -1.008746e-01 | 1.019611e-01 | 5.746375e-02 | 3.634664e-02 | -1.631798e-02 | 4.694669e-03 | -8.056104e-03 | 2.806857e-02 | -1.854857e-01 | -4.300339e-02 |

**Second MLP Layer Bias (,MLP\_Dim = 48)**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |
| -3.948552e-03 | -1.351664e-02 | 3.315831e-02 | -3.731062e-02 | -8.695372e-03 | 2.785660e-02 | -1.368493e-02 | 3.790501e-02 | 3.755065e-02 | 1.493644e-02 | -2.286415e-02 | -2.535901e-02 |

**9. Residual Connection**

**input\_x3 = input\_x2 + h4**(in this case, input\_x2 is value before LayerNorm2)

**Layer 3**

From now on, this is the repeat of layer 2.   
However, the input is the result of Layer 2, which is **input\_x3**

**1. Calculate LayerNorm 1**

**, ,**

**\*** In this case, h1 has shape of (n \* 12)

**Masked MSA block Weight**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |
| 1.729583e+00 | 1.795386e+00 | 1.594847e+00 | 1.742226e+00 | 1.789152e+00 | 1.541283e+00 | 1.858812e+00 | 1.845405e+00 | 1.967943e+00 | 1.561118e+00 | 1.865987e+00 | 1.729683e+00 |

**Masked MSA block Bias**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |
| -2.402721e-02 | -3.884875e-02 | 4.040448e-03 | -5.860642e-02 | 3.511279e-02 | 3.299000e-02 | -1.001769e-01 | 1.462631e-02 | -4.662107e-02 | 2.345084e-01 | -4.572881e-02 | -1.225817e-01 |

**2. Calculate Q,K,V, Multihead attention**

**, ,** \*Perform a single 12×12 multiplication. (You can also compute by splitting into n\*12)

**Masked MSA Multihead Attention block *in* Q, K, V weight**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Query Weight** | | | | | | | | | | | |
| -8.074458e-02 | -1.527655e-01 | -8.220527e-02 | 5.589002e-02 | 1.217387e-01 | 1.841144e-01 | 4.616685e-02 | -2.112111e-01 | 2.789603e-01 | -2.202297e-01 | -9.401225e-02 | -5.091482e-02 |
| -3.406392e-02 | 1.317771e-01 | 1.605297e-01 | 6.814778e-03 | -1.505139e-01 | -1.487920e-01 | -4.067770e-02 | -1.216573e-01 | 3.260824e-01 | 3.983261e-04 | 7.093691e-02 | -1.921406e-01 |
| 2.946655e-03 | 1.500054e-01 | -2.162834e-03 | 2.430795e-02 | -3.580060e-01 | -2.364348e-01 | 3.602637e-01 | 6.378414e-02 | 5.695076e-02 | -2.225916e-01 | -2.215335e-01 | 1.003324e-01 |
| -1.078874e-01 | 5.526710e-02 | 9.016913e-02 | -2.149014e-01 | -9.380607e-02 | 1.851926e-01 | 1.153719e-01 | 5.780471e-02 | 3.547637e-02 | 3.208186e-02 | -3.284916e-01 | 1.170587e-01 |
| -3.059078e-01 | -2.470222e-01 | 5.089273e-01 | -1.763547e-01 | 7.509974e-01 | 3.828113e-02 | -2.683822e-01 | -1.438510e-01 | 3.482106e-01 | -3.117459e-02 | 5.029828e-02 | -3.605950e-01 |
| 4.182880e-01 | -3.077720e-01 | -5.455999e-01 | 7.188264e-01 | 4.506584e-02 | -3.667283e-01 | 9.309708e-01 | 5.357420e-01 | -2.101556e-01 | -6.578912e-01 | -7.382463e-01 | 1.502163e-01 |
| -3.495197e-03 | -2.286678e-01 | -4.166804e-01 | -6.653655e-01 | 1.065230e+00 | 3.671809e-01 | -5.876834e-01 | 8.520470e-01 | -1.498710e+00 | 4.793041e-01 | -3.916142e-02 | 4.936333e-01 |
| -2.458334e-01 | 5.080886e-01 | -1.496832e-01 | -4.483705e-01 | 4.455538e-02 | 6.380055e-01 | -1.924866e-01 | -5.562857e-01 | -1.509962e-01 | 8.447312e-01 | 2.176599e-01 | -8.805032e-01 |
| 5.885034e-01 | -4.317944e-01 | -6.390578e-01 | 6.405872e-01 | 4.155094e-02 | -6.358574e-01 | 6.433270e-01 | 1.016803e+00 | -7.589518e-01 | -8.521565e-01 | -7.980556e-01 | 9.687834e-01 |
| -6.200528e-01 | 4.944947e-01 | -3.213366e-01 | -1.091953e-01 | 8.187163e-03 | 3.536356e-01 | -3.248939e-01 | 1.816190e-01 | -5.321940e-01 | 5.852949e-01 | 2.378217e-01 | -7.417203e-02 |
| -4.869077e-02 | 6.433913e-01 | 1.469366e-01 | 5.444482e-01 | -1.219432e+00 | -2.574964e-01 | 8.469025e-01 | -7.675541e-01 | 9.161193e-01 | -4.632445e-01 | -4.134924e-01 | -3.742158e-01 |
| 2.928643e-01 | 4.163838e-01 | -8.259466e-02 | -6.443046e-01 | 3.645095e-01 | 4.529645e-01 | -1.219549e-01 | -7.464389e-02 | -6.860425e-01 | 5.786003e-01 | -5.810809e-02 | -2.495915e-01 |
| **Key Weight** | | | | | | | | | | | |
| -4.807751e-02 | -9.242162e-02 | 1.044871e-02 | 1.075848e-01 | -7.684973e-02 | -1.902946e-01 | 2.418898e-01 | 9.342862e-02 | -1.161533e-01 | 1.958524e-02 | 4.939143e-01 | 1.211831e-01 |
| 1.990402e-02 | -2.564647e-02 | -1.538424e-01 | 3.809120e-01 | -6.588577e-02 | 1.251219e-01 | 2.634732e-02 | -1.444424e-01 | 3.680587e-01 | -3.135453e-01 | -1.155311e-02 | -2.097385e-01 |
| 1.374506e-01 | -2.229414e-01 | -7.793665e-02 | 1.788276e-01 | 1.344101e-01 | -1.453692e-01 | 1.490691e-01 | -1.195817e-01 | 1.280316e-01 | -2.821225e-02 | -3.782430e-01 | 2.283264e-01 |
| -4.448960e-01 | -5.859257e-02 | -2.273784e-01 | 3.729085e-01 | -1.832025e-02 | 5.651188e-01 | -1.512707e-03 | 9.471650e-02 | -2.577764e-01 | -2.012200e-01 | -2.964363e-02 | -2.681492e-01 |
| -4.258876e-01 | 2.764931e-01 | -6.994933e-02 | -2.156398e-02 | -6.322830e-01 | 9.972442e-03 | -2.622843e-01 | -2.231533e-01 | 2.155574e-01 | 1.340795e-01 | 5.359516e-01 | 2.616929e-01 |
| 4.473931e-01 | -5.291346e-01 | -3.622194e-02 | 2.681993e-01 | 3.048320e-01 | -8.299708e-01 | 1.295634e-01 | 1.721012e-01 | -3.141952e-01 | -4.191516e-02 | -1.043809e-01 | 7.284256e-01 |
| -4.681243e-02 | 1.870855e-01 | -4.333910e-01 | -6.689891e-01 | 8.100865e-01 | 4.051008e-01 | -5.886695e-01 | 3.973047e-01 | -1.141619e+00 | 8.084608e-01 | 2.328863e-01 | 1.312033e-01 |
| 2.508210e-02 | 1.743076e-01 | 9.892637e-01 | -7.359470e-01 | -5.310953e-02 | 1.418205e-01 | -5.334195e-01 | -9.163553e-01 | 3.952149e-01 | 8.476889e-01 | 3.972943e-01 | -8.342105e-01 |
| 4.321763e-01 | -5.769811e-01 | -4.731823e-01 | 2.153552e-01 | 7.400428e-01 | -4.896563e-01 | 1.721208e-01 | 6.726421e-01 | -8.226047e-01 | -1.858043e-01 | -3.708670e-01 | 7.428961e-01 |
| 5.301908e-01 | 1.922117e-01 | 3.689007e-01 | -9.138889e-01 | 2.781148e-01 | 4.057328e-01 | -1.860706e-01 | -2.542258e-01 | -3.692662e-01 | 3.740178e-01 | -3.068868e-01 | -2.228114e-01 |
| 2.995879e-01 | -5.046754e-01 | 5.964574e-01 | 4.075981e-01 | -3.337122e-01 | -5.164583e-01 | 4.429687e-01 | -3.738835e-01 | 7.948289e-01 | -5.705644e-01 | -3.960900e-01 | -2.135627e-01 |
| -1.865200e-01 | -2.246085e-01 | 4.699824e-01 | -4.913161e-01 | 7.748985e-01 | 2.419919e-01 | -6.584081e-01 | -1.452826e-01 | -3.141019e-01 | 9.948271e-01 | 4.093822e-01 | -6.203460e-01 |
| **Value Weight** | | | | | | | | | | | |
| 3.114341e-01 | -1.742191e-01 | -2.450296e-01 | -1.135639e-02 | -8.634908e-02 | -8.478434e-02 | 2.849338e-01 | -2.419736e-01 | -5.619132e-02 | -8.090781e-02 | 3.096182e-01 | 6.779769e-02 |
| 5.539706e-01 | 4.802223e-01 | 9.320119e-03 | -2.483850e-01 | -7.114676e-03 | -2.427709e-01 | -1.131786e-01 | -3.979350e-01 | 2.340028e-01 | 2.883392e-01 | -3.178863e-01 | 2.984040e-03 |
| -2.293994e-01 | -4.103361e-01 | -1.461912e-01 | -1.067840e-01 | 2.749963e-01 | 6.546049e-03 | 3.341171e-01 | 9.759494e-02 | -2.874720e-02 | 2.307698e-01 | 4.710787e-02 | -3.344728e-01 |
| -4.819911e-02 | -4.583348e-01 | 1.820955e-01 | -1.100346e-01 | 1.864210e-01 | 4.719472e-02 | 6.806206e-02 | -1.071141e-01 | 1.807569e-01 | -2.485354e-01 | -1.211310e-01 | 4.164360e-01 |
| 1.247744e-01 | 1.631722e-01 | -2.871226e-01 | 3.044999e-01 | -2.291562e-01 | 2.106858e-01 | -5.245624e-01 | -2.967300e-01 | 1.125463e-01 | 5.223181e-01 | -7.247754e-01 | 3.767092e-01 |
| 5.733922e-01 | -1.313932e-01 | 9.045974e-01 | 5.131675e-03 | 1.677125e-01 | -3.249928e-01 | 1.041192e-02 | -4.443370e-01 | -2.506574e-01 | 4.979029e-02 | 1.346475e-01 | 2.421432e-01 |
| -4.062411e-01 | -3.278851e-01 | 1.520162e-01 | 3.558004e-02 | -4.698613e-01 | -3.034643e-02 | 4.257220e-01 | 2.238287e-01 | -2.067605e-01 | 6.405828e-01 | 2.050410e-03 | -1.746734e-01 |
| 2.774968e-01 | -2.587448e-01 | -3.567062e-01 | -2.790404e-01 | -5.591266e-01 | 1.946327e-01 | -1.948346e-01 | 1.794376e-01 | 1.595736e-01 | -3.497660e-03 | 6.828648e-01 | 5.548087e-01 |
| 7.867305e-01 | -3.563537e-02 | -2.478265e-01 | -6.484011e-01 | -2.252886e-01 | -1.919284e-01 | 4.720704e-01 | -2.061963e-01 | 1.403017e-03 | 4.032412e-01 | -4.363633e-01 | -1.760170e-01 |
| -2.935042e-01 | -1.229727e-01 | -2.880693e-01 | 3.921317e-01 | 1.449002e-01 | 8.263685e-01 | 1.936697e-01 | 1.446422e-01 | -6.482433e-02 | -1.206179e-01 | -3.588179e-01 | -4.795861e-01 |
| -3.614096e-01 | 8.231920e-01 | -1.094603e-01 | -2.341235e-01 | 5.385849e-02 | -3.524358e-01 | 4.338840e-01 | -2.225449e-01 | -2.292364e-01 | -3.862143e-01 | -2.813339e-02 | 1.027331e-01 |
| -5.193973e-02 | -2.290022e-01 | 9.899805e-02 | 7.257112e-01 | -3.139459e-01 | 1.055938e+00 | 3.561758e-01 | -8.262034e-01 | -8.003629e-01 | -4.277416e-01 | 7.514923e-01 | 3.818447e-01 |

**Masked MSA Multihead Attention block *in* Q, K, V bias**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Query Bias** | | | | | | | | | | | |
| -1.616572e-01 | 5.113970e-01 | -1.669877e-01 | 6.334691e-01 | 2.551297e-01 | 1.062378e-01 | 3.860405e-02 | 2.784129e-01 | -2.410935e-01 | 3.093576e-02 | -7.223374e-02 | 4.195296e-01 |
| **Key Bias** | | | | | | | | | | | |
| 2.322809e-02 | -1.933946e-02 | 6.813013e-02 | -2.431024e-02 | 3.568509e-02 | -3.839408e-02 | -2.507732e-02 | 4.931458e-03 | 2.612824e-02 | -1.331860e-01 | 4.638669e-02 | 4.842025e-02 |
| **Value Bias** | | | | | | | | | | | |
| -8.873230e-03 | 3.915556e-01 | 6.868466e-02 | 2.088941e-02 | -5.364917e-02 | 1.168198e-01 | 2.448291e-01 | -9.719197e-02 | -9.092647e-02 | 1.567062e-02 | -3.010655e-01 | -1.500557e-01 |

**⇒ Casual Mask(Upper triangle) ⇒ ⇒**

\*In this case, Multihead(Q,K,V) has shape of (n \* 12)

If you calculate with 3 divided heads, you need to concat each heads.

**3. Calculate attn\_out score**

**Masked MSA Multihead Attention block *out* weight()**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |
| -1.611875e-01 | -3.071199e-01 | -1.622088e-02 | -1.651277e-01 | -8.474842e-01 | -9.346099e-02 | 3.804362e-01 | -4.491232e-01 | -9.215099e-01 | 8.857260e-01 | -3.522520e-01 | 3.764018e-01 |
| 4.134541e-02 | -5.057361e-02 | 1.802931e-01 | -2.466024e-02 | -4.573048e-01 | 5.902157e-01 | 5.819846e-01 | -9.293579e-01 | -1.457399e-01 | 4.376119e-01 | 6.421663e-01 | 7.178560e-01 |
| -2.831455e-01 | 2.576225e-01 | -2.405562e-01 | 4.739849e-02 | 3.510373e-01 | 1.411525e-01 | 5.646434e-01 | -5.993954e-01 | -5.679304e-01 | 6.943768e-01 | -3.429343e-01 | 5.711059e-01 |
| 2.500055e-01 | -7.337531e-02 | -6.342332e-01 | 8.519331e-03 | -5.954629e-01 | 3.146345e-01 | 6.286336e-03 | 2.821246e-01 | -3.799563e-01 | -1.948895e-01 | -8.175103e-02 | 6.717931e-01 |
| 2.861499e-01 | -2.360647e-01 | 3.471978e-02 | -3.277047e-01 | -7.467467e-01 | 4.547829e-01 | 5.832056e-01 | 5.570202e-01 | -2.193117e-01 | -6.276113e-01 | 7.358955e-01 | 1.007252e+00 |
| -1.823688e-01 | 6.908903e-01 | -1.303232e-01 | -6.909944e-02 | -3.092594e-01 | 4.979165e-01 | 3.877749e-01 | 2.316125e-01 | 8.035210e-01 | 1.843919e-01 | -6.346939e-01 | 8.569674e-01 |
| -2.578601e-01 | -3.112593e-01 | -3.661416e-01 | 4.063176e-01 | -1.004821e-01 | 1.104697e+00 | -6.405898e-01 | 9.387131e-02 | -5.203148e-01 | -4.513304e-01 | -6.440834e-01 | 7.065216e-01 |
| -1.216377e-02 | -1.733538e-01 | -3.441106e-01 | -1.639469e-01 | 1.121325e+00 | 4.163636e-01 | 8.072104e-03 | -1.641892e-01 | -1.572695e-01 | 4.765351e-01 | -1.544358e-01 | 8.756303e-01 |
| 3.735008e-01 | 4.142904e-01 | -3.543835e-01 | 2.544990e-01 | 2.223329e-01 | -7.981083e-02 | -5.780609e-02 | -5.498382e-01 | -2.003158e-02 | 8.754022e-02 | 1.093511e+00 | 5.865785e-01 |
| -4.198554e-01 | 5.411144e-01 | -4.779346e-01 | -2.998451e-01 | -2.561996e-01 | 2.216609e-01 | -1.328178e+00 | -7.873882e-01 | -4.670089e-01 | -2.471774e-01 | 8.150995e-01 | 2.552524e-01 |
| -1.220866e-01 | 1.250743e-01 | -3.118542e-01 | -2.727612e-01 | -1.533150e-01 | -5.668638e-01 | -5.417359e-01 | 1.082907e+00 | -7.007460e-01 | 5.900972e-01 | -5.064050e-01 | 6.121728e-01 |
| -1.760800e-01 | -5.038458e-01 | 1.763683e-01 | 1.126477e-01 | -6.646736e-01 | -8.819530e-02 | -4.862010e-01 | -2.521276e-01 | 5.478161e-01 | 1.013535e+00 | 1.511677e-01 | 6.255826e-01 |

**Masked MSA Multihead Attention block *out* bias**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |
| 1.305126e-01 | 3.493060e-01 | -2.620194e-01 | -4.220919e-02 | -4.452164e-01 | 6.638800e-02 | -1.422704e-02 | -2.829463e-01 | 2.971412e-01 | 3.402972e-01 | 2.962492e-01 | -2.501954e-01 |

**4. Residual Connection**

**input\_x2 = attn\_out + input\_x**(in this case, input\_x is position embedded matrix)

**5. Calculate LayerNorm 2**

**, ,**

**\*** In this case, h1 has shape of (n \* 12)

**MLP block Layer Norm weight(**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |
| 1.506261e+00 | 1.336491e+00 | 1.575295e+00 | 1.384330e+00 | 1.284732e+00 | 1.276426e+00 | 1.215312e+00 | 1.213865e+00 | 1.051055e+00 | 1.141071e+00 | 1.277975e+00 | 1.316890e+00 |

**MLP block Layer Norm bias**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |
| 2.702664e-02 | -5.897957e-03 | 1.807868e-01 | 8.363684e-02 | -2.029059e-01 | 2.816897e-01 | -9.424451e-03 | -7.911934e-01 | 8.365113e-01 | 1.063401e-01 | 6.450757e-01 | -2.760139e-01 |

**6. Calculate First MLP Layer**

\*In this case, h3 has shape of (n \* 48)

**First MLP Layer Bias (MLP\_Dim = 48)**

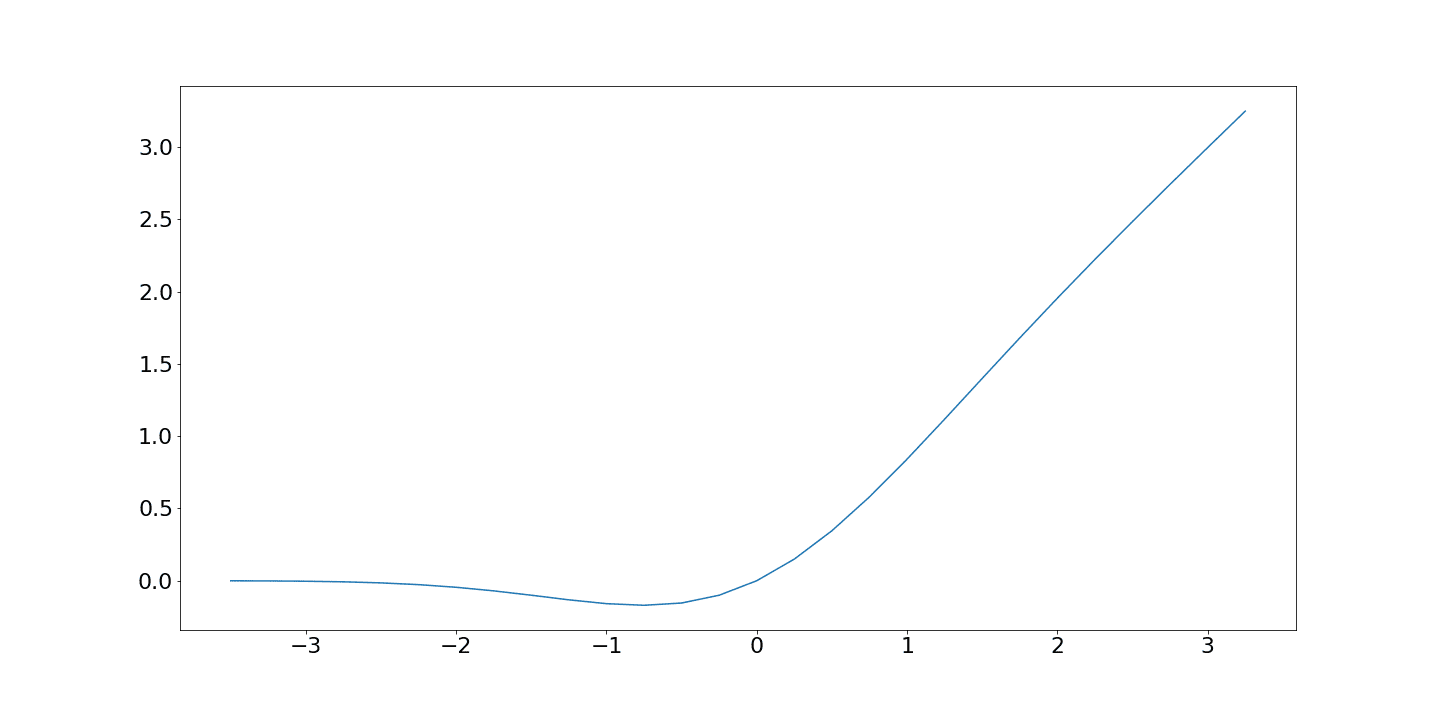
|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |
| -2.339137e-01 | -1.335417e-01 | -2.321306e-01 | -9.673117e-02 | -1.805049e-01 | -4.559627e-01 | -7.803965e-02 | -2.276850e-01 | -1.471694e-01 | -3.526739e-01 | -4.948885e-02 | -3.346940e-01 |
| -1.670950e-01 | -9.576345e-02 | 2.555533e-01 | -3.137249e-03 | 2.140468e-01 | 7.568748e-02 | -3.297214e-01 | -1.501297e-02 | -2.217852e-01 | -2.187582e-01 | -4.554493e-01 | 8.551886e-02 |
| -1.881120e-01 | -4.257603e-01 | -2.165808e-02 | -2.354921e-01 | -1.060185e-02 | -8.782493e-01 | -9.980758e-01 | -2.274001e-02 | 1.395253e-01 | -3.786539e-01 | -2.452119e-01 | -2.644412e-01 |
| 1.152479e-01 | -2.143915e-01 | -4.781533e-01 | -1.723182e-01 | -1.397481e-02 | 2.494209e-02 | -3.183931e-01 | -2.492628e-01 | -8.470304e-01 | -7.918781e-02 | -2.157585e-01 | -6.531413e-01 |

**First MLP Layer Weight (, MLP\_Dim = 48)**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |
| -7.407061e-01 | 4.702148e-01 | 2.713484e-01 | -1.799508e-01 | 1.344510e-01 | 1.866560e-02 | 3.235848e-01 | 2.358283e-01 | -2.310996e-01 | -2.264632e-01 | -4.233081e-01 | -2.450474e-01 |
| -2.489743e-03 | -3.248984e-01 | -2.791735e-01 | 5.735516e-02 | 4.086262e-01 | -4.765189e-01 | 1.021929e-01 | 3.580719e-01 | -2.382749e-01 | 5.391040e-02 | 4.452822e-02 | 1.138576e-01 |
| -1.486862e-01 | -1.797611e-01 | 4.210825e-01 | -2.125621e-01 | 4.697251e-01 | 1.534990e-01 | -7.296807e-03 | -9.180012e-02 | -7.190162e-02 | -5.133598e-01 | -2.209944e-01 | 7.006421e-02 |
| -1.202989e-01 | -3.083666e-01 | 5.337428e-01 | 2.449735e-01 | 9.621754e-02 | -1.338041e-01 | -2.414719e-01 | -3.379554e-01 | -1.310363e-01 | 1.439107e-01 | 8.787300e-02 | 1.732044e-01 |
| -4.687909e-02 | -3.291337e-02 | 6.029262e-02 | -1.912535e-01 | -1.762818e-01 | -4.393405e-01 | -1.687801e-01 | 1.568416e-01 | -7.225846e-02 | 4.660297e-01 | 2.518955e-02 | 3.320919e-02 |
| 4.861878e-01 | 1.589783e-01 | -3.270771e-01 | -4.816230e-01 | 1.762130e-02 | -2.121203e-01 | -3.906702e-02 | 3.396785e-01 | 1.133330e-01 | -2.240796e-01 | -2.577915e-01 | 2.423039e-01 |
| -8.045047e-02 | 3.660443e-02 | 3.602804e-01 | -3.085998e-01 | -4.449233e-01 | 3.409116e-03 | 3.282234e-01 | 3.826178e-01 | -1.016428e-01 | 1.748392e-01 | -1.068578e-01 | 7.144103e-02 |
| -3.245136e-01 | -1.884530e-01 | 5.745633e-02 | -3.619990e-02 | -6.286188e-02 | -2.231804e-01 | -2.147381e-01 | 6.880161e-02 | 1.535734e-01 | -2.364328e-01 | -9.809998e-02 | 4.505635e-01 |
| 4.261726e-01 | 3.188099e-02 | -3.084119e-01 | 1.988657e-02 | -1.045836e-02 | 2.064568e-01 | -1.085252e-01 | 2.018877e-01 | 2.345233e-01 | -9.903613e-02 | -2.169930e-01 | -3.895813e-01 |
| 1.535817e-01 | -2.025887e-01 | 5.743621e-01 | -1.855579e-01 | 1.201996e-01 | -5.433149e-01 | 9.473538e-04 | 2.620350e-01 | -2.003645e-01 | -1.946524e-01 | -5.549622e-01 | 2.926672e-01 |
| -5.813182e-02 | 8.230741e-02 | 7.125783e-01 | -1.234106e-01 | 1.154552e-01 | -4.849564e-01 | -2.342354e-01 | 5.262154e-02 | -5.267454e-02 | 8.728728e-02 | -3.950168e-01 | -3.451814e-02 |
| -3.596957e-01 | 3.374423e-01 | 3.430405e-01 | -4.408689e-01 | 3.166744e-01 | 5.161041e-02 | 1.367296e-02 | 1.603829e-01 | -6.390899e-01 | 1.133481e-01 | -6.279639e-01 | 4.766116e-01 |
| 8.883238e-02 | 4.194605e-01 | -8.828770e-02 | -3.497084e-01 | 2.429130e-02 | -1.106793e-01 | -4.504205e-02 | 2.038002e-01 | -8.694795e-02 | -1.484802e-01 | -5.603223e-01 | 3.679353e-01 |
| -3.862476e-01 | -1.366832e-01 | 1.665928e-01 | -1.586758e-01 | -1.301158e-02 | -2.440480e-01 | -8.813071e-02 | 2.809718e-01 | 1.157605e-02 | -1.701626e-01 | 3.041275e-01 | 6.397910e-02 |
| 2.695064e-01 | -4.031811e-01 | 2.270512e-01 | -8.399969e-02 | 6.013809e-02 | 2.850479e-01 | 2.246253e-02 | 4.591559e-02 | 6.562529e-02 | 9.712344e-02 | -3.326552e-01 | -1.418440e-01 |
| -3.484127e-01 | 2.805697e-01 | 3.623149e-01 | -1.326324e-01 | 2.159130e-01 | 3.811757e-02 | -3.637732e-01 | -1.173565e-02 | 3.980863e-02 | -2.811807e-01 | -7.253268e-02 | 2.811954e-01 |
| -3.785990e-01 | -3.015732e-01 | 2.199832e-01 | 3.033495e-01 | 5.275221e-02 | 4.741811e-02 | -1.777889e-01 | -1.064576e-01 | -1.303774e-01 | 1.794993e-01 | 5.001018e-02 | 2.876362e-01 |
| 1.418262e-01 | -1.963037e-01 | 4.982858e-01 | 8.464130e-02 | 1.860095e-01 | 1.356644e-01 | -7.088648e-02 | -3.259291e-01 | -1.673065e-01 | -6.907761e-02 | -3.041023e-01 | 1.956723e-01 |
| 1.814731e-02 | 7.116257e-02 | -5.760503e-02 | -5.550635e-02 | -2.851770e-01 | 3.258292e-02 | -3.956380e-01 | 1.425603e-01 | 1.330466e-01 | -5.451331e-02 | 1.615861e-01 | 5.977138e-02 |
| 1.144429e-01 | 7.409012e-02 | -2.279594e-01 | -2.248527e-01 | -2.428160e-01 | 3.945536e-01 | 1.652821e-01 | 2.315444e-01 | 4.241380e-02 | 2.095838e-01 | -5.275040e-01 | -2.748956e-01 |
| -4.792962e-01 | 8.157862e-02 | -1.473468e-01 | -2.425241e-01 | 1.427569e-01 | -1.564671e-01 | 3.528306e-01 | -2.352239e-01 | -7.574485e-02 | 2.157804e-01 | 6.641296e-02 | 2.123792e-01 |
| 3.015468e-01 | -1.985768e-01 | -3.253153e-01 | -5.821055e-02 | -6.710839e-02 | 1.516340e-01 | -2.184018e-02 | -8.156923e-02 | 1.355909e-01 | 1.417644e-01 | 3.415047e-02 | -2.367964e-02 |
| 7.307400e-03 | -2.873502e-01 | 7.163115e-01 | 1.764667e-01 | 2.555310e-01 | -4.321846e-01 | -1.802530e-01 | 3.551832e-01 | -1.184250e-01 | -2.385116e-01 | -3.919287e-01 | -1.431664e-01 |
| -7.333259e-02 | -1.265280e-01 | -1.674015e-01 | -2.915837e-01 | 4.772856e-01 | 1.996907e-01 | -3.428651e-01 | 3.843165e-01 | 2.638953e-02 | -8.865451e-02 | -1.997498e-01 | -3.121891e-02 |
| -1.326726e-01 | -2.901825e-01 | 3.689658e-01 | -2.198987e-02 | 1.162417e-01 | 1.582974e-01 | -2.674635e-01 | -2.660115e-01 | -2.609375e-02 | -8.730438e-02 | 7.679482e-02 | 3.969471e-01 |
| 2.074586e-01 | 3.718933e-01 | 6.953469e-02 | -2.323151e-01 | -1.618080e-01 | 1.227038e-01 | 2.183395e-01 | 6.200852e-01 | -2.370164e-01 | -4.685874e-01 | -3.444547e-01 | -4.036525e-01 |
| -3.124726e-01 | 3.009162e-01 | 1.596655e-01 | 6.698740e-02 | -3.701194e-01 | 6.775627e-03 | 1.415206e-01 | -3.210892e-01 | -3.793357e-01 | 2.392079e-01 | 1.440550e-01 | 3.306447e-01 |
| -5.289526e-01 | 8.492662e-02 | 1.550998e-01 | 1.740164e-01 | 7.714523e-02 | 2.956419e-02 | -5.579109e-01 | 1.495710e-01 | 1.852573e-01 | -7.823360e-02 | -4.327065e-02 | 2.429935e-01 |
| -3.091394e-02 | -4.245415e-01 | 6.330339e-01 | 1.385398e-01 | -3.406857e-02 | -1.657171e-01 | -1.567448e-01 | 1.663400e-01 | -1.553672e-01 | 2.219216e-01 | -1.734841e-01 | -1.722503e-01 |
| -1.933587e-01 | 2.269061e-01 | -1.525500e-01 | 3.117045e-01 | -4.244782e-01 | 6.312243e-01 | 4.049089e-01 | -3.720826e-02 | -7.420081e-01 | -2.529563e-02 | -5.647349e-01 | 8.941483e-02 |
| 9.881948e-02 | -2.826532e-01 | -3.003183e-01 | 1.608679e-01 | 4.169333e-01 | 4.812082e-02 | 2.502727e-02 | 2.188138e-01 | -8.192941e-01 | 1.787837e-01 | -9.199651e-02 | 1.195772e-01 |
| -9.218034e-02 | -1.315614e-01 | -1.365290e-01 | -6.034234e-01 | -2.715855e-02 | 2.822134e-01 | 4.322495e-02 | -2.404650e-02 | 1.753347e-01 | -3.564983e-01 | -3.807891e-02 | 1.900479e-01 |
| -4.581018e-01 | -2.835265e-01 | 4.218572e-01 | -8.890754e-02 | 1.041413e-01 | 5.223046e-01 | 2.433312e-01 | -1.308332e-01 | -2.499420e-01 | 1.624196e-02 | -2.912079e-01 | 1.527668e-01 |
| 8.749620e-01 | 1.873917e-01 | 1.045297e-01 | 1.712498e-01 | 8.179878e-02 | 1.530729e-01 | -1.663433e-01 | 2.408357e-01 | -5.129641e-01 | -4.068241e-01 | -2.906059e-01 | -2.935192e-01 |
| -3.737443e-01 | 1.059792e-01 | -1.453528e-02 | -2.637602e-01 | -1.103141e-01 | 1.977536e-01 | -3.780900e-02 | 2.499827e-01 | -6.307034e-02 | 2.080825e-01 | -2.058939e-01 | 4.978796e-02 |
| 9.563524e-02 | -2.724854e-01 | 2.126915e-01 | 9.571600e-03 | -2.780310e-01 | 3.356584e-02 | -2.949673e-02 | 6.706744e-01 | -6.818178e-01 | 3.125199e-01 | -1.068555e-01 | 1.290316e-02 |
| 7.913542e-02 | -3.044167e-01 | 3.980410e-01 | 7.705400e-02 | 2.544962e-01 | 2.823303e-01 | -3.035656e-01 | -1.553687e-01 | 3.386861e-02 | 1.265234e-01 | -6.275020e-01 | 5.358068e-02 |
| 1.181616e-01 | 3.933311e-01 | 2.194299e-01 | 1.974498e-01 | 6.571585e-02 | -2.515440e-01 | 1.764872e-01 | -1.151530e-01 | -3.844381e-01 | 3.240893e-01 | -2.258217e-01 | -4.229819e-01 |
| 8.645783e-02 | -1.406293e-01 | -3.595277e-01 | 5.089123e-01 | -9.240893e-02 | -2.848134e-01 | -2.704090e-01 | 1.020443e+00 | -3.384250e-01 | -9.304604e-02 | -4.612235e-01 | -1.502339e-03 |
| 9.281570e-02 | 3.274312e-01 | -1.690026e-01 | 9.500383e-02 | -4.052625e-02 | 2.095399e-01 | 5.788737e-02 | -1.538408e-01 | -8.142786e-02 | 1.025522e-01 | -1.968418e-01 | -1.512473e-01 |
| 1.537041e-02 | -1.279123e-02 | 1.843490e-02 | -5.231979e-01 | 3.668653e-01 | -2.599524e-01 | 2.008303e-01 | -1.276911e-01 | 2.195743e-01 | -1.327781e-01 | 1.467298e-01 | -1.794559e-02 |
| 2.136119e-01 | -5.357870e-01 | 5.227472e-02 | -4.600507e-01 | 3.239617e-01 | -5.296540e-02 | -9.913477e-02 | -5.315251e-02 | 4.279814e-01 | -8.946622e-02 | -1.250669e-01 | 2.633129e-03 |
| -4.015198e-01 | -2.280402e-02 | -4.237192e-01 | 6.499697e-02 | -1.466075e-02 | 3.905968e-01 | -2.433057e-02 | 1.770662e-01 | -8.328298e-02 | -2.521038e-01 | 1.674003e-01 | -2.183373e-01 |
| 7.161310e-02 | 3.350707e-01 | 7.563150e-02 | 6.961046e-02 | -5.072309e-01 | 9.271584e-02 | -3.068888e-01 | 1.686185e-01 | -9.923921e-02 | 3.691823e-02 | -6.487819e-02 | 1.725377e-01 |
| -4.263994e-02 | 1.106177e-01 | -1.866426e-01 | -2.320666e-01 | 4.661778e-01 | -3.460136e-01 | 1.487696e-01 | 1.329359e-01 | -6.634668e-01 | 4.017258e-01 | -6.626162e-01 | 6.550444e-02 |
| 5.948720e-01 | 1.751780e-01 | -2.851372e-02 | -5.911214e-02 | -1.863312e-01 | 5.775966e-02 | -2.405526e-02 | 8.348931e-02 | -5.857494e-02 | -1.489794e-02 | -8.177456e-03 | -3.390396e-01 |
| -8.407032e-02 | -1.484541e-01 | -7.093062e-02 | 3.361030e-01 | 2.669977e-01 | -7.066280e-02 | -2.964572e-01 | -5.825283e-02 | 9.502517e-02 | 5.746680e-02 | -4.981671e-02 | -3.175727e-01 |
| -1.876039e-01 | -4.855688e-01 | 5.323206e-01 | 8.439375e-02 | -2.220559e-01 | 1.890804e-01 | -5.699826e-01 | 5.064149e-02 | -1.735069e-01 | -2.765486e-01 | -1.478450e-01 | 5.660381e-01 |

**7. GELU Activation Function**

\*In this case, h3 has shape of (n \* 48)



**8. Calculate Second MLP Layer**

**Second MLP Layer Weight (, MLP\_Dim = 48)**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |
| -1.001900e-01 | 9.573150e-02 | 2.001865e-02 | 6.398644e-03 | -8.704739e-02 | 2.520619e-02 | -1.528755e-01 | -2.103156e-02 | 3.518328e-01 | -1.609405e-01 | 1.573184e-01 | -3.092529e-02 |
| 5.811081e-02 | -3.154481e-01 | 2.176723e-01 | -1.807786e-02 | -3.070042e-01 | 2.003009e-02 | 9.386827e-02 | -3.244537e-02 | -7.173909e-02 | 2.553182e-01 | 2.479120e-02 | -4.966386e-02 |
| -7.700775e-02 | 1.322476e-02 | -8.820883e-02 | -1.731340e-01 | 1.456881e-01 | -2.150075e-01 | -6.493449e-02 | 1.324209e-01 | -1.644444e-01 | 2.060802e-01 | -1.799051e-01 | 1.221655e-01 |
| 3.507537e-02 | 1.443712e-01 | 1.947217e-01 | 6.155910e-02 | -4.719202e-02 | 2.046581e-01 | -1.323490e-01 | -4.052258e-02 | -1.261590e-01 | 3.176828e-01 | -1.009093e-01 | -7.204355e-02 |
| 2.693501e-01 | 1.607902e-01 | -2.557203e-01 | -3.890818e-01 | 8.068238e-02 | -1.118062e-02 | 1.261644e-01 | 8.399332e-03 | 4.964903e-02 | -3.363835e-01 | 1.857069e-01 | 6.788755e-02 |
| 9.192804e-03 | -3.820490e-03 | -3.650165e-01 | 3.156689e-01 | -5.009492e-01 | -2.981642e-01 | -1.899505e-01 | 8.675805e-02 | 7.522355e-02 | -1.391195e-01 | -1.271736e-01 | -3.044436e-02 |
| -3.518137e-01 | 5.976449e-02 | 1.330373e-01 | 1.300550e-01 | -3.482774e-01 | 2.478135e-01 | -6.601378e-03 | 4.455683e-03 | -3.429554e-01 | 2.184441e-01 | 6.700184e-02 | -6.095569e-02 |
| -3.143157e-01 | 3.566917e-01 | 3.208302e-01 | 3.848317e-01 | 1.140289e-01 | -3.022105e-01 | -1.308777e-01 | 2.523021e-01 | 3.879063e-01 | 1.120343e-01 | -8.206747e-02 | 1.482885e-01 |
| 8.239231e-03 | 5.066751e-02 | 5.294375e-01 | 1.868631e-01 | 4.494779e-02 | -4.360750e-01 | 2.678881e-01 | 1.966770e-01 | -1.480970e-01 | -1.198953e-01 | 4.703106e-01 | 4.130470e-01 |
| -3.191724e-01 | 1.675158e-01 | 1.011895e-01 | 1.471350e-01 | 1.197284e-01 | 4.456691e-01 | 7.686862e-03 | -2.047042e-01 | 1.957769e-01 | -3.364050e-01 | 1.515757e-01 | 8.326938e-03 |
| 1.090133e-01 | -3.347990e-01 | 1.113266e-01 | 8.270128e-02 | 4.755110e-01 | 1.463695e-01 | -2.379817e-01 | -1.275725e-01 | 1.328388e-01 | -1.252293e-01 | 3.104192e-02 | 1.278344e-01 |
| 8.968584e-02 | -4.270653e-02 | -2.694970e-01 | -2.965172e-01 | 5.562755e-02 | 1.052662e-01 | -3.794592e-01 | 8.330018e-02 | 8.849520e-02 | 5.733828e-02 | 1.233126e-02 | -9.215771e-02 |
| -4.001059e-01 | 2.682266e-01 | 1.509463e-02 | 3.049763e-01 | -2.079641e-01 | 1.321010e-02 | -1.985912e-01 | 1.043925e-01 | 8.290872e-02 | 1.769142e-01 | -3.447292e-01 | -1.577196e-02 |
| 5.350352e-03 | 2.357320e-02 | 7.498701e-04 | -6.306037e-02 | 4.796336e-02 | 1.456480e-01 | -1.002524e-01 | 2.470768e-02 | -1.224672e-01 | -1.536756e-01 | 2.266693e-01 | -6.683125e-02 |
| 7.979627e-02 | -3.687399e-01 | 1.218348e-01 | 1.317093e-01 | 1.356520e-01 | 4.714464e-01 | 2.928097e-01 | -6.092766e-01 | -9.149545e-02 | -1.920645e-01 | -3.453627e-02 | -1.922166e-02 |
| 7.777356e-02 | -3.137318e-01 | 7.097069e-03 | 1.104052e-02 | -3.582885e-01 | -2.556901e-01 | -2.162398e-01 | -9.973919e-02 | 2.794691e-02 | -7.336335e-02 | 2.440193e-01 | 2.797066e-01 |
| 2.054067e-01 | -3.578380e-01 | 1.468620e-01 | 2.349646e-01 | -4.574813e-03 | 1.272237e-01 | -4.359640e-01 | 2.208755e-02 | 1.041093e-01 | 4.388558e-01 | 1.762932e-01 | -3.494963e-02 |
| -1.877902e-01 | 2.448003e-03 | -1.250853e-01 | 9.206844e-02 | 2.039811e-01 | 1.572626e-01 | -2.380684e-01 | -2.087109e-01 | -1.058760e-02 | 6.465733e-02 | 1.960868e-01 | 1.893379e-01 |
| 2.153639e-01 | 1.198723e-01 | -2.931992e-01 | 7.516059e-03 | -5.660396e-02 | 8.849885e-02 | 4.406412e-01 | -7.496878e-02 | 6.880966e-02 | 1.148522e-01 | -2.493734e-01 | -1.821197e-01 |
| 1.711047e-01 | 1.251518e-01 | 9.612910e-02 | 8.294780e-02 | 2.627338e-01 | 4.356048e-01 | 1.654836e-01 | -2.955881e-01 | 2.402067e-01 | -1.110195e-01 | 3.553458e-01 | -5.977723e-02 |
| -4.955898e-02 | -1.391876e-01 | -5.899129e-02 | -2.247971e-01 | -1.281264e-01 | -1.299542e-01 | -1.033085e-01 | 4.979230e-02 | 2.480288e-01 | -2.369355e-01 | -2.260818e-01 | 2.136836e-01 |
| 6.602324e-02 | -2.704353e-02 | 5.850916e-02 | 2.423859e-01 | 6.522271e-02 | -3.784789e-02 | -1.563601e-01 | 1.880956e-01 | -2.254918e-01 | 6.627198e-02 | 1.046849e-02 | 1.367362e-01 |
| 1.783085e-01 | 1.289343e-01 | 1.447652e-01 | 2.347179e-01 | -7.937696e-02 | 2.362113e-01 | 2.918994e-01 | 2.873047e-01 | 1.696763e-01 | -5.324769e-02 | 2.631712e-01 | -3.681649e-02 |
| 3.348752e-02 | -2.968041e-01 | -5.946373e-02 | 1.282106e-01 | -3.345774e-01 | -7.380527e-02 | -5.444933e-02 | -1.680044e-01 | -1.238607e-01 | 3.294440e-02 | -6.145305e-02 | -9.587910e-02 |
| 2.723045e-01 | -1.698807e-03 | 1.345286e-01 | -1.216680e-01 | -4.811804e-02 | 2.328965e-01 | 3.271082e-01 | 1.338285e-01 | -1.213321e-01 | 6.475700e-02 | 1.214756e-01 | -7.199297e-02 |
| 6.412013e-02 | -1.778480e-02 | 1.389401e-01 | -1.369909e-01 | -1.540729e-01 | -8.390867e-02 | -3.282119e-01 | 2.097541e-02 | 1.847607e-01 | 2.075156e-01 | -1.590512e-01 | -1.468552e-01 |
| -6.408008e-02 | 4.807422e-02 | 7.551344e-02 | -3.035340e-01 | 9.506208e-02 | 1.737473e-01 | 3.918855e-01 | 2.351356e-01 | 3.598003e-01 | -2.323225e-01 | 6.630446e-02 | 5.637794e-02 |
| -8.071034e-02 | 1.261248e-01 | 3.169872e-01 | -1.195279e-02 | 1.921837e-01 | 1.183652e-01 | 1.304888e-01 | -3.456403e-01 | 2.301244e-02 | -5.833953e-02 | -1.268284e-01 | 3.226210e-02 |
| 1.375034e-01 | 3.551999e-02 | -2.721040e-01 | -1.341755e-01 | -5.097118e-03 | 8.346883e-02 | 1.419445e-02 | -3.659086e-02 | 1.260853e-01 | -1.974557e-02 | -4.310500e-02 | 1.042166e-01 |
| -7.941066e-02 | -1.059815e-02 | 4.786863e-02 | -1.000667e-02 | -1.173575e-01 | -1.634201e-01 | 6.346902e-02 | 1.042948e-01 | -2.112149e-01 | -1.933932e-01 | 5.081375e-02 | 1.003526e-01 |
| -2.187940e-01 | 1.055615e-01 | -1.031295e-01 | 1.159079e-01 | 4.517388e-02 | 4.060474e-01 | -5.807969e-02 | -1.014466e-01 | 6.633941e-03 | 5.533603e-03 | 1.170136e-01 | 4.457420e-01 |
| -2.910607e-04 | 7.862720e-02 | -4.157287e-01 | -1.086658e-01 | -8.655859e-03 | 1.178228e-02 | 8.993856e-03 | -2.669697e-02 | 1.355190e-01 | -8.933140e-02 | -1.431681e-01 | 2.209063e-01 |
| 2.798193e-01 | 3.591115e-01 | -1.253376e-01 | -1.592516e-01 | -3.653444e-02 | -6.164820e-02 | -1.526254e-02 | 8.858134e-02 | 2.497247e-01 | -1.609668e-01 | -8.896314e-02 | 1.378489e-01 |
| -2.156219e-01 | 1.541410e-01 | 3.422294e-02 | -6.181699e-02 | 6.497209e-02 | -1.401898e-01 | 2.629982e-01 | -1.085840e-01 | -1.971260e-01 | 2.913640e-01 | -2.602851e-02 | 2.086662e-01 |
| -1.613535e-01 | 4.545048e-01 | -2.558958e-01 | 3.187943e-01 | -1.373879e-01 | -3.041355e-01 | -4.773759e-01 | 1.412365e-01 | -1.687407e-01 | -2.227959e-01 | 9.227125e-02 | 3.178653e-02 |
| -4.859428e-02 | -1.516803e-01 | -4.482586e-01 | -2.064303e-01 | 2.966486e-01 | 4.886375e-01 | -3.338425e-03 | -6.461766e-02 | 2.179467e-01 | -1.023794e-03 | -6.478142e-02 | -4.278761e-01 |
| -1.145445e-01 | -2.371357e-01 | -5.563863e-02 | -4.570931e-03 | 3.189014e-01 | -7.423902e-03 | -2.210494e-02 | -1.299923e-01 | 7.294966e-02 | 7.990742e-02 | -3.268691e-02 | 2.388134e-01 |
| -2.265776e-01 | 1.960553e-02 | -1.335674e-01 | -1.527418e-02 | 1.887652e-01 | -2.826084e-02 | -1.004604e-01 | 1.079457e-01 | -8.472058e-02 | 2.128719e-01 | 8.255862e-02 | -3.610107e-03 |
| -1.358309e-01 | -6.230179e-01 | 2.577787e-01 | -6.111281e-02 | -4.155640e-02 | -6.128101e-02 | 1.211711e-01 | -1.903097e-01 | -3.233748e-02 | -3.462576e-01 | 1.813898e-02 | 1.357240e-01 |
| 7.971001e-02 | -5.986970e-02 | 2.423960e-02 | 1.000202e-02 | -1.670472e-01 | -2.272098e-02 | -2.180628e-01 | -7.817398e-02 | 4.108184e-01 | -1.452578e-01 | 8.142355e-02 | -3.274282e-01 |
| -1.643790e-01 | -2.034982e-01 | -6.432073e-02 | 6.878307e-02 | 5.809408e-02 | -1.000704e-02 | 5.821665e-02 | -2.794458e-01 | -2.077595e-01 | 6.782206e-02 | -3.231739e-01 | -3.274964e-01 |
| 1.025315e-01 | 5.020021e-01 | -4.212791e-01 | -1.022338e-01 | -9.397118e-02 | -9.650169e-02 | 2.447532e-01 | -2.632615e-01 | 1.829671e-01 | 6.788112e-02 | -2.962983e-01 | -1.191733e-01 |
| 1.094645e-01 | 4.086205e-01 | 3.185429e-01 | -1.625232e-01 | -3.198189e-01 | 2.080289e-02 | 4.083220e-01 | 1.353575e-01 | -1.724747e-01 | 2.523609e-02 | -2.655759e-01 | 1.343497e-01 |
| -7.814331e-01 | 9.595106e-03 | -2.370389e-02 | -4.886037e-02 | 3.052009e-01 | -2.683413e-03 | 1.445575e-01 | 1.323780e-01 | -2.629035e-01 | 1.321469e-01 | 1.532616e-01 | 2.425803e-01 |
| -4.965171e-02 | 2.199712e-01 | -9.144165e-02 | 9.644609e-02 | -3.930572e-02 | 2.423394e-02 | -5.094026e-02 | -4.232626e-02 | -2.944301e-01 | 1.267468e-01 | 1.466083e-01 | -7.123435e-02 |
| 2.468563e-02 | -9.511229e-02 | -1.954282e-01 | 8.070748e-02 | 2.123200e-01 | 1.699228e-02 | 2.643239e-01 | 1.079883e-01 | 2.629357e-01 | -4.166730e-02 | 5.420226e-04 | -1.780213e-01 |
| 1.174035e-01 | 9.191134e-02 | 1.002374e-01 | 1.183300e-01 | -1.958878e-01 | 5.834109e-02 | -2.718769e-01 | 2.155416e-01 | 9.880982e-02 | -5.945246e-02 | -4.263182e-02 | -2.016584e-01 |
| -7.378770e-02 | -8.672845e-02 | 2.633601e-01 | -2.304027e-02 | -2.121707e-03 | -1.129749e-01 | 4.068375e-02 | 2.449576e-01 | -2.706168e-01 | -8.684234e-02 | -2.215243e-01 | 1.268921e-01 |

**Second MLP Layer Weight (MLP\_Dim = 48)**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |
| -6.939995e-02 | 5.329966e-02 | -1.058112e-01 | 3.569480e-02 | -4.951483e-02 | -3.812562e-02 | 7.017172e-04 | 9.182575e-02 | -6.459156e-02 | -6.986209e-03 | -2.252200e-02 | -5.476198e-02 |

**9. Residual Connection**

**input\_x3 = input\_x2 + h4**(in this case, input\_x2 is value before LayerNorm2)

**Layer 4**

From now on, this is the repeat of layer 3.   
However, the input is the result of Layer 3, which is **input\_x3**

**1. Calculate LayerNorm 1**

**, ,**

**\*** In this case, h1 has shape of (n \* 12)

**Masked MSA block Weight**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |
| 1.458215e+00 | 1.463444e+00 | 1.429149e+00 | 1.423266e+00 | 1.250993e+00 | 1.301825e+00 | 1.567622e+00 | 1.415227e+00 | 1.372509e+00 | 1.447445e+00 | 1.250621e+00 | 1.407622e+00 |

**Masked MSA block Bias**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |
| -1.358639e-01 | 3.165627e-02 | -8.581208e-02 | 1.724824e-02 | 8.328643e-02 | -3.852352e-01 | 9.926006e-02 | -3.757887e-02 | -2.403430e-01 | -5.805424e-02 | -2.048842e-01 | -1.027538e-01 |

**2. Calculate Q,K,V, Multihead attention**

**, ,** \*Perform a single 12×12 multiplication. (You can also compute by splitting into n\*12)

**Masked MSA Multihead Attention block *in* Q, K, V weight**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Query Weight** | | | | | | | | | | | |
| -3.336618e-02 | 7.307779e-02 | 2.094480e-01 | 8.678719e-03 | 1.863624e-02 | 5.136984e-01 | 4.020051e-02 | -5.008458e-01 | 1.056736e-01 | 1.913576e-01 | -8.593281e-03 | -5.377133e-01 |
| -7.102013e-02 | 4.301113e-02 | 6.215170e-02 | 2.096236e-01 | -3.152834e-01 | -1.854148e-01 | 2.555281e-01 | -3.369022e-01 | 4.560254e-01 | -3.800937e-01 | 3.213911e-01 | 3.497430e-01 |
| -1.269987e-01 | -9.052202e-02 | -1.689202e-02 | 7.380855e-02 | 4.345514e-01 | 9.885891e-02 | -1.842172e-01 | -3.815867e-01 | 4.000248e-01 | -3.411806e-02 | -6.790594e-01 | 1.099839e-01 |
| 3.608789e-01 | 2.047893e-01 | -1.524902e-01 | 2.030057e-01 | 6.341521e-02 | -4.579226e-02 | 5.358309e-01 | 3.403797e-02 | -8.239495e-02 | 1.066639e-01 | -4.414828e-01 | -5.111243e-01 |
| -3.136679e-01 | -6.621510e-01 | 2.329299e-01 | 2.513819e-02 | 2.878784e-01 | 8.561339e-02 | 3.078186e-01 | -8.321543e-01 | 3.517295e-01 | -1.125937e-01 | 1.858356e-01 | -9.192015e-02 |
| -1.816483e-01 | 9.918951e-02 | 8.480468e-02 | -4.288044e-01 | 3.327962e-01 | -1.156491e-01 | -5.019833e-01 | 9.287889e-02 | -2.488813e-02 | 2.815211e-01 | 4.092258e-01 | -3.817542e-01 |
| 1.904690e-02 | 9.548030e-01 | 6.839263e-02 | 1.186619e-01 | -5.936542e-01 | 2.718283e-01 | 2.647716e-01 | -7.803497e-01 | 2.093587e-01 | -2.972719e-02 | 2.380706e-01 | -6.150394e-01 |
| -7.623821e-02 | 2.301846e-01 | 2.991142e-02 | 3.352084e-01 | 1.356331e-01 | -8.335054e-01 | -2.391972e-01 | 5.806390e-02 | 6.583215e-01 | -2.895051e-01 | 2.583158e-01 | 1.074182e-01 |
| -1.696328e-01 | 1.807261e-01 | 1.033601e-01 | -1.381451e-01 | 7.753477e-02 | 4.631180e-01 | -1.782909e-01 | 1.195162e-01 | 1.256622e-01 | -2.546404e-01 | -2.798711e-01 | 1.953496e-02 |
| 1.541669e-01 | 3.539825e-01 | -1.593948e-01 | 4.980575e-02 | -1.590764e-01 | -2.326527e-01 | 2.667371e-01 | -6.219754e-02 | -5.292523e-02 | -3.088117e-01 | 1.080559e-01 | 2.799854e-01 |
| -7.273728e-02 | -3.328065e-02 | 2.331092e-01 | -2.497078e-01 | -2.849884e-01 | 3.918473e-01 | 3.261112e-01 | 5.406744e-02 | -2.820749e-01 | 7.698984e-02 | -5.050879e-02 | 5.921182e-02 |
| -5.036518e-03 | 8.702681e-02 | -1.139705e-01 | -1.186216e-01 | -2.811531e-01 | -9.222057e-02 | -6.385113e-02 | -7.930146e-02 | 6.765837e-02 | -1.146246e-01 | -1.183018e-01 | 3.569764e-01 |
| **Key Weight** | | | | | | | | | | | |
| -2.336561e-01 | -5.429694e-02 | 5.746371e-01 | -2.984619e-01 | -2.569328e-01 | 1.908454e-01 | 1.474066e-01 | -7.736810e-01 | 5.530822e-01 | -5.912734e-02 | 2.724263e-01 | -4.574540e-02 |
| 2.202852e-01 | -1.054905e-01 | -2.847105e-01 | 4.238989e-01 | -3.619812e-01 | -2.033854e-01 | 8.874188e-02 | 9.502814e-02 | 4.989996e-01 | -4.036045e-01 | -2.118256e-01 | 8.674614e-02 |
| -1.135122e-01 | 2.927800e-01 | 1.263660e-02 | -2.903121e-01 | -3.826191e-02 | -1.960930e-01 | 6.820650e-01 | -1.200792e-01 | -1.172365e-01 | -2.720714e-01 | -3.760321e-02 | 6.424744e-02 |
| -1.538543e-01 | -4.357303e-01 | 5.498429e-01 | 8.976770e-02 | 3.539187e-01 | -6.031747e-01 | 3.212569e-02 | -1.608170e-01 | -1.307287e-01 | -5.840592e-03 | -3.843780e-02 | 1.852389e-01 |
| -1.105515e-01 | -1.569398e-01 | -2.407776e-01 | -4.564327e-01 | -4.391087e-01 | 6.091647e-02 | 3.027206e-01 | -3.043164e-01 | 7.337332e-01 | -1.682532e-01 | 8.070192e-01 | 4.718095e-01 |
| -4.288348e-01 | 8.051032e-01 | 1.696213e-03 | -2.376302e-01 | -3.638903e-01 | 5.568781e-01 | -5.136786e-01 | -1.425109e-01 | -2.228325e-01 | 3.186181e-01 | 5.035289e-01 | -1.842418e-01 |
| -3.359190e-01 | 6.645427e-02 | 7.051926e-01 | 1.578869e-02 | -1.021648e-02 | -1.131633e-01 | 1.560864e-01 | -7.436604e-01 | 4.390702e-01 | -2.459109e-01 | -1.184068e-01 | -2.575208e-01 |
| -2.511050e-01 | 5.270276e-01 | -2.384357e-01 | 7.904853e-01 | -5.175995e-01 | -3.292604e-01 | -1.498706e-01 | 3.042511e-01 | 1.151336e-01 | -5.981798e-01 | -3.195230e-01 | 3.123964e-01 |
| -3.225083e-01 | 3.263148e-01 | 2.149561e-01 | -2.216646e-01 | 1.060791e-01 | 2.159901e-01 | -3.749361e-01 | 1.248750e-01 | 8.830497e-03 | -3.800415e-02 | 7.735326e-02 | 5.947044e-02 |
| 2.122089e-01 | 1.876835e-01 | -7.742295e-02 | 3.310193e-02 | 1.164716e-02 | -4.255324e-01 | 4.644585e-02 | 1.737862e-01 | -2.585222e-01 | -3.197967e-01 | -9.723674e-03 | 3.623211e-01 |
| -2.423319e-01 | 3.020115e-01 | 4.714529e-03 | -3.172952e-01 | -3.249044e-01 | 3.866093e-01 | 3.516473e-01 | 1.803217e-01 | -2.858295e-01 | 7.687337e-02 | -3.138705e-02 | 4.333322e-02 |
| -1.158093e-01 | 5.386351e-02 | -8.484332e-02 | 3.073884e-01 | -4.390672e-01 | -9.010261e-02 | 1.893743e-02 | 2.210675e-02 | 3.160686e-01 | -2.639491e-01 | -1.261150e-01 | 3.387169e-01 |
| **Value Weight** | | | | | | | | | | | |
| 2.131144e-01 | 4.009618e-01 | -3.330750e-01 | -4.408938e-01 | -1.542794e-01 | -2.116815e-02 | 5.285879e-01 | 1.188969e-01 | 3.815712e-01 | -1.509777e-01 | -2.409870e-01 | -4.975489e-01 |
| -8.017860e-02 | 1.609334e-01 | 4.325060e-01 | -2.830649e-01 | 1.214339e-01 | 2.325587e-02 | 6.984507e-01 | -3.846758e-01 | -5.010485e-01 | -3.030936e-01 | -8.752122e-02 | 2.296325e-01 |
| 8.535711e-01 | -1.160691e-01 | -3.676654e-01 | -4.542070e-01 | 1.111983e-01 | 1.928880e-01 | -1.931883e-03 | 9.890162e-02 | 3.650254e-01 | -3.247297e-01 | 2.195705e-01 | -1.441019e-01 |
| 2.395733e-01 | -2.382023e-01 | -2.722802e-01 | 3.708222e-01 | -1.199183e-01 | 2.707932e-01 | -4.788445e-01 | 2.497749e-01 | -3.017395e-01 | 6.829732e-02 | -1.603439e-01 | 1.049396e-01 |
| -2.766185e-01 | 3.452824e-01 | -1.572511e-01 | 1.454568e-01 | 1.524996e-01 | -2.972140e-01 | -2.496350e-01 | 4.505471e-01 | 7.912761e-02 | -5.489102e-01 | -3.033153e-02 | -4.649679e-01 |
| -4.184409e-01 | 5.090054e-01 | 1.558273e-01 | 5.864885e-01 | -2.219466e-01 | -1.037718e-01 | -3.247909e-01 | 2.329466e-02 | -6.233053e-01 | 1.913833e-01 | -9.652625e-02 | 1.587781e-01 |
| -3.961381e-01 | 2.277052e-01 | 7.490599e-01 | -6.794017e-01 | 3.432999e-01 | -3.876279e-01 | 4.394237e-01 | -5.816382e-01 | 2.756262e-01 | -5.143557e-01 | 2.838209e-01 | 6.155608e-01 |
| 1.063923e-01 | -1.619899e-01 | 3.022506e-01 | -3.085461e-01 | 6.360537e-01 | -2.081084e-01 | 2.776975e-01 | 6.000838e-02 | 6.327707e-02 | -8.053851e-02 | -4.428005e-01 | -4.138683e-01 |
| 5.243261e-01 | -2.499215e-01 | -6.112759e-02 | 2.369355e-01 | 3.613388e-01 | -1.061810e-01 | -8.130360e-02 | 6.401367e-02 | -1.641603e-01 | 1.045921e-01 | 1.749333e-02 | -2.519978e-01 |
| 6.125540e-01 | -5.780874e-02 | -4.462393e-02 | 4.252006e-01 | -3.096268e-01 | -1.260272e-01 | 2.595198e-01 | -3.355076e-01 | 6.035214e-01 | 6.567093e-02 | -2.004617e-02 | 1.956172e-01 |
| -2.921592e-01 | -1.801238e-01 | -8.832823e-02 | -1.172483e-01 | -2.864251e-02 | 4.068063e-01 | 7.224910e-01 | 3.480462e-02 | -3.282504e-03 | 5.600777e-01 | -1.765087e-01 | -2.218091e-01 |
| -3.923094e-01 | -2.880414e-01 | 1.041158e-01 | 2.761835e-01 | 4.131325e-02 | 6.014463e-02 | -1.515595e-01 | -3.434376e-01 | 5.676873e-01 | 9.619990e-02 | -1.530307e-01 | -1.772419e-01 |

**Masked MSA Multihead Attention block *in* Q, K, V bias**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Query Bias** | | | | | | | | | | | |
| 1.847811e-01 | 1.703554e-01 | -2.140412e-01 | -1.082390e-01 | 7.005569e-01 | 1.023555e-01 | 2.246431e-01 | -4.569552e-01 | -8.605098e-02 | -1.989951e-01 | -2.897147e-02 | 6.178432e-01 |
| **Key Bias** | | | | | | | | | | | |
| -3.081083e-02 | -5.456259e-02 | 1.295343e-02 | -2.183667e-02 | -1.291216e-01 | 7.636792e-02 | 1.206049e-01 | -3.734107e-02 | 7.430408e-03 | -2.060636e-02 | 7.015564e-02 | 6.708156e-02 |
| **Value Bias** | | | | | | | | | | | |
| 8.934123e-02 | 3.536984e-01 | 1.872270e-02 | 3.935791e-02 | -6.202467e-02 | 4.040784e-01 | -5.102294e-01 | 4.250880e-01 | 1.718299e-02 | -3.366733e-01 | 2.564412e-02 | 1.381274e-02 |

**⇒ Casual Mask(Upper triangle) ⇒ ⇒**

\*In this case, Multihead(Q,K,V) has shape of (n \* 12)

If you calculate with 3 divided heads, you need to concat each heads.

**3. Calculate attn\_out score**

**Masked MSA Multihead Attention block *out* weight()**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |
| -9.801374e-02 | -3.578707e-01 | 1.312597e-01 | -1.955681e-01 | 1.765530e-01 | -1.354076e-01 | -1.912541e-01 | 1.281650e-03 | 7.404264e-02 | 1.999018e-01 | 6.767318e-02 | -3.670009e-01 |
| -3.939244e-01 | 5.716508e-01 | -2.807944e-01 | -5.163181e-02 | 3.573954e-01 | 5.017658e-01 | 3.957895e-01 | 3.022109e-01 | -2.505264e-02 | 2.016470e-01 | -4.288531e-01 | -2.536830e-02 |
| 2.543949e-01 | 4.571468e-01 | -6.953181e-01 | -5.491031e-02 | -5.744328e-02 | 1.643471e-01 | -6.817882e-02 | 1.692621e-01 | -1.877144e-01 | 1.148598e-01 | 2.446896e-01 | 5.624747e-01 |
| -2.870822e-01 | -5.362307e-01 | -9.606065e-02 | 2.724842e-01 | 4.029868e-02 | 2.542123e-01 | -5.482429e-01 | -4.742019e-01 | 5.262833e-01 | 9.917699e-02 | 4.203142e-01 | 1.853572e-01 |
| 1.073997e-01 | 4.845926e-01 | 1.097417e-02 | -6.420212e-01 | -1.248184e-01 | -1.627429e-01 | 6.248393e-01 | -3.629765e-01 | 8.035030e-01 | -3.141823e-01 | -3.688802e-01 | 4.361274e-01 |
| 6.810845e-01 | 1.286806e-01 | 2.595489e-01 | -4.077342e-01 | 2.143350e-01 | -4.890030e-01 | -2.106132e-01 | 4.550616e-01 | -8.823615e-01 | 1.478893e-01 | -1.747465e-01 | 2.883518e-01 |
| -6.159213e-01 | 2.261946e-01 | -3.252428e-01 | -1.675852e-01 | -4.024347e-01 | -6.004952e-02 | -2.438198e-01 | 1.234189e-01 | -4.535520e-01 | -1.444479e-01 | 7.619237e-01 | -3.446315e-01 |
| 1.941817e-01 | -1.905416e-01 | 5.618314e-01 | 2.144715e-01 | -1.571761e-01 | -2.387096e-01 | 2.386239e-01 | 3.156302e-02 | 1.637698e-03 | -2.785412e-01 | -5.373078e-01 | -4.585020e-01 |
| -2.648098e-01 | -2.294587e-01 | -7.542020e-01 | 1.979015e-01 | 2.674588e-01 | 8.147826e-01 | -9.503420e-01 | -2.349603e-01 | 1.789421e-01 | 1.007601e-01 | 5.881946e-01 | 9.455259e-01 |
| 6.289387e-01 | -1.498046e-02 | 3.470444e-01 | -4.981950e-01 | 2.761702e-01 | -4.372341e-01 | 9.804690e-02 | 3.221408e-02 | -5.348438e-02 | 3.480203e-01 | -1.806201e-01 | 3.145395e-01 |
| 2.350551e-01 | -1.423095e-01 | 2.618307e-01 | 4.530314e-01 | 5.720775e-01 | -8.487263e-02 | 9.327213e-02 | -1.234895e-01 | 2.881182e-01 | 5.444154e-01 | -1.115423e-01 | -2.058974e-01 |
| -9.983974e-02 | 1.648085e-01 | 3.022950e-01 | 6.427335e-02 | -4.586047e-01 | -3.527155e-01 | 1.105006e-01 | -6.996971e-02 | -3.706842e-01 | -3.060291e-01 | -1.447432e-02 | -3.647243e-01 |

**Masked MSA Multihead Attention block *out* bias**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |
| 4.913821e-01 | -1.450489e-01 | -3.232883e-01 | -2.189465e-01 | -4.017782e-01 | 1.416263e-02 | -2.368885e-01 | 2.252333e-01 | 6.117298e-01 | -1.500485e-01 | 3.771459e-01 | 1.238598e-01 |

**4. Residual Connection**

**input\_x2 = attn\_out + input\_x**(in this case, input\_x is position embedded matrix)

**5. Calculate LayerNorm 2**

**, ,**

**\*** In this case, h1 has shape of (n \* 12)

**MLP block Layer Norm weight(**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |
| 1.622987e+00 | 1.219577e+00 | 1.401524e+00 | 1.269800e+00 | 1.337484e+00 | 1.330642e+00 | 1.471047e+00 | 1.581091e+00 | 1.235888e+00 | 1.450371e+00 | 1.307052e+00 | 1.654492e+00 |

**MLP block Layer Norm bias**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |
| 1.832695e-01 | 1.754968e-02 | -1.208258e-01 | 2.658323e-01 | -3.267767e-01 | -2.480022e-01 | -1.649831e-01 | -4.405640e-01 | 2.718236e-01 | -4.045325e-02 | 4.381487e-01 | 1.618518e-02 |

**6. Calculate First MLP Layer**

\*In this case, h3 has shape of (n \* 48)

**First MLP Layer Bias (MLP\_Dim = 48)**

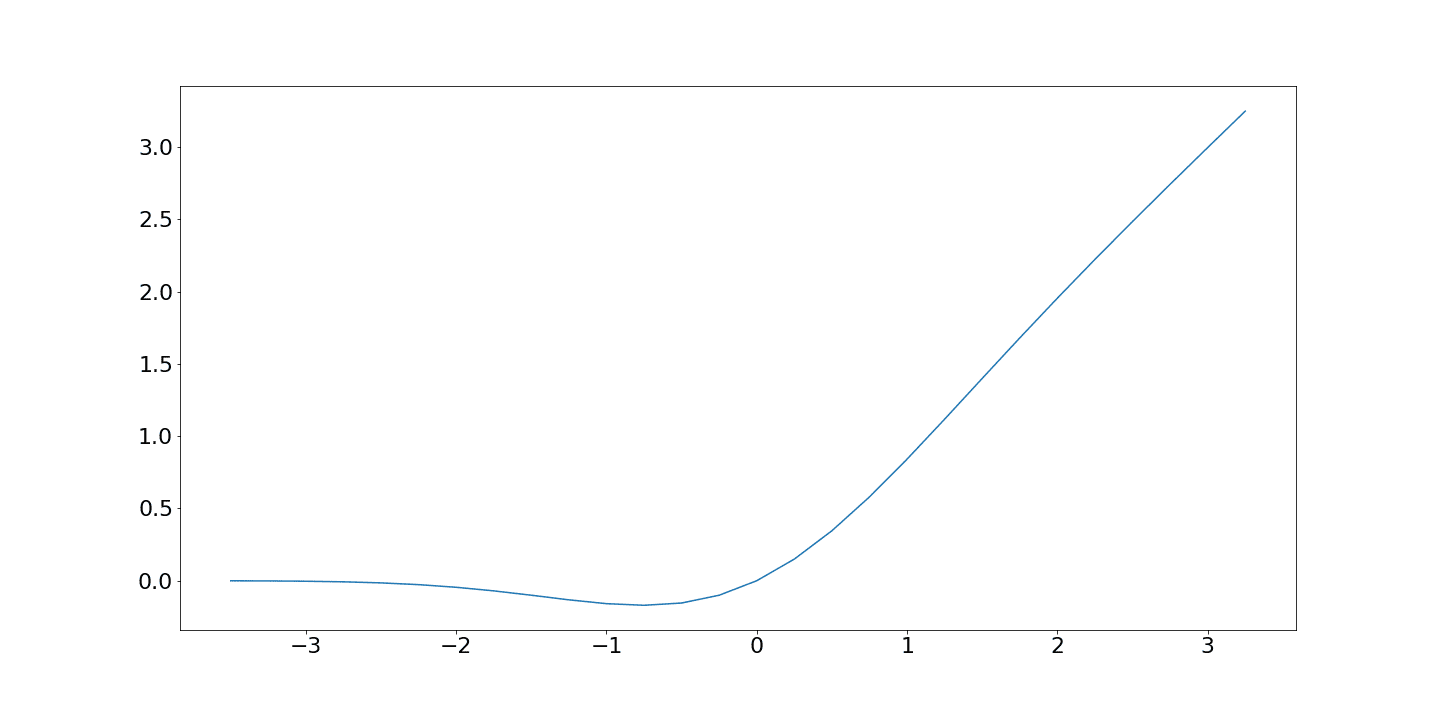
|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |
| -4.924934e-01 | -2.522521e-01 | 6.632397e-02 | 3.858205e-02 | -4.565489e-01 | 6.608301e-02 | 1.506560e-02 | 2.581410e-01 | -2.246986e-01 | -1.553286e-01 | 1.786142e-03 | -7.943134e-02 |
| -4.780445e-03 | -2.467909e-01 | -1.236851e-01 | -3.422969e-01 | -1.898925e-01 | 2.756123e-01 | 1.509177e-01 | 2.963639e-03 | -7.807726e-01 | -9.883624e-02 | -3.588946e-01 | -4.079152e-01 |
| 1.472205e-01 | -5.060826e-01 | -2.671350e-01 | -3.344570e-02 | -6.782183e-01 | 9.542701e-02 | -1.660492e-01 | -4.660834e-01 | -5.533690e-01 | -9.051205e-02 | -1.053229e-01 | -8.806627e-01 |
| -2.322753e-01 | -2.188329e-01 | 5.764171e-02 | -6.218042e-02 | 9.470392e-02 | -4.781679e-02 | 2.492606e-01 | -2.128662e-01 | 5.672255e-01 | -3.790032e-01 | -7.852150e-01 | -2.713441e-01 |

**First MLP Layer Weight (, MLP\_Dim = 48)**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |
| -2.637191e-01 | -2.813833e-02 | 2.291607e-01 | 5.446422e-01 | 2.260056e-01 | -1.307056e-01 | -2.669936e-01 | 5.383172e-01 | -7.664817e-01 | 5.327525e-02 | -9.387636e-02 | 1.819249e-01 |
| -1.657337e-03 | 1.782143e-01 | 1.541241e-01 | 3.795701e-01 | -7.270106e-02 | 2.759364e-01 | -8.827160e-02 | -3.285035e-01 | -4.654697e-02 | -2.961676e-01 | -1.313276e-01 | 2.425700e-01 |
| -4.490406e-01 | -8.366251e-02 | 1.096333e-01 | -1.438406e-01 | -2.206576e-01 | -1.806047e-01 | 1.167245e-01 | 3.035270e-01 | 4.835480e-02 | 7.032896e-01 | -2.403251e-02 | -2.175788e-01 |
| -2.999882e-01 | -2.464553e-01 | 2.608129e-01 | 3.821206e-01 | 3.958585e-01 | -1.748682e-02 | 1.442930e-01 | 1.620427e-01 | -3.640586e-01 | -6.822290e-02 | 6.190488e-02 | -6.248692e-01 |
| 2.858518e-01 | -1.249765e-01 | 4.440550e-01 | -1.309360e-01 | -3.417305e-01 | 1.600635e-01 | -4.272994e-01 | -1.008153e-02 | -2.840975e-02 | 1.132994e-01 | 2.715406e-01 | -4.199425e-02 |
| -5.298820e-01 | 3.554543e-02 | -2.635209e-01 | 1.129354e-01 | 1.883860e-01 | 5.010656e-01 | -2.978557e-02 | 1.119911e-01 | 2.220132e-01 | 3.524335e-02 | -3.034295e-01 | -3.920388e-01 |
| -5.824890e-01 | 1.681643e-01 | -8.147549e-02 | -2.181929e-01 | -7.210180e-02 | 8.091105e-03 | -9.951419e-02 | 5.348358e-01 | 2.070427e-01 | -5.352337e-02 | 1.805010e-01 | -3.874501e-02 |
| -4.222298e-01 | 2.453140e-01 | -1.335148e-02 | 4.702771e-01 | -3.038055e-01 | 1.989091e-01 | -8.813578e-02 | 1.574067e-02 | -2.584608e-01 | 1.677605e-01 | 6.902958e-02 | 2.191253e-01 |
| -5.090658e-01 | -1.690637e-01 | -2.583026e-01 | -4.252937e-02 | 2.555378e-01 | 2.534297e-01 | 1.848463e-01 | -8.163569e-02 | 1.820267e-01 | 1.223638e-01 | 9.264962e-02 | -4.259409e-01 |
| -4.709928e-01 | -5.773991e-01 | 4.371434e-01 | -2.756967e-01 | 3.366279e-02 | -5.248120e-02 | -1.181697e-01 | 6.200731e-03 | 1.963837e-01 | -1.924825e-01 | 4.996314e-01 | 5.367545e-02 |
| 9.369528e-02 | 1.338368e-02 | 1.024177e-01 | 4.281941e-01 | 7.940540e-02 | 4.808946e-01 | -3.035357e-01 | -3.611681e-01 | -3.814579e-01 | -1.384797e-01 | -4.304876e-02 | -3.855231e-02 |
| -1.724022e-01 | 1.645003e-01 | -1.295093e-01 | 6.318803e-02 | 3.756279e-01 | 3.741871e-01 | 3.736213e-01 | -4.400197e-01 | -2.539727e-01 | -7.948272e-02 | -2.425010e-01 | 1.661619e-01 |
| 9.886001e-02 | -2.188111e-01 | 5.925996e-01 | 1.536390e-01 | -2.847857e-01 | 3.620672e-01 | -2.738509e-01 | 1.983023e-01 | -1.516878e-01 | -1.991454e-01 | 1.485659e-01 | -1.231728e-01 |
| 3.080419e-01 | -7.417642e-01 | 2.333095e-01 | -1.338932e-01 | 4.505522e-01 | -4.569519e-01 | 2.648991e-01 | -1.790869e-01 | 1.913661e-01 | -2.907816e-01 | -5.546807e-02 | 1.677165e-01 |
| -3.982188e-02 | 1.213066e-02 | 1.040519e-02 | -2.111780e-02 | 3.160067e-01 | 6.025127e-01 | -5.431210e-01 | -1.273172e-01 | 1.775717e-01 | -2.990326e-01 | -3.790349e-01 | 8.228115e-02 |
| 1.902926e-01 | 3.799609e-01 | 2.418905e-02 | 5.124101e-01 | -3.738706e-01 | 4.441434e-01 | 3.417177e-01 | -1.983407e-01 | -5.058155e-01 | 6.194786e-02 | -4.956237e-01 | -9.457797e-02 |
| 3.873688e-02 | 2.756663e-01 | -5.948718e-02 | 1.368825e-01 | -1.823416e-02 | 4.521748e-01 | 2.291566e-01 | 1.698290e-01 | -3.404150e-02 | -3.941259e-01 | -1.055281e-01 | -7.436507e-01 |
| -9.423889e-02 | 6.755024e-03 | 2.972645e-02 | -4.815823e-02 | 1.969210e-01 | 2.553997e-01 | -5.480507e-02 | -1.408571e-01 | -2.194874e-01 | -3.742731e-01 | 3.396214e-01 | -4.994365e-01 |
| -5.109699e-01 | -2.987775e-01 | 2.171193e-01 | 1.336928e-01 | -1.337969e-01 | 3.648258e-01 | -9.504474e-02 | 2.812425e-01 | -1.323884e-01 | -1.838676e-01 | 2.946704e-01 | -2.255761e-01 |
| 1.272599e-01 | 1.034965e-01 | 1.092662e-01 | -9.330302e-02 | 8.355603e-03 | -2.998487e-01 | 2.907803e-01 | -7.244848e-02 | -1.116921e-01 | 7.540456e-01 | -1.190843e-01 | -4.456947e-01 |
| 2.032065e-01 | -1.454094e-01 | 1.020881e-01 | -2.585165e-01 | 1.138556e-01 | -1.123445e-01 | 3.129699e-01 | 4.176922e-01 | -1.272095e-01 | -2.389358e-01 | -3.523959e-01 | -1.900822e-01 |
| -4.057726e-02 | -3.262373e-01 | 8.455410e-02 | -8.171124e-02 | 4.759797e-02 | 5.673133e-01 | 3.880140e-01 | -1.586812e-01 | -4.953795e-02 | -1.071188e-01 | 2.658820e-01 | -2.840677e-01 |
| 2.592110e-01 | 1.126333e-01 | -3.124196e-02 | 3.106581e-01 | 6.349044e-01 | 2.820009e-01 | -7.632186e-02 | 2.795294e-01 | -9.609916e-02 | -4.266103e-01 | -6.208133e-01 | -5.566867e-01 |
| 1.714356e-01 | -3.586946e-02 | 5.783780e-01 | -2.409249e-01 | -2.872645e-01 | -2.569887e-02 | -3.604353e-01 | 3.088056e-01 | 2.004118e-01 | -3.191576e-02 | 9.245266e-02 | -7.193663e-03 |
| -2.358050e-01 | -1.274442e-01 | 6.667102e-01 | 6.546840e-02 | -2.990712e-01 | 5.054334e-01 | 2.189202e-02 | 4.408875e-01 | -1.355624e-01 | -3.410235e-01 | -1.496187e-01 | -1.463264e-01 |
| -3.513839e-01 | -1.955736e-02 | -8.038059e-02 | 2.329146e-01 | -1.628705e-01 | 3.129166e-01 | 5.099688e-01 | 6.018437e-01 | -4.757691e-01 | -2.381556e-01 | 2.241284e-01 | -5.438752e-01 |
| -5.823176e-01 | 2.202416e-01 | -2.629840e-01 | 1.466559e-01 | 6.403895e-01 | 1.209429e-01 | 2.647270e-01 | 2.371881e-01 | -2.086482e-01 | 8.136904e-02 | -3.085735e-01 | -2.714416e-01 |
| 4.684844e-01 | -4.062029e-01 | 5.060636e-01 | 7.617754e-01 | 1.563132e-01 | -9.855225e-02 | 2.026368e-02 | 1.702558e-01 | -6.126355e-01 | -1.461105e-02 | -7.035536e-01 | -4.312925e-02 |
| -2.394812e-01 | -2.300928e-01 | 4.493466e-01 | -3.106090e-01 | 6.628630e-01 | 9.743600e-02 | 2.646020e-01 | -1.651565e-01 | -5.341276e-01 | -2.023160e-01 | -1.274281e-01 | 2.364960e-01 |
| -9.770866e-02 | -1.062089e-01 | 1.683565e-01 | 2.463675e-01 | 1.974165e-01 | 6.811163e-01 | -3.629913e-01 | 2.431767e-01 | -1.612981e-02 | -6.457257e-01 | -6.335396e-02 | -2.695669e-01 |
| -4.706185e-01 | 1.248750e-01 | 5.560418e-02 | -4.274891e-01 | -3.297414e-03 | 1.587597e-01 | -4.014980e-01 | 1.917175e-01 | 3.120731e-01 | 9.915926e-02 | 1.621902e-02 | 2.369247e-01 |
| 4.719662e-01 | 1.384489e-01 | 2.563610e-01 | -1.462083e-01 | 1.168426e-01 | 2.486498e-02 | -3.969482e-01 | -2.427867e-01 | 6.300899e-02 | 3.521844e-01 | -3.036365e-01 | -8.419590e-02 |
| -1.998892e-01 | 1.315301e-01 | -2.216014e-01 | 3.406765e-01 | 2.111297e-01 | 2.504458e-01 | 7.576402e-01 | 1.460447e-01 | -2.709989e-01 | 1.532875e-01 | -3.665666e-01 | -7.900199e-01 |
| 2.986008e-01 | 7.632912e-02 | 5.651687e-01 | -2.835263e-01 | -1.317230e-01 | -7.915945e-02 | -3.226650e-01 | 2.293583e-01 | 2.089919e-01 | -3.185723e-02 | -2.947487e-01 | -2.380425e-01 |
| 1.640885e-01 | -1.237128e-01 | 8.782372e-02 | 4.503644e-01 | 8.148474e-02 | 1.162205e-01 | 1.686886e-01 | -3.277509e-01 | -3.638099e-01 | 3.182732e-01 | -9.377980e-03 | -5.023225e-01 |
| -2.924662e-02 | 4.162437e-01 | -6.928534e-02 | 2.375034e-01 | 1.386350e-01 | -1.134991e-01 | 5.335497e-01 | 3.260403e-01 | -3.169512e-01 | 7.412253e-02 | -2.637622e-01 | -5.349687e-01 |
| -4.372012e-02 | -5.760938e-01 | 3.306231e-01 | -3.599071e-01 | 2.811761e-01 | -2.457753e-02 | 1.558225e-01 | 4.545535e-01 | 1.428389e-01 | -2.117973e-01 | 2.401749e-01 | -3.478113e-01 |
| -3.426361e-01 | -3.664684e-01 | 9.586193e-02 | -1.467756e-01 | 2.198047e-01 | 2.221823e-02 | -5.337670e-01 | -5.934576e-03 | 6.112529e-02 | 4.221101e-01 | 3.237055e-01 | 7.674577e-02 |
| -1.038097e-01 | -5.839019e-02 | 1.058654e-01 | -1.046269e-01 | 1.364696e-02 | -1.516170e-01 | 2.753879e-01 | 4.666982e-01 | 2.259669e-02 | 1.941945e-01 | 7.294777e-02 | -6.190637e-01 |
| -2.695350e-01 | 2.201645e-01 | 2.764010e-01 | 1.901623e-01 | -1.255091e-01 | -5.163132e-04 | -3.032748e-01 | 5.437351e-03 | -1.506867e-02 | 7.039155e-01 | -4.296076e-01 | 4.488157e-02 |
| -3.430700e-01 | -1.336065e-01 | 4.537687e-01 | -4.197461e-02 | -2.224746e-01 | -3.202389e-01 | -3.237078e-02 | 3.038009e-01 | -1.284748e-01 | 4.371159e-01 | 4.645791e-01 | -2.276091e-01 |
| -1.518122e-01 | -1.137956e-01 | 2.409565e-01 | 1.894911e-01 | 7.853254e-03 | 1.877242e-01 | 4.610326e-03 | -4.606592e-01 | -1.110547e-01 | -7.074082e-02 | 2.478650e-01 | 2.882996e-01 |
| -1.129311e-01 | -6.277202e-03 | 5.895815e-01 | 1.239321e-01 | 4.592209e-01 | -2.705249e-01 | -4.582092e-01 | 2.040608e-01 | -9.857029e-02 | -1.783033e-02 | -5.039640e-02 | -1.461760e-01 |
| -5.295823e-02 | -3.212816e-01 | -9.102784e-02 | -3.743387e-01 | 6.302743e-02 | -2.049963e-01 | -1.307907e-01 | 8.366487e-02 | 2.193427e-01 | 5.863143e-02 | 3.524197e-01 | -1.772806e-01 |
| -3.389960e-01 | 2.636162e-01 | 4.123069e-01 | 2.528736e-02 | -7.555921e-02 | 5.322082e-02 | 1.607444e-01 | 4.668107e-01 | 2.833112e-03 | 5.246227e-02 | -2.619331e-01 | -5.940316e-01 |
| -3.017257e-01 | 3.163011e-02 | -4.739012e-01 | 2.921863e-01 | 3.513486e-01 | 3.352450e-01 | 4.685448e-01 | -1.774258e-01 | -9.191497e-02 | 2.160645e-01 | -2.266037e-02 | -4.131266e-01 |
| -1.802679e-01 | -6.344632e-02 | -3.019988e-01 | 1.627744e-01 | 1.783289e-01 | 2.152026e-01 | 3.392406e-01 | 5.855375e-01 | -3.132680e-01 | 9.581576e-02 | -3.352728e-01 | -8.034218e-02 |
| -5.947017e-01 | -1.238926e-01 | -1.222140e-01 | 4.734711e-01 | -3.298514e-01 | 1.902574e-01 | 1.653956e-01 | 2.833397e-01 | -2.471762e-01 | 4.996631e-01 | 6.295997e-02 | -3.082949e-01 |

**7. GELU Activation Function**

\*In this case, h3 has shape of (n \* 48)



**8. Calculate Second MLP Layer**

**Second MLP Layer Weight (, MLP\_Dim = 48)**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |
| 2.217273e-01 | 1.133027e-01 | -3.196297e-01 | -9.840307e-02 | 2.689188e-01 | -4.752865e-01 | -3.237737e-01 | -3.236059e-01 | -5.499043e-01 | -2.950560e-01 | 2.635692e-01 | -2.183958e-02 |
| -7.335449e-02 | 5.531641e-03 | 1.323749e-01 | 1.743747e-01 | 3.187521e-01 | 2.289189e-01 | -5.157757e-01 | 1.426261e-01 | -6.170610e-01 | 8.186173e-02 | 3.668916e-01 | 1.009434e-03 |
| -4.583896e-02 | 6.971537e-02 | -3.465885e-01 | -2.874904e-01 | 1.886761e-01 | -8.252855e-02 | -2.060653e-01 | 5.971790e-01 | 2.066537e-01 | 4.114162e-01 | 3.164836e-01 | 4.895755e-01 |
| -9.510979e-03 | -2.439681e-01 | 3.258361e-02 | 7.182454e-02 | -8.883783e-02 | 2.779018e-01 | 5.385316e-02 | 1.000407e-02 | -7.645392e-02 | -1.482136e-01 | -1.435529e-01 | -2.901480e-01 |
| -2.058171e-01 | -1.107119e-01 | 1.060309e-01 | -1.290972e-01 | -1.375879e-01 | 8.010866e-02 | 2.784211e-01 | 2.622758e-02 | -5.599802e-02 | -5.742429e-01 | -5.385607e-02 | -1.120007e-01 |
| -2.130898e-01 | 9.149173e-02 | 5.806584e-02 | 3.313804e-01 | -3.116261e-02 | -2.067506e-01 | -6.674829e-01 | 2.889967e-01 | -2.986722e-01 | -6.613690e-01 | -7.258736e-02 | 5.692824e-02 |
| -1.249496e-02 | -2.041704e-01 | 3.395835e-01 | -4.172975e-01 | -2.361400e-01 | -2.490772e-02 | 1.536386e-01 | 3.332504e-01 | 1.170874e-02 | 2.406465e-01 | -1.235314e-01 | 9.303728e-01 |
| -3.068185e-01 | -1.913250e-01 | 6.335375e-02 | 3.487525e-01 | -3.313475e-01 | -3.469917e-01 | 2.821724e-01 | -1.474714e-01 | 4.780640e-01 | -1.169282e-01 | -4.431629e-01 | -6.000200e-01 |
| 4.751111e-01 | 1.262084e-02 | -1.638248e-01 | -8.682099e-02 | 1.643180e-01 | -2.497904e-01 | -1.849357e-01 | -4.146455e-01 | -4.630007e-01 | 6.976036e-04 | -2.726556e-01 | 3.959203e-01 |
| 4.847667e-01 | 4.902806e-01 | -9.200784e-02 | -3.884129e-01 | -3.053054e-01 | -1.124456e-01 | -4.915102e-02 | -3.855508e-02 | -7.142316e-01 | -1.555290e-01 | 1.915907e-01 | 4.344622e-01 |
| 3.467337e-01 | -6.084457e-01 | 6.162719e-02 | 2.841789e-01 | 6.275973e-01 | 2.148530e-01 | -2.962044e-01 | -2.918035e-02 | -7.371193e-01 | 5.072587e-01 | -2.822929e-01 | -1.531991e-01 |
| -1.959795e-01 | -2.308958e-01 | 6.419477e-02 | -5.056978e-02 | 2.543988e-01 | -5.241727e-02 | 6.570294e-01 | 6.951016e-02 | 5.590041e-01 | -3.582273e-01 | -3.326224e-01 | -3.895148e-02 |
| 4.920350e-01 | 1.495582e-01 | -3.538401e-02 | 3.380933e-01 | -2.208799e-02 | -6.200792e-02 | -2.263491e-01 | 2.550602e-01 | 1.850568e-01 | -8.284675e-02 | 3.931175e-01 | -4.182865e-01 |
| -9.806275e-02 | -5.277232e-02 | -1.633180e-01 | 1.192621e-01 | 2.878210e-01 | 1.949759e-01 | -9.769053e-02 | -2.670781e-01 | -3.128213e-01 | -1.540638e-02 | 4.813694e-02 | -5.325030e-01 |
| -1.949494e-01 | 4.910172e-01 | -2.502958e-01 | 2.588474e-02 | -3.313701e-01 | -1.911667e-01 | -2.013744e-01 | -1.185488e-01 | -3.565041e-02 | -3.884450e-01 | -1.693748e-02 | -1.038315e-02 |
| 7.693582e-02 | 2.403778e-01 | 3.085659e-01 | 6.734315e-02 | 1.037761e-01 | -2.041006e-01 | 4.124604e-01 | 1.032827e-01 | -6.490542e-02 | -3.318205e-01 | 1.824989e-01 | 2.610047e-01 |
| 3.338648e-02 | -9.530368e-02 | -5.193932e-01 | 6.592563e-01 | -3.459219e-01 | 4.497138e-01 | -2.998323e-01 | -6.402257e-01 | 6.831321e-01 | 1.832608e-01 | 4.776954e-01 | 6.488616e-02 |
| -4.392649e-01 | 7.126846e-02 | 4.010280e-01 | 6.606444e-02 | 2.198492e-01 | 7.680587e-01 | -1.039260e-01 | -4.984837e-02 | 2.996561e-01 | 7.913937e-02 | 5.398920e-01 | -2.744916e-01 |
| -3.127235e-01 | -3.575595e-01 | 5.557080e-01 | 6.213169e-01 | -3.028163e-01 | 5.102366e-01 | -6.096515e-02 | 7.537160e-02 | 5.694547e-02 | -2.233950e-01 | 2.760396e-01 | 3.894331e-01 |
| -1.610394e-01 | 1.735031e-01 | -2.470737e-01 | -2.250801e-01 | -2.006407e-01 | 9.340706e-02 | 4.916839e-01 | 2.963395e-01 | -2.234115e-01 | 4.908628e-01 | -2.214612e-01 | -3.095674e-01 |
| -2.253840e-01 | 4.490652e-01 | -3.025989e-01 | -3.717393e-01 | -3.344783e-01 | 4.269840e-01 | 4.303567e-01 | 4.178675e-01 | -2.413049e-01 | 2.765776e-03 | 5.494927e-01 | -1.860339e-01 |
| -3.348572e-03 | 1.089360e-01 | 7.892962e-01 | 1.451188e-01 | 1.192601e-01 | -8.705124e-02 | 4.367687e-01 | -3.363511e-01 | -2.055520e-01 | 1.361530e-01 | -4.678160e-02 | -3.360002e-01 |
| 2.713710e-01 | 2.453146e-01 | -3.582925e-01 | 2.147152e-01 | -2.623170e-01 | 7.770702e-01 | 4.313174e-01 | -7.262094e-02 | -5.328558e-01 | -2.639149e-01 | -7.912279e-02 | -7.016425e-01 |
| 2.944233e-01 | -7.225907e-02 | -2.929634e-01 | -1.588192e-01 | -6.119867e-01 | 1.395556e-01 | -3.267784e-01 | -3.424564e-01 | 4.056102e-02 | -6.178980e-01 | -3.730871e-03 | -1.688756e-01 |
| 3.109978e-01 | -1.496342e-01 | 2.630197e-01 | 3.086983e-01 | -4.649634e-01 | 2.708937e-01 | 1.591076e-01 | 1.167192e-01 | 1.679279e-01 | -3.182894e-01 | -3.178480e-01 | 1.881531e-02 |
| -3.766223e-01 | -3.549276e-01 | -1.581030e-01 | 4.218027e-02 | 2.238953e-01 | 1.153349e-01 | 2.935668e-01 | 4.898262e-01 | 3.183748e-01 | 5.010725e-01 | -6.035564e-02 | -5.455701e-01 |
| 5.833293e-01 | 3.530753e-01 | -1.168370e-01 | -5.619134e-01 | 4.276567e-01 | -9.830670e-02 | -4.047313e-01 | -2.900383e-01 | 6.654019e-01 | -3.482323e-01 | 4.301098e-01 | 1.228099e+00 |
| 5.087927e-01 | -5.207971e-01 | 6.439629e-01 | -1.913060e-01 | 9.232467e-02 | -3.853960e-01 | -2.258007e-01 | -1.865552e-01 | 6.546202e-01 | 5.272927e-02 | 1.094432e-01 | 3.366978e-01 |
| 5.224709e-01 | -5.084698e-01 | -2.506593e-02 | -2.938778e-02 | -2.364403e-01 | 1.017893e-01 | 2.437439e-01 | -4.941366e-01 | -3.557674e-02 | 2.128037e-01 | -1.859568e-01 | 1.501292e-01 |
| 2.499823e-01 | -1.331396e-01 | -9.627739e-02 | 2.461664e-01 | 4.133919e-01 | 2.470512e-02 | 3.628211e-01 | -1.308820e-01 | -1.930609e-01 | 2.480360e-01 | -3.704071e-02 | 2.469324e-01 |
| 1.227169e-01 | 1.763445e-01 | 1.022095e-02 | 3.413510e-02 | -2.000347e-01 | 1.442529e-01 | 1.199005e-01 | -4.217359e-01 | 7.735363e-02 | 1.428954e-01 | -1.911688e-02 | -4.365029e-01 |
| 9.560791e-02 | -2.871523e-01 | 2.983463e-01 | -6.746199e-02 | 5.857652e-02 | -4.025386e-01 | 9.241872e-02 | -5.871117e-02 | 3.489687e-01 | -1.296031e-01 | 2.755407e-01 | 1.289121e-02 |
| -9.584627e-01 | -5.476910e-01 | 2.285792e-01 | -2.798307e-03 | 1.007107e-02 | 2.676085e-01 | 6.385922e-01 | -1.271969e-01 | 5.854232e-02 | 1.455035e-01 | -8.135046e-01 | -5.350905e-01 |
| -2.560254e-01 | 6.430269e-01 | 1.292345e-01 | -7.598704e-01 | 2.668960e-01 | -3.360850e-01 | 2.768500e-03 | -2.987543e-01 | 5.314191e-01 | -2.191015e-01 | 4.188395e-02 | -1.991084e-01 |
| -1.042221e-01 | 2.726752e-01 | -9.061091e-04 | 2.263791e-02 | -1.164683e-01 | -1.850937e-01 | 2.066910e-01 | 2.159652e-01 | 6.967700e-02 | 2.552165e-01 | -7.157313e-01 | 5.044759e-01 |
| -3.116859e-02 | 2.825525e-01 | 1.011413e-02 | 1.408441e-01 | 8.939561e-02 | -3.515796e-01 | 4.502942e-02 | 5.131189e-01 | 3.024620e-01 | -5.352160e-01 | 2.661342e-01 | -3.336607e-01 |
| 1.703150e-01 | 1.814244e-02 | 7.140961e-01 | -3.823968e-01 | -2.809014e-01 | 1.725343e-01 | 8.494524e-02 | 3.448499e-01 | 1.187244e-01 | 1.929398e-02 | 1.259548e-01 | 2.996040e-01 |
| -6.311427e-01 | -9.540294e-02 | -1.099152e-01 | 2.625802e-01 | -3.050751e-01 | -5.500780e-01 | -5.323665e-01 | 3.239766e-01 | -6.200181e-01 | -9.945664e-02 | -1.597655e-01 | -2.037054e-01 |
| -3.735641e-01 | -3.713366e-01 | -9.245238e-02 | 5.270341e-01 | 1.270510e-01 | -7.420775e-01 | 1.004694e-01 | 3.738729e-01 | -1.244722e-01 | -1.825366e-01 | 1.280052e-01 | -2.274937e-01 |
| -4.521537e-01 | 2.460561e-01 | -2.057325e-03 | 6.936060e-01 | 3.231373e-01 | 3.032118e-01 | -8.689903e-02 | 2.373290e-01 | -1.420249e-01 | 2.403039e-01 | -1.507350e-01 | 3.454075e-01 |
| -7.047696e-02 | -2.808912e-02 | -1.368086e-01 | -2.606003e-01 | 1.899178e-01 | -4.857893e-01 | 3.079709e-01 | 4.527581e-02 | -2.405786e-01 | 4.266238e-01 | 6.562909e-02 | -2.606337e-02 |
| 1.725129e-01 | 2.129316e-01 | -4.203041e-01 | -3.065416e-01 | -3.737423e-01 | 2.876209e-01 | 5.812224e-01 | 3.227012e-01 | 1.146504e-01 | -1.693030e-01 | -6.092895e-01 | -8.466532e-03 |
| -9.290665e-02 | 2.959101e-01 | -2.821760e-01 | -3.269067e-01 | 1.002636e-01 | -8.286114e-02 | -2.676941e-01 | -2.307458e-01 | -6.103382e-01 | -4.578504e-01 | 8.551680e-02 | -2.160883e-01 |
| 4.046700e-01 | 8.305890e-02 | 2.175631e-01 | -6.308727e-01 | 3.968441e-01 | 2.786479e-01 | -4.271181e-02 | 3.510938e-01 | -4.015974e-01 | -1.172716e-01 | -2.255165e-01 | -1.065637e-01 |
| 4.780970e-01 | -1.003428e-01 | -2.421147e-01 | -3.200853e-01 | 2.077872e-01 | -7.594048e-02 | 9.222544e-02 | 3.283994e-01 | 6.880514e-02 | 2.278119e-02 | -1.147205e-01 | 9.003656e-02 |
| 9.394629e-02 | -9.061906e-02 | 4.804462e-02 | -1.498169e-01 | -1.279312e-01 | -1.758227e-01 | -2.250707e-01 | -2.600563e-01 | 1.586354e-01 | 1.043324e-01 | -2.782239e-01 | 3.884619e-01 |
| -8.323374e-04 | -7.777071e-03 | 3.392064e-01 | -3.697823e-01 | -3.157530e-01 | -2.070774e-01 | 4.432471e-01 | -1.150389e-01 | 4.430614e-01 | 1.575907e-01 | -4.144217e-01 | 3.045566e-01 |
| -3.836867e-01 | 9.975248e-02 | -6.154922e-01 | -1.276620e-01 | -1.331947e-01 | 3.644754e-01 | -5.131371e-02 | -5.409805e-02 | -3.053703e-01 | 5.902761e-01 | 7.203277e-01 | 1.351596e-03 |

**Second MLP Layer Weight (MLP\_Dim = 48)**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |
| 3.647600e-02 | 2.320009e-02 | -8.298698e-03 | 3.798847e-02 | -1.708913e-01 | 1.392411e-02 | 2.147764e-01 | -9.326314e-02 | 1.449290e-01 | -2.219994e-02 | 1.933442e-01 | -1.302793e-01 |

**9. Residual Connection**

**= input\_x2 + h4**(in this case, input\_x2 is value before LayerNorm2. =[4,12])

**Output Layer**

\*In this case, logits has shape of [1, 300] (if you need 4 tokens, keep all

**Output Layer Weight (=[300, 12])**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |
| -7.012981e-01 | -1.534881e-02 | 3.749951e-01 | 6.869908e-02 | 2.214945e-01 | 8.481278e-02 | -1.625734e-01 | 3.728701e-01 | -6.124342e-01 | 5.233702e-02 | -2.821224e-02 | -3.558294e-01 |
| 5.747641e-01 | -1.283839e-02 | 7.790766e-01 | 2.710546e-01 | 3.476255e-01 | -4.909758e-01 | -2.627245e-01 | 7.810609e-01 | -5.572628e-01 | -4.511980e-01 | -2.059188e-01 | 1.297116e-02 |
| -7.000353e-01 | -1.606948e-02 | 3.742004e-01 | 6.764980e-02 | 2.222537e-01 | 8.457713e-02 | -1.621842e-01 | 3.719840e-01 | -6.114433e-01 | 5.054276e-02 | -2.905967e-02 | -3.546697e-01 |
| -7.691151e-02 | 3.564835e-01 | 7.681263e-01 | 8.244079e-01 | 1.806321e-01 | 1.546510e-01 | -6.287482e-02 | 1.376739e-01 | -8.978835e-01 | -9.053059e-01 | 4.105914e-01 | 9.150273e-01 |
| 6.375547e-02 | 2.058683e-01 | -2.818737e-01 | -1.940697e-01 | -4.425125e-01 | -4.207795e-01 | 4.967715e-01 | -3.647259e-02 | -3.831129e-01 | 2.439543e-01 | -4.852616e-01 | -5.757291e-01 |
| 2.246160e-01 | -9.037864e-02 | 1.475167e-01 | -2.453872e-01 | -9.823159e-02 | -5.208553e-01 | -2.466254e-01 | -1.107216e+00 | 7.473120e-03 | 4.328158e-01 | -1.959456e-02 | -1.553835e-02 |
| 2.941775e-01 | 3.583975e-01 | -4.338071e-01 | 2.452606e-02 | -4.062870e-01 | 5.602590e-01 | -1.812271e-01 | -6.758379e-01 | -2.132618e-01 | 2.661316e-01 | -5.010597e-01 | 3.082531e-01 |
| 4.863762e-01 | 2.155438e-01 | 6.794329e-01 | -1.077169e-01 | -1.320064e-01 | -4.036469e-01 | -9.464066e-02 | 4.580882e-01 | 3.483165e-01 | 6.968014e-02 | 2.007455e-01 | 2.875810e-01 |
| 2.032448e-01 | 4.525948e-01 | 1.755809e-01 | -6.609076e-02 | -7.480044e-01 | 8.781306e-02 | -3.205666e-01 | -4.011980e-01 | -3.835826e-01 | -1.102135e-01 | -5.450822e-01 | 5.414720e-01 |
| 1.800572e-01 | -6.858487e-02 | 2.240251e-01 | -2.040183e-01 | -2.258659e-01 | -4.687809e-01 | -7.088593e-01 | -6.956212e-01 | 4.577834e-02 | 1.215202e-01 | -1.690491e-01 | 5.446649e-01 |
| 3.582377e-01 | 1.941983e-01 | 6.861368e-01 | -1.582965e-01 | -4.325330e-02 | 4.395774e-02 | -2.608127e-01 | 3.878188e-01 | 2.548632e-01 | -4.434481e-01 | 3.023050e-01 | 5.732037e-01 |
| 1.119262e-02 | 1.420789e-01 | 2.853532e-01 | -3.825569e-01 | -2.024527e-01 | 3.444151e-01 | 4.055303e-01 | 4.625521e-01 | 2.265968e-01 | -5.193948e-01 | 2.306034e-01 | 4.692274e-01 |
| 4.328303e-01 | 3.359342e-02 | 1.319500e-02 | -3.228879e-01 | 1.933933e-01 | -4.733142e-01 | -2.576093e-01 | -1.107972e-01 | 6.193715e-01 | 5.286608e-01 | 7.138918e-02 | -1.376688e-01 |
| 5.236815e-01 | 1.549037e-01 | -1.612758e-01 | -7.403072e-02 | 2.395601e-01 | -1.427385e-02 | 5.785968e-01 | 1.704287e-01 | 1.360354e-01 | -6.435586e-01 | -2.910423e-01 | -4.419883e-01 |
| -6.909894e-01 | -3.423115e-01 | 2.557515e-01 | -2.415295e-01 | -5.452796e-01 | 1.189954e-02 | 2.003596e-02 | -3.962016e-02 | 4.245621e-02 | -4.862174e-01 | 4.394194e-01 | 2.483280e-01 |
| 3.303732e-01 | 4.524538e-01 | -4.134766e-01 | -5.724636e-02 | 1.775235e-01 | 6.082065e-02 | 2.057210e-01 | -3.233865e-01 | -1.984698e-01 | 2.767485e-01 | -4.618651e-01 | -4.700254e-01 |
| -1.059577e-01 | 1.960026e-01 | -4.298541e-01 | -2.617688e-01 | -1.601622e-02 | -2.178185e-01 | 5.991670e-01 | 2.202472e-02 | -3.510796e-01 | -3.398077e-01 | -5.980545e-01 | -5.933843e-01 |
| -7.549241e-01 | 1.935679e-01 | -7.567414e-02 | -2.390226e-01 | 2.548902e-01 | -5.244452e-01 | 4.757861e-01 | 6.853558e-01 | 2.763959e-01 | 1.720261e-01 | 4.082734e-02 | -3.335191e-01 |
| -4.667164e-01 | -2.189571e-01 | -1.712346e-02 | 4.339891e-01 | 4.837156e-01 | -2.240702e-01 | 4.881597e-01 | 6.659451e-01 | 2.370680e-01 | -1.183140e-01 | 1.921059e-01 | -2.004119e-01 |
| -1.227853e-01 | 3.539467e-01 | 4.421140e-02 | -1.794862e-01 | -7.248461e-02 | 3.955189e-01 | 4.440015e-01 | 5.009142e-01 | 4.289640e-01 | 2.151972e-01 | -5.740832e-02 | 5.461831e-01 |
| 4.055106e-01 | 4.891977e-04 | 6.454903e-01 | -4.631345e-01 | -4.148870e-02 | -5.924683e-01 | -4.410275e-01 | -3.697713e-01 | 1.893042e-02 | -4.642654e-01 | 4.348386e-01 | 3.093281e-01 |
| -3.466196e-01 | -2.724262e-01 | 1.511395e-01 | 5.457464e-01 | -1.464042e-02 | -5.453664e-01 | 4.279306e-01 | 2.468832e-01 | 8.542333e-02 | 2.715232e-01 | 3.783229e-01 | -5.075352e-01 |
| -2.855732e-01 | -4.549870e-01 | -5.336958e-01 | 2.315951e-01 | -1.010827e-01 | 3.912259e-02 | 5.484520e-01 | 1.647787e-01 | -3.854800e-01 | -1.741846e-01 | -1.499654e-01 | -3.120022e-01 |
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| -5.950575e-01 | -2.607828e-01 | -1.492610e-01 | -1.652257e-01 | 6.597859e-01 | 6.753357e-02 | 3.852933e-01 | 4.435240e-01 | -6.713662e-02 | 6.235499e-02 | 3.357226e-02 | 4.202919e-01 |
| -7.002187e-01 | -1.596377e-02 | 3.743213e-01 | 6.781137e-02 | 2.221641e-01 | 8.461222e-02 | -1.622275e-01 | 3.720925e-01 | -6.115835e-01 | 5.079700e-02 | -2.893803e-02 | -3.548507e-01 |
| -6.998496e-01 | -1.617154e-02 | 3.740782e-01 | 6.748927e-02 | 2.223837e-01 | 8.454014e-02 | -1.621019e-01 | 3.718362e-01 | -6.113114e-01 | 5.029562e-02 | -2.916063e-02 | -3.544978e-01 |
| -6.358842e-01 | -4.643276e-01 | -1.860153e-01 | -4.227049e-01 | 6.072330e-01 | -8.354766e-02 | 1.171048e-01 | -9.583254e-02 | -7.123872e-02 | 2.633387e-01 | 1.587517e-01 | 2.940271e-01 |
| -4.307144e-01 | -4.039995e-03 | -1.631369e-01 | 2.865252e-02 | 8.513364e-01 | -2.031735e-01 | 1.882816e-01 | -1.612825e-01 | -3.080851e-01 | 3.950988e-01 | 1.277847e-01 | 1.667186e-01 |
| -2.966916e-01 | -3.709307e-01 | 1.440474e-01 | -4.980917e-01 | 5.874037e-01 | 2.522300e-01 | 9.348671e-02 | -5.062460e-01 | -4.886105e-01 | -1.002699e-01 | -2.490174e-01 | 1.932226e-01 |
| -5.653682e-01 | -9.780824e-02 | -1.706734e-01 | -4.925620e-01 | 4.536302e-01 | -2.083654e-01 | 1.902497e-01 | -4.134712e-01 | -2.568449e-01 | 4.912808e-01 | -1.158507e-01 | 7.575758e-02 |
| -5.031611e-01 | -3.852426e-01 | -9.341512e-02 | -2.244191e-01 | 6.233771e-01 | -9.733605e-02 | 1.046435e-01 | -2.882444e-01 | -4.200029e-01 | 3.041402e-01 | -1.864697e-01 | 2.254546e-01 |
| -2.438939e-02 | 1.491146e-01 | 5.414713e-01 | -2.892575e-01 | 7.240265e-01 | -1.959528e-02 | 5.178985e-01 | 1.608314e-01 | -2.475921e-01 | -1.301636e-01 | -2.440752e-01 | 4.788448e-02 |
| -5.629395e-01 | -1.127251e-03 | 2.309619e-01 | 8.657265e-02 | 2.482783e-01 | 1.217730e-02 | -8.709555e-03 | 2.067412e-01 | -5.652074e-01 | -3.724813e-01 | -1.555559e-01 | -2.818453e-01 |
| -6.792443e-01 | -4.364758e-01 | 1.536802e-01 | 2.493901e-01 | 5.216363e-01 | 7.167722e-02 | -4.728608e-01 | -1.181901e-01 | 6.554493e-03 | 1.495810e-01 | -4.263786e-02 | -1.558620e-01 |
| -2.656567e-01 | -1.773294e-01 | -8.235857e-02 | -1.053245e-01 | 7.216421e-01 | 2.427686e-01 | 1.811282e-02 | -3.524410e-02 | -3.500068e-01 | 1.961893e-01 | -4.734639e-02 | 3.640189e-01 |
| -4.719831e-01 | -4.958117e-01 | -1.228248e-01 | -1.262700e-01 | 6.490315e-01 | 6.527299e-02 | 2.325578e-01 | -7.479934e-02 | -3.138428e-01 | 3.992445e-02 | 2.677410e-02 | 2.097016e-01 |
| -1.530838e-02 | 2.744761e-01 | -2.479224e-01 | 2.641425e-01 | 8.195106e-01 | 1.851365e-01 | 1.295613e-01 | 3.275081e-01 | 1.703734e-01 | -1.462339e-01 | -2.275846e-01 | -1.529858e-01 |
| -3.636718e-01 | -3.943503e-01 | -6.201497e-03 | -8.295124e-02 | 7.328712e-01 | 1.548334e-01 | 2.575523e-01 | -9.987404e-02 | -4.423646e-01 | -3.514697e-02 | -4.205506e-02 | 2.535165e-01 |
| -2.346762e-01 | -3.719035e-01 | 2.276712e-01 | -2.767938e-01 | 6.109959e-01 | 4.262795e-01 | -2.716951e-01 | 1.178918e-01 | -1.812908e-01 | -4.197240e-01 | -1.719792e-02 | 2.471015e-01 |
| -5.081754e-01 | -4.495680e-01 | -1.735399e-01 | -3.977873e-01 | 5.686693e-01 | 9.833208e-02 | 2.183898e-01 | 1.551204e-01 | -3.169313e-01 | -2.586118e-01 | -7.366555e-02 | 2.467189e-01 |
| -5.003190e-01 | -4.484852e-01 | -7.208015e-02 | -1.566063e-01 | 7.169023e-01 | 6.993099e-02 | 1.233056e-01 | -1.444334e-01 | -2.763187e-01 | 2.145926e-01 | 2.072869e-01 | 3.327538e-01 |
| -4.871619e-01 | -3.871877e-01 | -5.982564e-02 | -3.523351e-01 | 7.137013e-01 | 2.852140e-02 | -7.189197e-02 | 9.892782e-02 | -1.348056e-01 | 6.387780e-02 | -1.835377e-01 | 3.107722e-01 |
| -7.494816e-01 | -3.639610e-01 | -6.439112e-02 | -4.344888e-01 | 4.294006e-01 | 1.153835e-01 | 1.220665e-01 | 1.079179e-01 | 5.699143e-02 | 9.660471e-02 | 5.602522e-02 | 3.535020e-01 |
| -7.021098e-01 | -1.490870e-02 | 3.755276e-01 | 6.935717e-02 | 2.209873e-01 | 8.493834e-02 | -1.628395e-01 | 3.734307e-01 | -6.130904e-01 | 5.343659e-02 | -2.770237e-02 | -3.565667e-01 |
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| -2.153716e-01 | -4.764836e-01 | 5.718586e-01 | -2.772400e-01 | 3.952997e-01 | 3.196102e-01 | 1.944506e-01 | 1.352575e-01 | -5.696371e-01 | -5.481298e-01 | -1.213194e-02 | 3.678485e-02 |
| 3.850613e-01 | 1.360441e-01 | 5.133645e-01 | -3.353720e-01 | 7.045113e-01 | 2.107662e-01 | -1.774154e-02 | -2.286882e-01 | -2.370800e-01 | 1.814616e-01 | -1.595607e-01 | 2.220000e-01 |
| -2.080429e-01 | -2.025147e-01 | 1.695374e-01 | 3.247795e-02 | 5.687010e-01 | 1.774893e-01 | 3.477945e-02 | 2.828386e-01 | -3.788227e-01 | -3.789899e-01 | -1.050505e-01 | 2.051560e-02 |
| -4.580196e-01 | -3.072393e-01 | -1.707797e-01 | -1.940982e-01 | 7.309248e-01 | 1.086948e-01 | -1.108195e-01 | -1.447522e-01 | -3.193443e-01 | 2.114535e-01 | -7.015441e-02 | 3.968154e-01 |
| -2.936917e-01 | -1.764576e-01 | -2.307184e-01 | -2.973326e-01 | 6.075957e-01 | 1.935598e-01 | -2.757112e-01 | -2.132300e-01 | -4.782390e-01 | 8.118139e-03 | -2.340877e-01 | 2.460958e-01 |
| -6.440459e-02 | -1.413748e-01 | 3.821807e-01 | -2.860893e-01 | 6.287783e-01 | 3.188772e-01 | -1.340346e-01 | -3.904669e-01 | -4.485946e-01 | 2.059337e-01 | -3.227309e-01 | 2.672389e-01 |
| -3.234040e-01 | -7.538027e-02 | 3.760491e-01 | -3.297514e-01 | 6.278787e-01 | 2.256039e-01 | 2.616164e-01 | -1.601070e-01 | -4.399673e-01 | 6.021263e-02 | -4.522793e-01 | 2.210108e-01 |
| -9.599178e-03 | 8.092006e-02 | 6.023921e-01 | -3.999971e-01 | 5.279318e-01 | 3.003182e-01 | 1.761356e-01 | 1.473715e-01 | -1.640823e-01 | -1.181556e-01 | -4.092340e-01 | 2.279363e-01 |
| -4.772364e-01 | -1.447575e-01 | -3.809597e-01 | 2.096809e-01 | 5.629574e-01 | 2.857996e-01 | -3.634940e-01 | 3.234265e-01 | 3.635583e-01 | 9.060378e-03 | 2.645303e-01 | -1.158467e-01 |
| 5.857022e-02 | -5.474910e-02 | -2.782157e-01 | 4.817305e-01 | 7.894015e-01 | -2.070993e-01 | 2.387859e-01 | -3.035171e-01 | -4.001247e-01 | 1.617120e-01 | 1.516796e-01 | -2.078943e-01 |
| -3.835204e-01 | 1.678890e-01 | 2.051277e-01 | -2.009509e-01 | 5.572851e-01 | 1.339021e-01 | -1.908535e-01 | 7.948463e-01 | 2.248035e-02 | -2.084577e-01 | -1.439855e-02 | 2.218509e-01 |
| -7.883090e-01 | -3.739692e-01 | -1.504513e-01 | -5.555227e-02 | 3.946035e-01 | 1.061481e-01 | 4.121031e-02 | 9.459268e-02 | -2.128707e-01 | 7.832510e-03 | -3.676014e-02 | -1.781881e-01 |
| -1.645316e-01 | -4.395887e-01 | 6.369650e-01 | -2.326524e-01 | -5.675975e-02 | -8.279357e-01 | -1.746097e-01 | -1.593307e-01 | -1.802557e-01 | 4.575218e-01 | -5.581927e-01 | -5.245048e-01 |
| -1.668178e-01 | -7.074085e-01 | 1.447532e-01 | 4.330518e-01 | 4.447982e-01 | 1.459783e-01 | 1.025829e-01 | -2.123495e-01 | -5.884358e-01 | -5.498333e-01 | -5.542061e-02 | -2.597900e-01 |
| -3.550547e-01 | -9.717638e-02 | 6.398174e-01 | 3.573947e-02 | 3.022959e-01 | 2.664548e-01 | 9.074777e-02 | 4.635019e-01 | -2.768514e-02 | -3.343628e-01 | -4.460742e-01 | -1.942942e-01 |
| 2.216273e-01 | 4.434219e-02 | 7.381237e-01 | 7.131148e-02 | 4.297073e-01 | 3.261477e-01 | -2.278876e-01 | 2.792663e-01 | -3.610021e-01 | -3.867026e-01 | -2.612419e-01 | 2.206918e-01 |
| 1.540252e-01 | -9.572404e-03 | 7.250658e-01 | 2.967392e-01 | 5.563549e-01 | 2.224988e-01 | 2.142649e-01 | 5.196905e-01 | -1.367502e-01 | -3.349116e-01 | -2.354581e-01 | -1.975307e-01 |
| -6.060443e-02 | -8.267936e-01 | 3.125984e-01 | -7.875821e-02 | 3.406548e-01 | 1.676472e-01 | -3.586636e-01 | -1.750606e-01 | -8.458237e-01 | 1.032407e-01 | -2.653333e-01 | -2.930214e-01 |
| -7.823076e-01 | -5.979748e-01 | -3.966425e-02 | 3.734010e-01 | 5.378022e-01 | -2.739295e-01 | 3.187715e-01 | 1.513423e-01 | -3.886468e-01 | -1.136711e-01 | -1.557109e-01 | -1.804512e-01 |
| -7.113910e-01 | -4.131953e-01 | 5.148436e-01 | -1.016524e-01 | -1.575616e-01 | 1.256337e-01 | 1.444226e-01 | 2.589256e-01 | -5.167560e-01 | -3.693629e-01 | -4.865914e-01 | -2.833372e-01 |
| -5.260523e-01 | -2.588758e-01 | 4.714725e-01 | 2.198477e-01 | 4.225246e-01 | 3.358539e-01 | 2.547836e-01 | 3.919939e-01 | -4.386269e-02 | -2.339309e-01 | -4.148364e-01 | -1.950931e-01 |
| -3.159560e-01 | -4.413661e-02 | 2.242743e-01 | 5.826489e-02 | 5.343807e-01 | 3.371488e-01 | -4.051743e-01 | 5.350824e-02 | 1.013978e-01 | -5.214702e-01 | 4.674041e-02 | -1.964328e-01 |
| 2.771134e-01 | -6.413653e-01 | 6.050456e-01 | 2.059053e-01 | -2.402142e-02 | 1.130681e-01 | -4.119713e-01 | 2.136530e-01 | -6.100997e-01 | -2.925247e-01 | -1.459803e-01 | -4.223858e-01 |
| -7.706261e-01 | -3.426419e-01 | 4.413107e-01 | -1.395518e-01 | 2.881173e-01 | 2.962736e-01 | -3.309541e-01 | 6.452674e-02 | -2.325010e-01 | -2.647622e-01 | -3.927692e-01 | -1.589403e-01 |
| -4.531375e-01 | -3.366653e-01 | 4.732955e-01 | -2.358461e-01 | 2.985690e-01 | 2.536418e-01 | -2.455834e-01 | 3.167972e-01 | -4.604683e-01 | -4.733773e-01 | -4.013008e-01 | -1.779151e-01 |
| -4.336995e-01 | -1.965338e-01 | 5.328446e-01 | -7.966431e-02 | 3.503082e-01 | 2.809504e-01 | -3.487691e-01 | 4.507131e-01 | -1.413873e-01 | -3.029085e-01 | -4.509254e-01 | -2.138900e-02 |
| -5.776948e-01 | -2.927523e-02 | 5.428417e-01 | -5.997303e-02 | 2.796442e-01 | 2.146986e-01 | -2.614280e-01 | 4.678572e-01 | -2.598878e-02 | -9.973990e-02 | -4.829116e-01 | -2.458683e-01 |
| -5.826425e-01 | -5.250519e-01 | 1.402856e-01 | 4.628528e-02 | 5.061423e-01 | 3.377785e-02 | -1.648275e-01 | -4.929553e-02 | -5.907162e-01 | 4.180099e-01 | -4.432134e-01 | -2.059047e-01 |
| -4.942750e-01 | -4.684952e-02 | 5.133657e-01 | 1.329600e-01 | 3.975275e-01 | 3.104959e-01 | 2.240212e-01 | 5.618958e-01 | -1.454026e-01 | -5.287844e-02 | -4.638450e-01 | -1.833441e-01 |
| -2.930788e-01 | -1.051969e-01 | 4.375615e-01 | 3.633689e-01 | 5.744742e-01 | 2.297805e-01 | 3.427715e-01 | 2.804537e-01 | -2.382085e-01 | -4.147364e-01 | -2.637431e-01 | -3.241757e-01 |
| 1.695275e-01 | -1.169845e-01 | 3.062500e-01 | -9.065144e-02 | -8.541207e-02 | -1.646103e-01 | -2.087596e-01 | -5.742273e-02 | 1.365981e-01 | 3.512342e-01 | 2.298089e-02 | -3.178463e-01 |
| -4.445782e-02 | 1.922020e-01 | 5.832497e-01 | -4.276887e-02 | -3.700502e-02 | 3.259747e-01 | -2.409173e-01 | 4.108668e-01 | 6.867246e-02 | -1.406345e-01 | -3.682519e-02 | 4.305610e-01 |
| -1.942122e-01 | -3.823451e-01 | 3.143716e-01 | 2.072088e-01 | 2.620291e-01 | -1.402605e-01 | -3.293250e-01 | 4.772456e-01 | -9.818434e-02 | -3.817738e-01 | 3.007326e-01 | -3.765539e-01 |
| -4.070430e-01 | -1.047595e-01 | 4.244281e-01 | -5.011898e-02 | 1.204166e-01 | 1.610903e-01 | -8.028563e-02 | 5.148040e-02 | -3.411996e-01 | -2.713428e-01 | -5.883548e-01 | -3.654879e-01 |
| -5.862983e-01 | -1.750753e-01 | 3.751129e-01 | -1.902485e-01 | 4.230833e-01 | 2.186926e-01 | -1.809500e-01 | 3.289036e-01 | -2.888194e-01 | -3.461519e-01 | -3.999906e-01 | -2.153640e-01 |
| -7.019061e-01 | -2.536966e-01 | 2.817383e-01 | -1.053250e-02 | 4.462650e-01 | 1.685090e-01 | 1.335222e-01 | 3.162641e-01 | -4.432721e-01 | -3.520202e-01 | -3.040058e-01 | -1.779318e-01 |
| -2.698220e-02 | -1.457990e-02 | -7.592254e-02 | -6.009977e-03 | -8.269783e-02 | -1.120277e-01 | -2.270082e-01 | 1.787355e-01 | -1.011193e-01 | 2.360591e-01 | -3.485929e-01 | -3.340365e-01 |
| -6.840807e-01 | -4.145209e-01 | 2.881118e-01 | 1.892412e-01 | 4.247157e-01 | 1.067291e-01 | 1.133254e-01 | 4.204974e-01 | -1.693071e-01 | -2.477670e-01 | -2.145402e-01 | -3.572562e-01 |
| 8.538638e-02 | 2.901128e-01 | 6.214806e-01 | 1.076991e-01 | 4.347050e-01 | 9.876048e-02 | -2.817720e-01 | 4.650835e-01 | -5.066568e-01 | 1.362680e-01 | -3.651535e-01 | -1.203260e-01 |
| -2.969579e-01 | -2.674543e-01 | -6.828578e-02 | -6.897876e-02 | 3.510098e-01 | 1.634886e-01 | 7.987593e-02 | 5.165491e-01 | 1.391499e-01 | -3.266697e-02 | -2.528659e-01 | -1.522495e-01 |
| -4.878820e-01 | -1.064465e-01 | 2.412809e-01 | -7.971299e-02 | 3.796884e-01 | 1.321534e-01 | -2.045757e-01 | 3.152354e-01 | -1.541088e-01 | -1.119958e-01 | -1.202506e-01 | -2.460062e-02 |
| -3.196955e-01 | -4.289355e-02 | 3.010070e-01 | -9.126277e-02 | 3.878591e-01 | -2.673780e-02 | 1.536889e-02 | 2.454010e-01 | -1.619146e-01 | -1.369955e-01 | -2.312706e-01 | -2.073101e-01 |

**Output Layer Bias (=[25,12])**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |
| -6.634552e+00 | 6.170157e-01 | -6.652421e+00 | -2.061713e+00 | -2.618940e-01 | -9.812099e-01 | -4.086130e-01 | 2.244326e-01 | -1.604753e-02 | -1.650872e-01 | 3.644174e-01 | 1.281040e+00 |
| -3.348395e-01 | 3.984979e-01 | 5.732086e-01 | 2.346973e-01 | 4.229756e-01 | 5.645238e-01 | 1.288048e+00 | 7.176578e-01 | -5.842587e-01 | -9.027578e-02 | 3.294218e-01 | 7.591552e-01 |
| 7.350406e-01 | 5.201762e-01 | 5.522144e-02 | -6.799488e-01 | 3.278614e-01 | 1.995024e-01 | 2.804384e-02 | 8.363327e-01 | -2.651612e-01 | -5.968131e-02 | 1.748500e-01 | 5.121496e-01 |
| 7.254930e-01 | -1.940286e-01 | -1.007436e-01 | -8.137538e-02 | 7.344745e-01 | -2.029971e-01 | 3.190012e-01 | -3.805647e-01 | 2.356556e-01 | 1.223961e+00 | -4.116027e-01 | 6.232842e-01 |
| 1.515677e-01 | -5.519732e-01 | 2.323481e-01 | 3.491233e-01 | -4.297716e-01 | 8.013657e-02 | -1.870994e-01 | -1.938767e-01 | -2.161007e-01 | -2.870471e-01 | -2.489797e-01 | -1.498195e-02 |
| 4.191538e-02 | 4.852690e-01 | 1.362205e-01 | 2.425593e-03 | -1.212436e+00 | -7.682367e-02 | 3.267876e-01 | 1.153915e-01 | 2.531457e-01 | 2.712769e-01 | -5.576001e-01 | -3.059282e-01 |
| 1.504552e-01 | -9.292938e-01 | -3.395756e-01 | 3.848313e-01 | -5.840351e-02 | 7.237568e-01 | 6.706707e-01 | -8.526660e-01 | 1.942796e-01 | 1.471369e-01 | 2.065965e-01 | -2.156182e-01 |
| 4.419324e-01 | -6.669522e+00 | 6.506515e-01 | -7.080079e-02 | 2.516094e-01 | 4.616310e-01 | -2.852116e-01 | -2.317584e-01 | 6.433147e-01 | 5.152933e-02 | -2.729456e-01 | -2.284579e-01 |
| -1.001484e+00 | -3.011953e-01 | -4.050147e-01 | 4.069330e-02 | -4.604845e-01 | 5.794752e-01 | -2.953122e-01 | 1.812937e-01 | -5.359137e-01 | -5.210617e-01 | -9.048456e-01 | -1.808623e+00 |
| 7.753787e-01 | -7.041377e-01 | 3.785975e-01 | 1.691801e-01 | -3.763646e-01 | -1.057818e-02 | -5.064652e-01 | -3.206836e-01 | -9.285566e-01 | 2.203624e-01 | -6.486045e-01 | 3.793363e-01 |
| -7.123774e-01 | 2.220378e-01 | 3.181592e-01 | -7.812145e-02 | -5.709406e-01 | -1.573624e-01 | -4.984484e-01 | 2.815996e-02 | -6.509402e-02 | -3.364364e-01 | -8.824155e-01 | -4.284362e-02 |
| -7.043603e-01 | -7.395552e-01 | 1.228538e-01 | -6.967743e-01 | 8.308882e-03 | 2.390303e-01 | -2.494228e-01 | -5.407260e-01 | -3.086866e-01 | -7.927525e-01 | 7.516963e-01 | -1.907963e-01 |
| -5.205950e-01 | -3.470486e-01 | -2.901392e-01 | -2.198520e-02 | 1.959537e-01 | -7.598581e-01 | 4.007582e-01 | -8.535799e-01 | -4.466481e-01 | -1.101548e-01 | -4.685671e-01 | -5.979004e-01 |
| -4.026540e-03 | -7.631497e-01 | -4.699306e-01 | -8.578670e-01 | -8.053812e-02 | 6.843362e-02 | -7.536829e-02 | -1.355171e+00 | -3.222896e-01 | -3.221138e-01 | -9.717227e-01 | -6.495908e-01 |
| -2.427230e-02 | -4.718605e-01 | -5.657589e-01 | -3.547646e-01 | -1.255663e-01 | -7.103180e-01 | -4.068964e-01 | 2.851010e-02 | -5.291488e-01 | -2.707802e-01 | -1.231791e+00 | -3.484359e-01 |
| -1.620721e-01 | -2.557324e-01 | -3.777580e-01 | -4.875548e-01 | -5.987243e-01 | -5.977625e-01 | -2.507184e-01 | -1.546408e+00 | -9.076051e-01 | -8.210282e-01 | -2.155222e-01 | -8.418477e-03 |
| -2.443368e-01 | -5.114459e-01 | 7.932869e-02 | -6.177450e-01 | 1.888654e-01 | -7.219968e-01 | -1.573663e-01 | -5.368091e-01 | -6.038482e-01 | -5.591719e-01 | -3.409569e-01 | 1.124179e-01 |
| 1.241688e+00 | -4.871779e-01 | 8.720687e-01 | 2.752028e-01 | -3.140719e-01 | 8.705854e-01 | 6.174989e-01 | 2.374939e-01 | -8.679842e-01 | -4.773482e-01 | -9.438970e-01 | -9.291019e-01 |
| 1.870508e-01 | 1.253110e+00 | 4.761325e-01 | 2.542902e-01 | -1.866368e+00 | 3.568156e-01 | -7.835507e-01 | 1.323103e+00 | -2.621019e-01 | -1.434869e+00 | 6.420482e-01 | -1.906960e-02 |
| 2.694338e-01 | -1.572783e+00 | -8.111336e-01 | -2.235330e-01 | 6.322753e-02 | -8.965231e-02 | 9.027214e-02 | -6.649862e+00 | -6.655046e+00 | -1.582260e-01 | -2.064944e-01 | -1.989877e-01 |
| 4.142733e-02 | -3.298040e-01 | -1.217898e-01 | -2.286313e+00 | -3.094601e-01 | -5.606790e-01 | -4.817659e-01 | 1.694102e-01 | -1.650945e-01 | -2.875136e-01 | -1.893099e-01 | -6.114040e-01 |
| -7.815899e-01 | -5.040283e-01 | -6.623353e+00 | -6.651492e+00 | -4.910293e-01 | 2.097927e-01 | 2.330415e-01 | -3.063605e-01 | -1.381634e+00 | -3.614333e-01 | -3.656227e-01 | 3.501629e-01 |
| 3.097835e-02 | -6.611194e-02 | 5.015392e-02 | 1.586669e-01 | -6.950897e-01 | -9.305867e-01 | -9.290990e-01 | -2.793964e-01 | -2.807159e-01 | -6.123894e-01 | -2.086361e-01 | -4.466833e-01 |
| -9.102922e-01 | -4.136308e-01 | -6.826615e-01 | -7.439186e-01 | -5.644350e-01 | -9.231557e-01 | -1.020903e+00 | -7.249500e-01 | -7.534400e-01 | -4.553648e-01 | -4.105859e-01 | -8.478576e-01 |
| -6.373712e-01 | -5.124789e-01 | -1.035026e+00 | -8.139002e-01 | -1.134562e+00 | -1.404207e+00 | -8.742224e-01 | -1.091110e+00 | -8.025752e-01 | -1.134119e+00 | -1.075411e+00 | -1.125656e+00 |

**Softmax**

300 different probability will be calculated, and select the highest probability.  
Then, select the token from the first tokenizer table.