

First Author

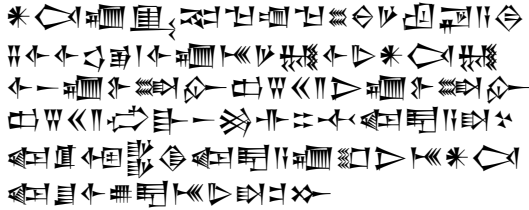
Affiliation / Address line 1
Affiliation / Address line 2
Affiliation / Address line 3
email@domain

Second Author

Affiliation / Address line 1
Affiliation / Address line 2
Affiliation / Address line 3
email@domain

Abstract

This paper announces the discovery of the use of neural nets almost 4,000 years before their use in the modern era. Newly discovered tablets preserve a perceptron used for calculating the numbers on Plimpton 322, the most important object in the history of mathematics. The native programming language used by the ancient Babylonian “cuneogrammers” uses sexagesimal numbering leading to some “weirdness”.



1 Introduction

The history of math is long, but the history of programming is longer. Cuneiform, arguably the first writing in the world, is known for its sheep receipts and beer ration lists as well as complaints about substandard copper (Oppenheim, 1954) and women complaining at each other (Matuszak, 2020). This article adds neural network programming to that vaunted list of human achievements. A set of newly discovered cuneiform tablets preserve the mechanism for performing simple neural network calculations. These methods, it seems, were used to calculate the lengths of triangles; a well known example of this exercise is preserved on the tablet known as Plimpton 322¹. It is remarkable that no historian of math or cuneiform scholar has ever consider this possibility. This paper covers the background, a description of

the cuneogramming language, and includes a facsimile copy of the most important tablet as an appendix.

Unfortunately, the hardware required to execute these programs (i.e. a living Babylonian mathematician) has not been adequately preserved, but we have managed to write a Python library which emulates it.² The assumption is that these calculations were done by hand in their copious free time between inventing the wheel and the concept of zero. While the actual output of these tablets is relatively simple by modern standards, the implications of this discovery are profound. Future work will explore how these techniques could have been used in the realm of astronomical calculation and elucidate the full extent of Babylonian computational prowess.

2 Description of the Language

Programs in 𒂗𒍪𒍪 (EME.ŠID.A “language of counting”) follow a tabular structure with three main sections: (i) a header, denoted by 𒂗𒍪 (DUB “tablet”), (ii) a sequence of instructions, and (iii) a colophon detailing the tablet’s authorship. Each instruction spans four columns, which we have taken to calling the *arguments*, *opcode*, *destination*, and *line number*. These columns are usually tab-separated, though in a few documents they are TAB-separated (using the cuneiform sign TAB 𒀵). Instructions are grouped into blocks by means of horizontal lines.






Arguments An instruction’s arguments may be numbers, register addresses, or a combination of the two. Numbers are encoded following standard Babylonian conventions (?), with 𒌦 denoting the radix point which separates the integer part from a following fraction. There is





¹An important and real description of this interesting object is found in Robson (2002).

²github.com/MrLogarithm/emeszida









an explicit representation for zero (𐎶), making these tablets some of the earliest unambiguous examples of the mathematical concept of zero.


A register address is denoted by the phrase $\text{NID}_2.\text{KAS}_7\ n\text{-KAM}$ 𐤀𐤍𐤏𐤍 n (‘‘thing.account n -th’’, ‘‘the item in the n -th place’’), where n is any number. 𐤀𐤍𐤏𐤍 expressions can be nested to perform a kind of pointer dereferencing: for example, if 𐤀𐤍𐤏𐤍 (register 1) contains the value 𐤍𐤏 (3), and 𐤀𐤍𐤏𐤍 (register 3) contains the value 𐤍𐤏𐤍 (7), then 𐤀𐤍𐤏𐤍 𐤀𐤍𐤏𐤍 will evaluate to 7 (the value in the register pointed to by 𐤀𐤍𐤏𐤍).

If an instruction has multiple arguments, these must be delimited by a wide space (distinct from the short space used to separate groups of digits within a number), or by one of the phrases *a-na*  “to” or *i-na*  “from”. By convention, the choice of delimiter depends on the instruction’s opcode (see below), with multiplication operations preferring space delimiters, addition preferring , and subtraction preferring . There is no mechanism to enforce these conventions, but we recommend following them because  is hard enough to read at the best of times.

Destination In most cases, the destination column of an instruction will be a register address where the output is to be stored, e.g.   . Some control-flow instructions (see below) instead expect the destination to be a line number.  SUD (“distant, remote”) can be used as a null destination, for statements which produce no output.

Opcodes Each instruction has a single opcode belonging to the following vocabulary:

-  DAḤ.HA, “add”
-  BA.ZI, “tear out”
-  A.RA , “multiply”
-  IGI, “reciprocal”
-  ME, “to be”
-  *ta-mar*, “you will see”
-  NIGIN.NA, “start again”
-  TUKUM.BI DIRIG, “if it exceeds”

-  TUKUM.BI SIG, “if it it is weak”





The first three of these are binary operators for addition, subtraction, and multiplication respectively. The subtraction operator deserves special attention for its use in constructions of the following shape, which appear hundreds of times throughout the Babylonian programming corpus:




This instruction subtracts $\{\text{I}\}\{\text{II}\}\{\text{III}\}$ from zero and stores the result in $\{\text{IV}\}\{\text{V}\}\{\text{VI}\}\{\text{VII}\}$. This effectively negates the first argument, and seems to have been the primary way by which Babylonian cuneogrammers represented negative numbers, as their primitive and archaic notation otherwise lacked a means to encode such values. This curious practice gives definitive proof that the invention of negative numbers occurred centuries earlier than previously believed.

The language does not appear to have any kind of binary division operator. Rather, a unary ∇ operator was used to find the reciprocal of the denominator, which was then multiplied by the numerator using the binary \boxtimes operator.

\triangleright is a unary assignment operator which stores a value in a destination register. $\blacktriangleleft\!\!\!\rightarrow\!\!\!\rightarrow\!\!\!\rightarrow$ functions as a unary print operator.

 includes three types of control-flow instructions.  functions like GOTO, and jumps the program counter to the specified line number.  functions like the x86 jz instruction, and jumps to the specified line number if and only if its argument is zero.  is similar, and jumps if the argument is greater than zero.

Line Numbers Every line of an  program ends in a mandatory line number. However, these numbers are not generally sequential, and need not even be distinct. For example, most lines of the perceptron tablet are labeled with the number 0 (zero); only lines that are the destination of some control-flow instruction receive non-zero identifiers.

2.1 Fractional Indexing

Both line numbers and register addresses in can have fractional parts. The original scribes seem to have exploited this fact



Figure 1: BM 34580, courtesy of the Trustees of the British Museum, CC BY-NC-SA 4.0

to establish non-overlapping “namespaces” for the different parts of their code. For example, in the perceptron tablet, all of the model parameters are stored in addresses with integer part 1; the program inputs all have integer part 2; the matrix multiplication subroutine uses addresses with integer part 3; and so on. The fractional parts of register addresses also appear to follow some standard conventions, with the $X;0$ register typically storing a subroutine’s return address, while $X;1$ onward were used for its arguments.

The perceptron tablet also uses fractional register addresses to perform a kind of multi-dimensional array indexing. As an example, the first layer of the perceptron has a 50×2 weight matrix, and this is stored in registers $1;0,0,0$ through $1;0,49,1$. The integer part of these addresses denotes the “data” portion of memory; the first digit after the radix point identifies this as the 0th model parameter; and the second and third digits can be treated as a pair of indices ranging from 0–49 and 0–1 respectively. To access a specific element in this matrix, the scribes use repeated division by 60 to implement a kind of “bit-shift” instruction, in order to shift integer indices into the correct positions after the radix point. By adding the bit-shifted element indices (e.g. $0;0,4,7$ for the element in row 5, column 8) to a pointer to the top corner of the matrix ($1;0,0,0$) they obtain the address of the desired element ($1;0,4,7$).

Notably, this practice limits the size of their model parameters to at most 60×60 , as for larger values the addresses would carry over to higher digits and thus begin to overwrite

one another. This limitation may explain why AI never made waves in Babylonian society, as their models were all too small to be truly revolutionary.

3 Description of the Texts

The Sealand corpus contains numerous fragments implementing recognizable procedures such as bit-shifting, populating an array, computing dot products, and so on. However, only a single text is known to have been preserved in its entirety.³ Spanning close to 1700 lines, this impressive text is divided into five sections implementing what modern readers will immediately recognize to be a multi-layer perceptron. The first section straightforwardly defines a matrix-multiplication subroutine. This is called by a subroutine defined in section two, which applies each layer of the perceptron to a given input, and applies a ReLU-style activation between each pair of layers. Section three implements the tablet’s “main” method, which loads an input to memory, calls the perceptron subroutine, and prints the resulting output. Section four loads the model parameters, which appear to comprise weight matrices of sizes 50×2 , 25×50 , and 1×25 , plus bias vectors of sizes 50, 25, and 1 respectively. The final section lists pairs of inputs, whose values (incredibly!) correspond to the second and third columns of Plimpton 322. Interestingly, this section very closely resembles the tables

³All of the known texts are reproduced in github.com/MrLogarithm/emeszida/tree/main/programs, and the long text is reproduced in facsimile in the appendix of this work.

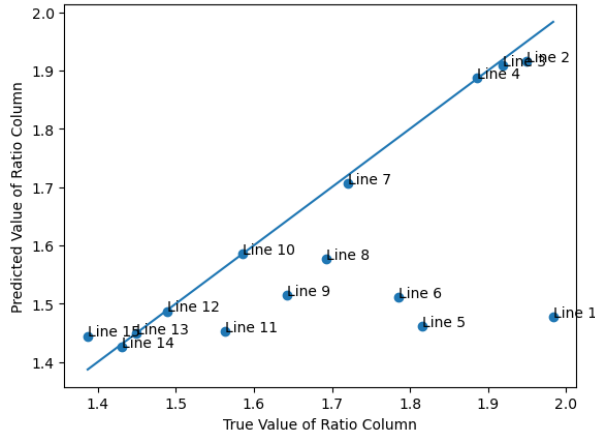


Figure 2: Outputs from the perceptron tablet vs. true value of each line from column 1 of Plimpton 322. If a point falls upon the line, the model output for that line exactly equals the value on Plimpton 322.

of parameters found in later astronomical calculations (see Figure 1).

When the program is executed, it produces a single numeric output for each input pair. These outputs correspond remarkably closely to the values in the first column of Plimpton 322, as demonstrated in Figure 2. The correspondence is not perfect, however, and the values which should match lines 1, 5, and 6 of Plimpton 322 are significantly larger than expected. This implies that, although the code on this tablet is clearly *related* to Plimpton 322, it could not have been used to directly populate the table in that text. Perhaps the outputs from this model were refined in some later step to produce the more exact ratios in the Plimpton text, or perhaps the Babylonians were disillusioned by the imprecision of their machine learning models and simply abandoned them for tried-and-true manual methods. Given how miniscule the cuneogramming corpus is relative to the larger body of Babylonian administrative writing, we lean towards the latter explanation.

The tablets preserve a number of methods for performing simple neural network calculations. Simple array operations as well as the calculation of the dot product are included in the corpus. All of this comes together in the large perceptron tablet. It is clear that the cuneogrammers were slowly developing their skills as some of the earlier and simpler methods date as far back as the Old Akkadian pe-

riod (c. 2300–2150 BCE) while the perceptron tablet is from the Old Babylonian period (c. 1900–1600 BCE).

4 Implications and Future Work

This completely rewrites the history of modern computing and artificial intelligence. Instead of focusing on figures such as Ada Lovelace and Grace Hopper we should be looking at pioneers thousands of years earlier like Enheduana the world’s first known author (Helle, 2023) and now the world’s first known programmer.

Other ancient corpora which have resisted decipherment, and which boast a similar numeric component, may represent additional examples of ancient programming traditions (Kelley et al., 2022).

Acknowledgments

The search for these tablets and our effort to understand them was inspired by Ramsey Nasser’s **قلب** programming language (<https://github.com/nasser/>).

References

- Sophus Helle. 2023. *Enheduana: the complete poems of the world’s first author*. Yale University Press, New Haven, CT.
- Kathryn Kelley, Logan Born, M. Willis Monroe, and Anoop Sarkar. 2022. [Image-aware language modeling for proto-elamite](#). *Lingue e linguaggio*, (2):261–294.
- Jana Matuszak. 2020. *»Und du, du bist eine Frau?!«: Editio princeps und Analyse des sumerischen Streitgesprächs »Zwei Frauen B«*. De Gruyter.
- A. L. Oppenheim. 1954. [The seafaring merchants of ur](#). *Journal of the American Oriental Society*, 74(1):6–17.
- Eleanor Robson. 2002. [Words and pictures: New light on plimpton 322](#). *The American Mathematical Monthly*, 109(2):105–120.

A Example Appendix

[illegible]

123456789101112131415161718192021222324252627282930313233343536373839404142434445464748495051525354555657585960616263646566676869707172737475767778798081828384858687888990919293949596979899100101102103104105106107108109110111112113114115116117118119120121122123124125126127128129130131132133134135136137138139140141142143144145146147148149150151152153154155156157158159160161162163164165166167168169170171172173174175176177178179180181182183184185186187188189190191192193194195196197198199200201202203204205206207208209210211212213214215216217218219220221222223224225226227228229230231232233234235236237238239240241242243244245246247248249250251252253254255256257258259260261262263264265266267268269270271272273274275276277278279280281282283284285286287288289290291292293294295296297298299300301302303304305306307308309310311312313314315316317318319320321322323324325326327328329330331332333334335336337338339340341342343344345346347348349350351352353354355356357358359360361362363364365366367368369370371372373374375376377378379380381382383384385386387388389390391392393394395396397398399400401402403404405406407408409410411412413414415416417418419420421422423424425426427428429430431432433434435436437438439440441442443444445446447448449450451452453454455456457458459460461462463464465466467468469470471472473474475476477478479480481482483484485486487488489490491492493494495496497498499500501502503504505506507508509510511512513514515516517518519520521522523524525526527528529530531532533534535536537538539540541542543544545546547548549550551552553554555556557558559560561562563564565566567568569570571572573574575576577578579580581582583584585586587588589590591592593594595596597598599600601602603604605606607608609610611612613614615616617618619620621622623624625626627628629630631632633634635636637638639640641642643644645646647648649650651652653654655656657658659660661662663664665666667668669670671672673674675676677678679680681682683684685686687688689690691692693694695696697698699700701702703704705706707708709710711712713714715716717718719720721722723724725726727728729730731732733734735736737738739740741742743744745746747748749750751752753754755756757758759760761762763764765766767768769770771772773774775776777778779780781782783784785786787788789790791792793794795796797798799800801802803804805806807808809810811812813814815816817818819820821822823824825826827828829830831832833834835836837838839840841842843844845846847848849850851852853854855856857858859860861862863864865866867868869870871872873874875876877878879880881882883884885886887888889890891892893894895896897898899900901902903904905906907908909910911912913914915916917918919920921922923924925926927928929930931932933934935936937938939940941942943944945946947948949950951952953954955956957958959960961962963964965966967968969970971972973974975976977978979980981982983984985986987988989990991992993994995996997998999100010011002100310041005100610071008100910101011101210131014101510161017101810191020102110221023102410251026102710281029103010311032103310341035103610371038103910401041104210431044104510461047104810491050105110521053105410551056105710581059106010611062106310641065106610671068106910701071107210731074107510761077107810791080108110821083108410851086108710881089109010911092109310941095109610971098109911001101110211031104110511061107110811091110111111121113111411151116111711181119112011211122112311241125112611271128112911301131113211331134113511361137113811391140114111421143114411451146114711481149115011511152115311541155115611571158115911601161116211631164116511661167116811691170117111721173117411751176117711781179118011811182118311841185118611871188118911901191119211931194119511961197119811991200120112021203120412051206120712081209121012111212121312141215121612171218121912201221122212231224122512261227122812291230123112321233123412351236123712381239124012411242124312441245124612471248124912501251125212531254125512561257125812591260126112621263126412651266126712681269127012711272127312741275127612771278127912801281128212831284128512861287128812891290129112921293129412951296129712981299130013011302130313041305130613071308130913101311131213131314131513161317131813191320132113221323132413251326132713281329133013311332133313341335133613371338133913401341134213431344134513461347134813491350135113521353135413551356135713581359136013611362136313641365136613671368136913701371137213731374137513761377137813791380138113821383138413851386138713881389139013911392139313941395139613971398139914001401140214031404140514061407140814091410141114121413141414151416141714181419142014211422142314241425142614271428142914301431143214331434143514361437143814391440144114421443144414451446144714481449145014511452145314541455145614571458145914601461146214631464146514661467146814691470147114721473147414751476147714781479148014811482148314841485148614871488148914901491149214931494149514961497149814991500150115021503150415051506150715081509151015111512151315141515151615171518151915201521152215231524152515261527152815291530153115321533153415351536153715381539154015411542154315441545154615471548154915501551155215531554155515561557155815591560156115621563156415651566156715681569157015711572157315741575157615771578157915801581158215831584158515861587158815891590159115921593159415951596159715981599160016011602160316041605160616071608160916101611161216131614161516161617161816191620162116221623162416251626162716281629163016311632163316341635163616371638163916401641164216431644164516461647164816491650165116521653165416551656165716581659166016611662166316641665166616671668166916701671167216731674167516761677167816791680168116821683168416851686168716881689169016911692169316941695169616971698169917001701170217031704170517061707170817091710171117121713171417151716171717181719172017211722172317241725172617271728172917301731173217331734173517361737173817391740174117421743174417451746174717481749175017511752175317541755175617571758175917601761176217631764176517661767176817691770177117721773177417751776177717781779178017811782178317841785178617871788178917901791179217931794179517961797179817991800180118021803180418051806180718081809181018111812181318141815181618171818181918201821182218231824182518261827182818291830183118321833183418351836183718381839184018411842184318441845184618471848184918501851185218531854185518561857185818591860186118621863186418651866186718681869187018711872187318741875187618771878187918801881188218831884188518861887188818891890189118921893189418951896189718981899190019011902190319041905190619071908190919101911191219131914191519161917191819191920192119221923192419251926192719281929193019311932193319341935193619371938193919401941194219431944194519461947194819491950195119521953195419551956195719581959196019611962196319641965196619671968196919701971197219731974197519761977197819791980198119821983198419851986198719881989199019911992199319941995199619971998199920002001200220032004200520062007200820092010201120122013201420152016201720182019202020212022202320242025202620272028202920302031203220332034203520362037203820392040204120422043204420452046204720482049205020512052205320542055205620572058205920602061206220632064206520662067206820692070207120722073207420752076207720782079208020812082208320842085208620872088208920902091209220932094209520962097209820992100210121022103210421052106210721082109211021112112211321142115211621172118211921202121212221232124212521262127212821292130213121322133213421352136213721382139214021412142214321442145214621472148214921502151215221532154215521562157215821592160216121622163216421652166216721682169217021712172217321742175217621772178217921802181218221832184218521862187218821892190219121922193219421952196219721982199220022012202220322042205220622072208220922102211221222132214221522162217221822192220222122222223222422252226222722282229223022312232223322342235223622372238223922402241224222432244224522462247224822492250225122522253225422552256225722582259226022612262226322642265226622672268226922702271227222732274227522762277227822792280228122822283228422852286228722882289229022912292229322942295229622972298229923002301230223032304230523062307230823092310231123122313231423152316231723182319232023212322232323242325232623272328232923302331233223332334233523362337233823392340234123422343234423452346234723482349235023512352235323542355235623572358235923602361236223632364236523662367236823692370237123722373237423752376237723782379238023812382238323842385238623872388238923902391239223932394239523962397239823992400240124022403240424052406240724082409241024112412241324142415241624172418241924202421242224232424242524262427242824292430243124322433243424352436243724382439244024412442244324442445244624472448244924502451245224532454245524562457245824592460246124622463246424652466246724682469247024712472247324742475247624772478247924802481248224832484248524862487248824892490249124922493249424952496249724982499250025012502250325042505250625072508250925102511251225132514251525162517251825192520252125222523252425252526252725282529253025312532253325342535253625372538253925402541254225432544254525462547254825492550255125522553255425552556255725582559256025612562256325642565256625672568256925702571257225732574257525762577257825792580258125822583258425852586258725882589259025912592259325942595259625972598259926002601260226032604260526062607260826092610261126122613261426152616261726182619262026212622262326242625262626272628262926302631263226332634263526362637263826392640264126422643264426452646264726482649265026512652265326542655265626572658265926602661266226632664266526662667266826692670267126722673267426752676267726782679268026812682268326842685268626872688268926902691269226932694269526962697269826992700270127022703270427052706270727082709271027112712271327142715271627172718271927202721272227232724272527262727272827292730273127322733273427352736273727382739274027412742274327442745274627472748274927502751275227532754275527562757275827592760276127622763276427652766276727682769277027712772277327742775277627772778277927802781278227832784278527862787278827892790279127922793279427952796279727982799280028012802280328042805280628072808280928102811281228132814281528162817281828192820282128222823282428252826282728282829283028312832283328342835283628372838283928402841284228432844284528462847284828492850285128522853285428552856285728582859286028612862286328642865286628672868286928702871287228732874287528762877287828792880288128822883288428852886288728882889289028912892289328942895289628972898289929002901290229032904290529062907290829092910291129122913291429152916291729182919292029212922292329242925292629272928292929302931293229332934293529362937293829392940294129422943294429452946294729482949295029512952295329542955295629572958295929602961296229632964296529662967296829692970297129722973297429752976297729782979298029812982298329842985298629872988298929902991299229932994299529962997299829993000300130023003300430053006300730083009301030113012301330143015301630173018301930203021302230233024302530263027302830293030303130323033303430353036303730383039304030413042304330443045304630473048304930503051305230533054305530563057305830593060306130623063306430653066306730683069307030713072307330743075307630773078307930803081308230833084308530863087308830893090309130923093309430953096309730983099310031013102310331043105310631073108310931103111311231133114311531163117311831193120312131223123312431253126312731283129313031313132313331343135313631373138313931403141314231433144314531463147314831493150315131523153315431553156315731583159316031613162316331643165316631673168316931703171317231733174317531763177317831793180318131823183318431853186318731883189319031913192319331943195319631973198319932003201320232033204320532063207320832093210321132123213321432153216321732183219322032213222322332234322532263227322832293230323132323233323432353236323732383239324032413242324332443245324632473248324932503251325232533254325532563257325832593260326132623263326432653266326732683269327032713272327332743275327632773278327932803281328232833284328532863287328832893290329132923293329432953296329732983299330033013302330333043305330633073308330933103311331233133314331533163317331833193320332133223323332433253326332733283329333033313332333333343335333633373338333933403341334233433344334533463347334833493350335133523353335433553356335733583359336033613362336333643365336

[illegible][illegible][illegible]

[illegible][illegible]

1
 2
 3
 4
 5
 6
 7
 8
 9
 10
 11
 12
 13
 14
 15
 16
 17
 18
 19
 20
 21
 22
 23
 24
 25
 26
 27
 28
 29
 30
 31
 32
 33
 34
 35
 36
 37
 38
 39
 40
 41
 42
 43
 44
 45
 46
 47
 48
 49
 50
 51
 52
 53
 54
 55
 56
 57
 58
 59
 60
 61
 62
 63
 64
 65
 66
 67
 68
 69
 70
 71
 72
 73
 74
 75
 76
 77
 78
 79
 80
 81
 82
 83
 84
 85
 86
 87
 88
 89
 90
 91
 92
 93
 94
 95
 96
 97
 98
 99
 100
 101
 102
 103
 104
 105
 106
 107
 108
 109
 110
 111
 112
 113
 114
 115
 116
 117
 118
 119
 120
 121
 122
 123
 124
 125
 126
 127
 128
 129
 130
 131
 132
 133
 134
 135
 136
 137
 138
 139
 140
 141
 142
 143
 144
 145
 146
 147
 148
 149
 150
 151
 152
 153
 154
 155
 156
 157
 158
 159
 160
 161
 162
 163
 164
 165
 166
 167
 168
 169
 170
 171
 172
 173
 174
 175
 176
 177
 178
 179
 180
 181
 182
 183
 184
 185
 186
 187
 188
 189
 190
 191
 192
 193
 194
 195
 196
 197
 198
 199
 200
 201
 202
 203
 204
 205
 206
 207
 208
 209
 210
 211
 212
 213
 214
 215
 216
 217
 218
 219
 220
 221
 222
 223
 224
 225
 226
 227
 228
 229
 230
 231
 232
 233
 234
 235
 236
 237
 238
 239
 240
 241
 242
 243
 244
 245
 246
 247
 248
 249
 250
 251
 252
 253
 254
 255
 256
 257
 258
 259
 260
 261
 262
 263
 264
 265
 266
 267
 268
 269
 270
 271
 272
 273
 274
 275
 276
 277
 278
 279
 280
 281
 282
 283
 284
 285
 286
 287
 288
 289
 290
 291
 292
 293
 294
 295
 296
 297
 298
 299
 300
 301
 302
 303
 304
 305
 306
 307
 308
 309
 310
 311
 312
 313
 314
 315
 316
 317
 318
 319
 320
 321
 322
 323
 324
 325
 326
 327
 328
 329
 330
 331
 332
 333
 334
 335
 336
 337
 338
 339
 340
 341
 342
 343
 344
 345
 346
 347
 348
 349
 350
 351
 352
 353
 354
 355
 356
 357
 358
 359
 360
 361
 362
 363
 364
 365
 366
 367
 368
 369
 370
 371
 372
 373
 374
 375
 376
 377
 378
 379
 380
 381
 382
 383
 384
 385
 386
 387
 388
 389
 390
 391
 392
 393
 394
 395
 396
 397
 398
 399
 400
 401
 402
 403
 404
 405
 406
 407
 408
 409
 410
 411
 412
 413
 414
 415
 416
 417
 418
 419
 420
 421
 422
 423
 424
 425
 426
 427
 428
 429
 430
 431
 432
 433
 434
 435
 436
 437
 438
 439
 440
 441
 442
 443
 444
 445
 446
 447
 448
 449
 450
 451
 452
 453
 454
 455
 456
 457
 458
 459
 460
 461
 462
 463
 464
 465
 466
 467
 468
 469
 470
 471
 472
 473
 474
 475
 476
 477
 478
 479
 480
 481
 482
 483
 484
 485
 486
 487
 488
 489
 490
 491
 492
 493
 494
 495
 496
 497
 498
 499
 500
 501
 502
 503
 504
 505
 506
 507
 508
 509
 510
 511
 512
 513
 514
 515
 516
 517
 518
 519
 520
 521
 522
 523
 524
 525

[illegible]

[illegible][illegible][illegible]

[illegible][illegible]

[illegible]

一 二 三 四 五 六 七 八 九 十 十一 十二 十三 十四 十五 十六 十七 十八 十九 二十 二十一 二十二 二十三 二十四 二十五 二十六 二十七 二十八 二十九 三十 三十一 三十二 三十三 三十四 三十五 三十六 三十七 三十八 三十九 四十 四十一 四十二 四十三 四十四 四十五 四十六 四十七 四十八 四十九 五十 五十一 五十二 五十三 五十四 五十五 五十六 五十七 五十八 五十九 六十 六十一 六十二 六十三 六十四 六十五 六十六 六十七 六十八 六十九 七十 七十一 七十二 七十三 七十四 七十五 七十六 七十七 七十八 七十九 八十 八十一 八十二 八十三 八十四 八十五 八十六 八十七 八十八 八十九 九十 九十一 九十二 九十三 九十四 九十五 九十六 九十七 九十八 九十九 一百

[illegible][illegible][illegible]

[illegible][illegible][illegible]

[illegible][illegible][illegible]

[illegible][illegible][illegible]

[illegible][illegible]

[illegible][illegible][illegible]

[illegible][illegible]

[illegible][illegible][illegible]

一、二、三、四、五、六、七、八、九、十、十一、十二、十三、十四、十五、十六、十七、十八、十九、二十、二十一、二十二、二十三、二十四、二十五、二十六、二十七、二十八、二十九、三十、三十一、三十二、三十三、三十四、三十五、三十六、三十七、三十八、三十九、四十、四十一、四十二、四十三、四十四、四十五、四十六、四十七、四十八、四十九、五十、五十一、五十二、五十三、五十四、五十五、五十六、五十七、五十八、五十九、六十、六十一、六十二、六十三、六十四、六十五、六十六、六十七、六十八、六十九、七十、七十一、七十二、七十三、七十四、七十五、七十六、七十七、七十八、七十九、八十、八十一、八十二、八十三、八十四、八十五、八十六、八十七、八十八、八十九、九十、九十一、九十二、九十三、九十四、九十五、九十六、九十七、九十八、九十九、一百。

[illegible]

 乾 ☰ 天
 坤 ☷ 地
 震 ☳ 雷
 巽 ☴ 風
 坎 ☵ 水
 離 ☲ 火
 兌 ☱ 澤
 艮 ☶ 山
 巽 ☴ 風
 坎 ☵ 水
 離 ☲ 火
 兌 ☱ 澤
 震 ☳ 雷
 巽 ☴ 風
 坎 ☵ 水
 離 ☲ 火
 兌 ☱ 澤
 震 ☳ 雷
 巽 ☴ 風
 坎 ☵ 水
 離 ☲ 火
 兌 ☱ 澤
 震 ☳ 雷
 巽 ☴ 風
 坎 ☵ 水
 離 ☲ 火
 兌 ☱ 澤
 震 ☳ 雷
 巽 ☴ 風
 坎 ☵ 水
 離 ☲ 火
 兌 ☱ 澤
 震 ☳ 雷
 巽 ☴ 風
 坎 ☵ 水
 離 ☲ 火
 兌 ☱ 澤
 震 ☳ 雷
 巽 ☴ 風
 坎 ☵ 水
 離 ☲ 火
 兌 ☱ 澤
 震 ☳ 雷
 巽 ☴ 風
 坎 ☵ 水
 離 ☲ 火
 兌 ☱ 澤
 震 ☳ 雷
 巽 ☴ 風
 坎 ☵ 水
 離 ☲ 火
 兌 ☱ 澤
 震 ☳ 雷
 巽 ☴ 風
 坎 ☵ 水
 離 ☲ 火
 兌 ☱ 澤
 震 ☳ 雷
 巽 ☴ 風
 坎 ☵ 水
 離 ☲ 火
 兌 ☱ 澤
 震 ☳ 雷
 巽 ☴ 風
 坎 ☵ 水
 離 ☲ 火
 兌 ☱ 澤
 震 ☳ 雷
 巽 ☴ 風
 坎 ☵ 水
 離 ☲ 火
 兌 ☱ 澤
 震 ☳ 雷
 巽 ☴ 風
 坎 ☵ 水
 離 ☲ 火
 兌 ☱ 澤
 震 ☳ 雷
 巽 ☴ 風
 坎 ☵ 水
 離 ☲ 火
 兌 ☱ 澤
 震 ☳ 雷
 巽 ☴ 風
 坎 ☵ 水

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65
66
67
68
69
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
92
93
94
95
96
97
98
99
100
101
102
103
104
105
106
107
108
109
110
111
112
113
114
115
116
117
118
119
120
121
122
123
124
125
126
127
128
129
130
131
132
133
134
135
136
137
138
139
140
141
142
143
144
145
146
147
148
149
150
151
152
153
154
155
156
157
158
159
160
161
162
163
164
165
166
167
168
169
170
171
172
173
174
175
176
177
178
179
180
181
182
183
184
185
186
187
188
189
190
191
192
193
194
195
196
197
198
199
200
201
202
203
204
205
206
207
208
209
210
211
212
213
214
215
216
217
218
219
220
221
222
223
224
225
226
227
228
229
230
231
232
233
234
235
236
237
238
239
240
241
242
243
244
245
246
247
248
249
250
251
252
253
254
255
256
257
258
259
260
261
262
263
264
265
266
267
268
269
270
271
272
273
274
275
276
277
278
279
280
281
282
283
284
285
286
287
288
289
290
291
292
293
294
295
296
297
298
299
300
301
302
303
304
305
306
307
308
309
310
311
312
313
314
315
316
317
318
319
320
321
322
323
324
325
326
327
328
329
330
331
332
333
334
335
336
337
338
339
340
341
342
343
344
345
346
347
348
349
350
351
352
353
354
355
356
357
358
359
360
361
362
363
364
365
366
367
368
369
370
371
372
373
374
375
376
377
378
379
380
381
382
383
384
385
386
387
388
389
390
391
392
393
394
395
396
397
398
399
400
401
402
403
404
405
406
407
408
409
410
411
412
413
414
415
416
417
418
419
420
421
422
423
424
425
426
427
428
429
430
431
432
433
434
435
436
437
438
439
440
441
442
443
444
445
446
447
448
449
450
451
452
453
454
455
456
457
458
459
460
461
462
463
464
465
466
467
468
469
470
471
472
473
474
475
476
477
478
479
480
481
482
483
484
485
486
487
488
489
490
491
492
493
494
495
496
497
498
499
500
501
502
503
504
505
506
507
508
509
510
511
512
513
514
515
516
517
518
519
520
521
522
523
524
525
526
527
528
529
530
531
532
533
534
535
536
537
538
539
540
541
542
543
544
545
546
547
548
549
550
551
552
553
554
555
556
557
558
559
560
561
562
563
564
565
566
567
568
569
570
571
572
573
574
575
576
577
578
579
580
581
582
583
584
585
586
587
588
589
590
591
592
593
594
595
596
597
598
599
600
601
602
603
604
605
606
607
608
609
610
611
612
613
614
615
616
617
618
619
620
621
622
623
624
625
626
627
628
629
630
631
632
633
634
635
636
637
638
639
640
641
642
643
644
645
646
647
648
649
650
651
652
653
654
655
656
657
658
659
660
661
662
663
664
665
666
667
668
669
670
671
672
673
674
675
676
677
678
679
680
681
682
683
684
685
686
687
688
689
690
691
692
693
694
695
696
697
698
699
700
701
702
703
704
705
706
707
708
709
710
711
712
713
714
715
716
717
718
719
720
721
722
723
724
725
726
727
728
729
730
731
732
733
734
735
736
737
738
739
740
741
742
743
744
745
746
747
748
749
750
751
752
753
754
755
756
757
758
759
760
761
762
763
764
765
766
767
768
769
770
771
772
773
774
775
776
777
778
779
780
781
782
783
784
785
786
787
788
789
790
791
792
793
794
795
796
797
798
799
800
801
802
803
804
805
806
807
808
809
810
811
812
813
814
815
816
817
818
819
820
821
822
823
824
825
826
827
828
829
830
831
832
833
834
835
836
837
838
839
840

[illegible]

↑ ↑ ↑ ↑ ↑ ↑ ↑ ↑ ↑ ↑

[illegible]

~~~~~

|  |  |  |  |
|--|--|--|--|
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |