Exploring the World of Science

University of Michigan Science Olympiad
2021 Invitational Tournament

Codebusters C

Test length: 50 Minutes

Team name: _____ **Team number:** _____

Student names: _____

Question	Value	Incorrect letters	Deduction	Score
Timed	100			
1	100			
2	150			
3	250			
4	250			
5	350			
6	300			
7	400			
8	600			
9	250			
10	150			
11	150			
12	450			
13	150			
14	250			
15	200			
16	200			
17	600			
18	500			
19	500			
Bonus				
Final Score				

The following tables might be useful during the event.

	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**	**O**	**P**	**Q**	**R**	**S**	**T**	**U**	**V**	**W**	**X**	**Y**	**Z**
A	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
B	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A
C	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B
D	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C
E	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D
F	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E
G	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F
H	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G
I	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H
J	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I
K	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J
L	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K
M	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L
N	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M
O	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N
P	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Q	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
R	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
S	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
T	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
U	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
V	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
W	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
X	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
Y	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X
Z	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y

A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**	**O**	**P**	**Q**	**R**	**S**	**T**	**U**	**V**	**W**	**X**	**Y**	**Z**
0	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

A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**	**O**	**P**	**Q**	**R**	**S**	**T**	**U**	**V**	**W**	**X**	**Y**	**Z**
Z	Y	X	W	V	U	T	S	R	Q	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A

1	3	5	7	9	11	15	17	19	21	23	25
1	9	21	15	3	19	7	23	11	5	17	25

AAAAA	A	**AABBA**	G	**ABBAA**	N	**BAABA**	T
AAAAB	B	**AABBB**	H	**ABBAB**	O	**BAABB**	U/V
AAABA	C	**ABAAA**	I/J	**ABBBA**	P	**BABAA**	W
AAABB	D	**ABAAB**	K	**ABBBB**	Q	**BABAB**	X
AABAA	E	**ABABA**	L	**BAAAA**	R	**BABBA**	Y
AABAB	F	**ABABB**	M	**BAAAB**	S	**BABBB**	Z

Frequency Table of English letters:

E -	12.51%	S -	6.54%	C -	3.06%	G -	1.96%	K -	0.67%
T -	9.25%	R -	6.12%	U -	2.71%	W -	1.92%	X -	0.19%
A -	8.04%	H -	5.49%	M -	2.53%	Y -	1.73%	J -	0.16%
O -	7.60%	L -	4.14%	F -	2.30%	B -	1.54%	Q -	0.11%
I -	7.26%	D -	3.99%	P -	2.00%	V -	0.99%	Z -	0.09%
N -	7.09%								

Frequency Table of Spanish letters:

E -	14.08%	I -	5.98%	M -	3.08%	Y -	1.09%	Z -	0.47%
A -	12.16%	L -	5.24%	P -	2.89%	V -	1.05%	Ñ -	0.17%
O -	9.20%	D -	4.67%	B -	1.49%	G -	1.00%	X -	0.14%
S -	7.20%	T -	4.60%	H -	1.18%	F -	0.69%	K -	0.11%
N -	6.83%	U -	4.69%	Q -	1.11%	J -	0.52%	W -	0.04%
R -	6.41%	C -	3.87%						

For the purposes of cryptograms it is customary to treat n and ñ as distinct letters, but a and á are the same letter. Likewise for e and é, and i and í. In other words, all the accent marks get amputated when working with cryptograms. Also, while some older Spanish dictionaries consider ch, ll, and rr, to be their own letters—this has fallen out of modern usage. Accordingly, “burro” is considered as five letters: “b-u-r-r-o” and not as four letters “b-u-rr-o.”

Morse Code:

A	●−
B	−●●●
C	−●−●
D	−●●
E	●

F	●●−●
G	−−●
H	●●●●
I	●●
J	●−−−

K	−●−
L	●−●●
M	−−
N	−●
O	−−−

P	●−−●
Q	−−●−
R	●−●
S	●●●
T	−

U	●●−
V	●●●−
W	●−−
X	−●●−
Y	−●−−
Z	−−●●

0	−−−−−
1	●−−−−

2	●●−−−
3	●●●−−

4	●●●●−
5	●●●●●

6	−●●●●
7	−−●●●

8	−−−●●
9	−−−−●

●	E
●●	I
●●●	S
●●●●	H
−●●●	B
−−−−−	0
●●●●●	5

−	T
●−	A
●●−	U
●●●−	V
−●●−	X
●−−−−	1
−●●●●	6

−●	N
●−●	R
●●−●	F
−●−●	C
●●−−−	2
−−●●●	7

−−	M
●−−	W
●−●●	L
−●−−	Y
●●●−−	3
−−−●●	8

−●●	D
●−−●	P
−−●●	Z
●●●●−	4
−−−−●	9

−●−	K
●−−−	J
−−●−	Q

−−●	G

−−−	O

Codebusters Division C - University of Michigan Invitational School:_____

Timed Question **[100 points]** Solve this quote from one of my favorite shows. When you have solved it, raise your hand so that the time can be recorded and the solution checked.

PE BAA YDPEQN, ZEC LBEEZY JPE JPYD UCKCENC BAZEC. YZ

JPE, FZM OMNY BYYBLH.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
Frequency	3	5	5	2	9	1		1		3	1	2	2	3	1	5	1				1				7	5
Replacement																										

Codebusters Division C - University of Michigan Invitational

1) **[100 points]** Solve this Caesar Cipher with a shift of 11.

T	Q		E	T	X	P		E	C	L	G	P	W		T	D		A	Z	D	D	T	M	W	P	,		H	S	P	C	P		L	C	P
																											,											

E	S	P		E	Z	F	C	T	D	E	D		Q	C	Z	X		E	S	P		Q	F	E	F	C	P	?
																												?

2) **[150 points]** Solve this quote from a Russian author. It has been encoded with a Caesar Cipher.

X	L	I	V	I	'	W		S	R	P	C		S	R	I		X	L	M	R	K		X	L	E	X		G	E	R		W	E	Z	I		E
					'																																	

Q	E	R		J	V	S	Q		Q	E	H	R	I	W	W		E	R	H		X	L	E	X	'	W		Y	R	G	I	V	X	E	M	R	X	C	.
																										'													.

Codebusters Division C - University of Michigan Invitational School:_____

3) **[250 points]** Solve this Aristocrat encoded with a K1 alphabet.

EHR EXMPWQ SDO MPVMPMEO: EXO FPMGODQO SPL XFNSP

QEFBMLMEJ; SPL M'N PRE QFDO STRFE EXO FPMGODQO.

K1	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
Frequency		1		4	9	6	2	1		1		3	9	2	9	9	5	3	5	1		1	1	4		
Replacement																										

4) **[250 points]** Solve this saying by Benjamin Franklin.

SVJ UPOMJLS NQJLSCPU CU SVJ FPYMB CL, FVTS ZPPB GTD

C BP CU CS?

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
Frequency		3	6	1		2	1			4		3	2	1	1	6	1		6	2	4	3			1	1
Replacement																										

5) **[350 points]** Solve this Aristocrat about the existence of extraterrestrial life.

TDSHEASHT A ERAUF ERH TIYHTE TAOU ERZE AUEHKKAOHUE

KAJH HQATET HKTHGRHYH AU ERH IUALHYTH AT ERZE UDUH

DJ AE RZT EYAHV ED BDUEZBE IT.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
Frequency	13	2		5	17	1	1	17	3	2	4	1			2		1	7	2	12	9	1			4	4
Replacement																										

6) **[300 points]** Solve this Aristocrat.

L SLT HYE YLC PVVT DYBEFXY PZDDVB VIRVBZVTQVC LTU

DBLGVNNVU WLB VTMEJC VGVT YZC CFWWVBZTXC LWDVB L

DZSV.

Replacement																										
K2	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
Frequency		7	6	6	3	2	2	1	1	1		8	1	2		2	1	1	2	7	2	15	4	2	5	5

Codebusters Division C - University of Michigan Invitational School:_____

7) **[400 points]** Solve this Aristocrat with spelling errors. The last word is LIFE.

I BIQ SDZ CIVKO PSZ SIMOP SZQ ZFV ZW PDNBK DIO HQZP

CMOUZTKVKC PDK TIJFK ZW JMWK.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
Frequency		2	3	4		2		1	6	2	7		3	1	4	5	3		4	2	1	3	3			8
Replacement																										

8) **[600 points]** Solve this xenocrypt from a Spanish novel, which has been encoded with a K1 alphabet. The keyword is in English.

VQFK FC JQDUKÑQ Z XCXH FWJNQU HPQU, RQTSWK GH FHZQT

GQJWTH SWK RWKEK NHJKT WD NQFITK KD KUVH XCEH KU

EKÑHTUK FQTCT.

K1	A	B	C	D	E	F	G	H	I	J	K	L	M	N	Ñ	O	P	Q	R	S	T	U	V	W	X	Y	Z
Frequency			4	3	3	6	2	9	1	4	13			3	2		1	10	2	2	8	6	2	6	3		2
Replacement																											

Codebusters Division C - University of Michigan Invitational

9) **[250 points]** Decrypt the following cipher text which was encoded using the Affine Cipher with a=11 and b=3.

R	B	K		K	B	V	T		Q	B	E		M	U	D	H		K	N	Z	V		L	N	E	C		E	C	V

P	Q	N	A	V	I	T	V	.
								.

10) **[150 points]** Encrypt the phrase **The quick brown fox jumps over the lazy dog** using the Affine Cipher with a=15 and b=9.

T	H	E		Q	U	I	C	K		B	R	O	W	N		F	O	X		J	U	M	P	S		O	V	E	R		T	H	E		L	A	Z	Y

D	O	G	.
			.

Codebusters Division C - University of Michigan Invitational School:_____

11) **[150 points]** A phrase by Robert Frost has been encoded using the Vigenère cipher with a code word of TRAVEL. What does it say?

B	E	T	C	V

P	X	N	O	M

H	D	B	T	A

I	W	F	F	L

P	Z	Z	P	K

P	T	C	M	Y

Z	Z	V	Z	P

P	T	I	N	Z

H	L	U	F	U

O	P	T	Y	V

I	O	K	Z	X

J	O	I

12) **[450 points]** Solve this cipher.

A BOOK IS NOT BADLY ENDED BY OLD LINES IDEAS BASED

WORLD TOWNS UNDER ADOPT AWAKE ONION ASHES GAMMA ELVIS

GEESE ULTRA ENTRY CHILI MEDIA ULTRA ABYSS ACRES ACTOR

JUICE ORBIT SHARP LEMON GOATS LOGIC QUICK HEAVY AGING

WORLD FIFTY UPPER PEARL GRIND TOOTH LAUGH DUSTY GAVEL

AN EYE DAISY DEMON HOWLS CRIME ALBUM POUND GENIE

STRAW BEADS BEEPS EARTH WIRES PAINT ALLOW CHESS LIGHT

CURSE DOCKS HEIST GATES

13) **[150 points]** Using a key of **VEIL** compute the decryption matrix for a 2x2 Hill with a 26 character alphabet.

$$\begin{pmatrix} V & E \\ I & L \end{pmatrix} \equiv \begin{pmatrix} 21 & 4 \\ 8 & 11 \end{pmatrix}$$

$$\left(\begin{array}{|c|c|} \hline \quad & \quad \\ \hline \quad & \quad \\ \hline \end{array} \right)$$

14) **[250 points]** Decode this phrase which has been encoded using a 2x2 Hill cipher with a keyword of **DENT.**

$$\begin{pmatrix} D & E \\ N & T \end{pmatrix} \equiv \begin{pmatrix} 3 & 4 \\ 13 & 19 \end{pmatrix}$$

I	Y	J	T	B	L	F	J	B	U

Codebusters Division C - University of Michigan Invitational School:_____

15) **[200 points]** Solve this quote from Oscar Wilde which has been encoded using the Morbit Cipher. You are told that **2=●●, 4=●–, 6=××, 9=–●, 1=—, and 7=×–.**

9 2 5 6 9 1 7 1 5 4 5 9 5 2 5 5 9 8 2 9 6 8 2 4 5

5 9 7 4 3 1 3 9 5 6 8 4 2 5 2 5 6 2 5 2 6 4 5 9 8

4 8 8 4 7 2 7 4 3 7 5 3 9 3 8 9

16) **[200 points]** Solve this quote from another one of my favorite shows which has been encoded using the Pollux Cipher. You are told that **3=●, 4,9=–, 5,8=×.**

9813667672995141731818663853451230155230294547333 1816

0418223774289920321838797633601952305129849983460213 5631

5864046265939301839410408194713310198287469452997639553364

76756118106796

17) **[600 points]** A phrase has been encoded as a Patristocrat using a K1 alphabet. What does it say?

RSCLW RTWRU WIPWD CSKPI PGFPB WCWDS RUOCS KPXRB

PFDCS SBRSJ WDCLP CWQPC SXRBP FDCGR BQSFP DSCLG

CJPQG OIPGF UPDD

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
Frequency		5	11	8		5	5		3	2	2	3			2	13	3	8	10	1	3		8	2		
Replacement																										

18) **[500 points]** A quote from Bill Watterson has been encoded as a Patristocrat using a randomized alphabet. The first four letters are INMY.

ZOGXS BZOZS OJFUS ORUFL SRFOF YNMXF OSDET PIZFO

RZVZI NFPFY NITRS VZOUZ OEYID NFVSN QFNHP

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
Frequency		1		2	2	10	1	1	4	1		1	1	6	9	3	1	4	7	2	3	3		2	3	8
Replacement																										

Codebusters Division C - University of Michigan Invitational School:_____

19) **[500 points]** Solve this Patristocrat encoded with a K2 alphabet. The word **over** is repeated twice.

TBGQB THOTG VCTBY HZWGQ LWHZT BYCKW FQBVC KWFQY

QTBSJ HWNDW UHTBY VTXXW FWBHF WGJAH G

Replacement																									
K2	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
Frequency	1	8	3	1		4	5	7		2	2	1		1	1		5		1	8	1	3	9	2	4	2