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Solve the following cryptarithmic Problem.

1. SEND + MORE = MONEY. 2, 3, 4, 5

	S	E	N	D
	9	~~6~~5	~~7~~6	7
	M	O	R	E
	1	0	8	~~6~~5
M	0	N	E	Y
1	0	~~7~~6	~~6~~5	2

9 5 6 7
1 0 8 5
1 0 6 5 2

Characters		codes
S	→	~~8 or 9~~ 9
E	→	~~6~~ 5
N	→	~~7~~ 6
D	→	7
M	→	1
O	→	0
R	→	8
Y	→	2

Writing in the form of Equation

$D + E = Y + 10 \cdot X_1$

$X_1 + N + R = E + 10 \cdot X_2$

$X_2 + E + O = N + 10 \cdot X_3$

$X_3 + S + M = O + 10 \cdot X_4$

$X_5 = M$

1. M=1, since carry from two digits and and another carry can't total more than 19

2. S can be 8 or 9 since

$S + M + X_3 > 9 \rightarrow S + X_3 > 8$

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3. $O = 0$, since $S + M + X_3$ must be at least 10 and at most 11.
But $M = 1$ so $O = 0$

4. $N = E$ or $N = E + 1$.
Since $N <> E$, $N = E + 1$.

let $S = 9$, $X_3 = 0$
Choose E as first choice as variable selection since it appears most.
$X_1 + N + R = E + 10 X_2$
let $E = 5$ and $X_1 = 1$, $N = 6$
$1 + 7 + R = 16$
Hence $R = 8$.

Also $D + E + Y = 10$.
$D + 6 + Y = 10$.
~~$D + Y = 4$.~~ ~~This value differs~~.

Thus. $S = 9$, $E = 5$, $N = 6$, $D = 7$.
$M = 1$, $O = 0$, $R = 8$, $Y = 2$.

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2. ONE + ONE + TWO = FOUR

	2	1	
	O	N	E
	4	2 ~~5~~ 9	3
	O	N	E
	4	2 ~~5~~ 9	3
	T	W	O
	~~04~~	~~28~~	4
F	O	U	R
1	4	~~8~~ ~~6~~ 7	0

Character		Code	
O	—	2	
N	—	9	
E	—	4	3
T	—	6	3
W	—	8	
F	—	1	
U	—	7	
R	—	0	

	2	1	
	O	N	E
	2	9	4
	O	N	E
	2	9	4
	T	W	O
	~~16~~	8	2
F	O	U	R
1	2	7	0

	2	1	
	2	9	4
	2	9	4
	6	8	2
1	2	7	0

1. F = 1 or 2, But as O cant be ~~greater than (9, 8 or 7)~~ greater than 4, so F cant get carry 2.

Reason. ~~2+~~ O + O + T = O + ~~10~~ 20

If O = 9. T = ~~11~~ which is Not possible

O = 5, T =

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1. F = either 1 or 2. As sum of three one digit numbers and their carry (max 2) cant exceed 29.

lets put F = 1.

2. Equations.

$E + E + O = R + 10 \cdot X_1$ — (i)

$X_1 + N + N + W = U + 10 \cdot X_2$ — (ii)

$X_2 + O + O + T = O + 10 \cdot X_3$ — (iii)

$X_3 = F = 1$. — (iv).

2. $X_2 + O + O + T = O + 10 \cdot X_3$

Since first letter can't be 0, ($O \neq 0$, $T \neq 0$).

let $X_2 = 2$, $O = 2$.

$2 + 2 + 2 + T = 2 + 10$.

$\therefore T = 12 - 6 = 6$.

3. $X_1 + N + N + W = U + 10 \cdot X_2$.

let, $N = 9$. $X_1 = 1$

$1 + 18 + W = U + 20$.

$W = U + 1$ ——— (v).

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4. $E + E + O = R + 10 \cdot X_1$.

we know
$X_1 = 1$, $O = 2$.

$2E + 2 = R + 10$

$2E = R + 8$. — (vi).

Solving eqn (v).
we have Numbers available (3, 4, 5, 7, 8)

$W = U + 1$.
if $U = 7$.
$W = 8$.

Solving eqn (vi).
Numbers available (3, 4, 5, 0).

$2E = R + 8$
if $E = 4$.
$8 = R + 8$
$\therefore R = 0$.

Thus, Solution is.

Character	Code.
O	2
N	9
E	4
T	6
W	8
F	1
U	7
R	0

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2. RIGHT + RIGHT = WRONG.

					Char		Code
R	I	G	H	T	R	→	4
4	2	0	36	5	I	→	2
R	I	G	H	T	G	→	0.
4	2	0	36	5	H	→	6
W	R	O	N	G.	T	→	5
8.	4	1	73	0	W	→	8
					O	→	1
4	2	0	6	5	N.	→	3
4	2	0	6	5			
8	4	1	3	0.			

equations.

$T + T = G + 10.x_1$ — (i)

$x_1 + H + H = N + 10.x_2$ — (ii)

$x_2\ G + G + O = O + 10\ x_3$ — (iii)

$x_3 + I + I = R + 10.x_4$ — (iv)

$x_4 + R + R = W$ — (v)

Since G is repeated most let put G=0.

$T + T = 0 + 10.1$ & x_1 must be 1.

$2T = 10$

$T = 5.$

eqn (iii).

$x_2 + 0 + 0 = 0 + 10.x_3$ [x_3 must be 0].

$x_2 + 0 + 0 = 0.$ [O cant be 0, Thus $x_2 = 1$]

$0 = 1.$

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$X1 + H + H = N + 10 \cdot 1$

$1 + 2H = N + 10$

$2H = N + 9.$ — (iv)

$X3 + I + I = R + 10 \cdot X4.$

$X3 = 0.$

and. adding.

$X4 + R + R = W.$

$2I = R + 10 \cdot X4$

$X4 + 2R = W.$

$2I + R = W + 9X4.$ — (v).

Solving eqn (iv).

If $H = 6$

$12 = N + 9$

$\therefore N = 3.$

Solving (v).

Remaining Numbers (2, 4, 5, 7, 8).

$2I + R = W + 9X4.$

let. $I = 2, X4 = 0$

Then.

$R = 4.$

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Putting R = 4 we get

$4 + 4 = W$

$W = 8$

Solution is:

R = 4
I = 2
G = 0
H = 6
T = 5
W = 8
O = 1
N = 3

Q. No. 3.

WRONG + WRONG = RIGHT.

					Char	Code.
1	1		1			
W	R	O	N	G	W	2
2 3	5 7 8 4	6	4 1	2 7	R	7 4
W	R	O	N	G	O	6 7
2 3	5 7 8 4	6	4 1	2 7	N	4 6
R	I	G	H	T	G	2 5
4 6 5 7	4 5 9	2 7	8 9 3	4	T	5 9
		1			H	8 3
2	4	9 7	6	8 5	T	4 0.
2	4	9 7	6	7 8 5	2 4 7 6 5	
4	9	8 5	3	6 0	2 4 7 6 5	
					= 4 9 5 3 0	

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Equations.

$G + G =$

$G + G = T + 10 \cdot Y_1$

$Y_1 + N + N = H + 10 \cdot Y_2$

$Y_2 + O + O = G + 10 Y_3$

$Y_3 + R + R = I + 10 \cdot Y_4$

$Y_4 + W + W = R + 10 \cdot$

Since G cant be 0 and W and R too.
So.

~~let~~ from eqn (i).

let $G = 7$.

$7 + 7 = T + 10 \cdot 1$.

$14 = T + 10$.

$T = 4$.

from (ii).

Since 4 and 7 cant be used.

$1 + N + N = H + 10 \cdot Y_2$

let $N = 6$

$1 + 6 + 6 = H + 10 \cdot 1$

$13 = H + 10 \cdot 1$

$\therefore H = 3$.

from (iii).

since 3, 4, 6, 7 are already used.

$Y_2 + O + O = G + 10 \cdot Y_3$.

$1 + 20 = 7 + 10$.

$20 = 16$

$O = 8$.

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Again (3, 4, 6, 7, 8).

from (iv).

$1 + 2R = I + 10 \cdot X4$

if $R = 2$.

$1 + 4 = I + 10 \cdot 0$

$I = 5$.

from eqn v.

$0 + W + W = 2$.

Thus $W = 1$.

The final solution is

W	1
R	2
O	8
N	6
G	7
I	5
N	3
T	4

Soln 1:

$$\begin{array}{r} 1\ 2\ 8\ 6\ 7 \\ 1\ 2\ 8\ 6\ 7 \\ \hline 2\ 5\ 7\ 3\ 4 \end{array}$$

Soln 2.

$$\begin{array}{r} 2\ 4\ 7\ 6\ 5 \\ 2\ 4\ 7\ 6\ 5 \\ \hline 4\ 9\ 5\ 3\ 0 \end{array}$$

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iv) LOGIC + LOGIC = PROLOG.

							Character		code.
	L	O	G	I	C	L		→	9
	9	0	4	5	7	0		—	0
	L	O	G	I	C	G		→	4
	9	0	4	5	7	I		→	5
P	R	O	L	O	G	C		→	2
1	8	0	9	0	4	P		→	1
						R		→	8.

	9	0	4	5	2
	9	0	4	5	2
1	8	0	9	0	4

$C + C = G + 10 \cdot x_1$
$x_1 + I + I = O + 10 \cdot x_2$
$x_2 + G + G = L + 10 \cdot x_3$
$x_3 + O + O = O + 10 \cdot x_4$
$x_4 + L + L = R + 10 \cdot x_5$
$x_5 = P$

Reasoning

1. P=1, as sum of two digit number and their carry will always be ~~equal~~ less than 19.

2. As sum of O should be Give its own thus O must be 0.
from iv).
$x_3 + O + O = O + 10 \cdot x_4$
$\therefore x_3 = 0$
$x_4 = 0$.

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3. $x_1 + I + I = 0 + 10 \cdot x_2$

I must be equal to 5.

$x_1 + 5 + 5 + 0 + 10 \cdot x_2$.

$\therefore x_2 = 1$ and $x_1 = 0$.

2. from eqn (i).

$C + C = G + 10 \cdot 0$.

$\therefore$ let $C = 2$

$2 + 2 = 4 \cdot G$

$\therefore G = 4$.

3 from eqn (iii).

$T + 0 + 4 + 4 = L + 10 \cdot 0$.

$L = 9$.

4 from eqn (4)

used ~~Remaining~~ Numbers (0, 1, 2, 4, 5, 9).

$0 + L + L = R + 10 \cdot 1$.

$2L = R + 10$.

~~let~~ $L = 9$. & from (iii))

Thus $R = 8$.

Solution is

$L = 9$ $\quad$ $P = 1$

$O = 0$ $\quad$ $R = 8$.

$G = 4$

$I = 5$

$C = 2$

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S=3 1

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v) CROSS + ROADS = DANGER

						C	9
	C	R	O	S	S	R	6
	9	6	2	3	3	O	2
	R	O	A	D	S	S	3
	6	2	5	1	3	A	5
D	D	A	N	G	E	R	D	1
1	5	8	7	4	6	N	8
						G	7
						E	4

Equations

$S + S = R + 10 \cdot x_1$ — (i)

$x_1 + S + D = E + 10 \cdot x_2$ — (ii)

$x_2 + O + A = G + 10 \cdot x_3$ — (iii)

$x_3 + R + O = N + 10 \cdot x_4$ — (iv)

$x_4 + C + R = A + 10 \cdot x_5$ — (v)

$x_5 = D$ — (vi)

$D = 1$. $\therefore x_5 = 1$.

1 D=1, since the sum of two digits number and carry can't be greater than 19.

2. from eqn (i).

let. $S = 3$.

$8 + 3 = R + 10 \cdot 0$

$\therefore R = 6$

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3. from eqn (2)

$S = 3, \quad D = 1.$

$\therefore \cancel{S+} \; X_1 + S + D = E + 10 \times 1.$

$0 + 3 + 1 = E + 10.0$

$\therefore E = 4.$

4. from eqn (3).

$\cancel{C + R \times 2} + O + A = G + 10.\times 3.$

$0 + 0 + A = G + 10.\times 3.$

let $O = 2$ and $A = 5.$

$7 = G + 10.0$

$\therefore G = 7.$

4. from eqn (iv).

$\times 3 + R + O = N + \times 4.10.$

$0 + 6 + 2 = N + 0.$

$\therefore N = 8.$

5. Since we have $R = 3$ and $A = 5.$

Putting it in equation.

$X_4 + C + R = A + 10.\times 5.$

$0 + C + 6 = 5 + 10.$

$\therefore C = 15 - 6$

$\therefore C = 9.$

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The required solution is:

C = 9
R = 6
O = 2
S = 3
A = 5
D = 1
N = 8
G = 7
E = 4.

vi] BASE + BALL = GAMES.

					Char	code
B	A	S	E		B	7
7	4	8	3		A	4
B	A	L	L		S	8
7.	4	5	5		E	3
G	A	M	E	S.	L	5
1	4	9	3	8	G	1.
					M	9.

1. Equations:

$E + L = S + 10 \cdot x_1$

$x_1 + S + L = E + 10 \cdot x_2$

$x_2 + A + A = M + 10 \cdot x_3$

$x_3 + B + B = A + 10 \cdot x_4$

$x_4 = G$

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1. $G = 1$. Since the sum of two digit Numbers and their sum can't be more than 19.

2. L Must be 5 because to get sum of two numbers interchanging initial and final value, as in eqn (i) and (ii).

E can be either 2 or 3

S can be either 7 or 8.

from eqn (i).

let $E = 3$.

$3 + 5 = 8 + 10 \cdot x_1$.

$8 = 8 + 10 \cdot x_1$. $[x_1 = 0]$.

$S = 8$.

so, from eqn (ii).

$x_1 + S + L = E + 10 \cdot x_2$.

$0 + 8 + 5 = 3 + 10 \cdot x_2$.

$x_2 = 1$.

3. The Numbers already used $(1, 3, 5, 8)$.

from eqn (3)

$x_2 + 2A = M + 10 \cdot x_3$.

lets put value of A one unused number $A = 4$

$1 + 8 = M + 10 \cdot x_3$.

$9 = M$. $[x_3 = 0]$

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4. The already used Numbers : (4, 3, 4, 5, 8, 9).
solving eqn (iv)

$$\cancel{Y}_3 + 2B = A + \cancel{Y}_4 \cdot 10$$
$$0 + 2B = 4 + 10.$$
$$2B = 14.$$
$$\therefore B = 7.$$

Thus there are unique numbers for unique alphabet.

Our solution is.

B = 7
A = 4
S = 8
E = 3
L = 5
G = 1
M = 9

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(vii) ONE + ONE = TWO.

O	N	E	O	2
2	3	1	N	3
O	N	E	E	1
2	3	1	T	4
T	W	O	W	6
4	6	2		

Equations

$$E + E = O + 10 \cdot X_1$$
$$X_1 + N + N = W + 10 \cdot X_2$$
$$X_2 + O + O = T$$

1. O, N and T can't be 0 as we know we can't solve criptarithmic by 0 at starting.

2. We can assign value ~~from~~ (1, 2, 3, 4) to O because, There can't be carry over.
But O is sum of two ~~d~~ some digits
It can ~~have~~ be odd number.
value that can be assigned to O = {1, 2, 4}

let O = 2,
Then.
from ①.

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$2E + 1 = 2 + 10 \cdot x_1$ $[x_1 = 0]$.
$E = 1$.

3 from eqn (iii)

$x_2 + O + O = T$
$x_2 + 4 = T$
let $x_2 = 0$.
Then.
$T = 4$.

4. Since $x_2 = 0$, ~~There~~ N must be Number below 5. Thus.
let $N = 3$.
from eqn (ii)
$O + 3 + 3 = W + 10 \cdot x_2$.
$6 = W + 0$
$\therefore W = 6$.

Thus every Alphabet have unique Number.
The Ans is obtained

$O = 2$
$N = 3$
$E = 1$
$T = 4$
$W = 6$

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KYOTO + OSAKA = TOKYO

K	Y	O	T	O	K
6	3	5	7	5	Y
O	S	A	K	A	O
1 6	7	0	6	0	T
T	O	K	Y	O	S
7	0	6	3	5	A → O
					K

6 3 5 7 5

K	Y	O	T	O
6	1	5	2	5
O	S	A	K	A
5	4	0	9	0
T	O	K	Y	O
	5	6	1	5

K	Y	O	T	O
5	1 3 2	2	9 7 8	2
O	S	A	K	A
2	1	0	3 5	0
T	O	K	Y	O
8 9	2 1 3	3 5	6 3	2
			2	

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K	Y	O	T	O	K →	4
4	1	3	7	3	Y →	1
O	S	A	K	A	O →	3
3	2	0	4	0	T →	7
T	O	K	Y	O.	S →	2
7	3	4	1	3.	A →	0.

Equations:

$$O + A = O + \cancel{10 \times 1} \quad \text{— (i)}$$

$$T + K = Y + 10 \times 1 \quad \text{— (ii)}$$

$$X_1 + O + A = K \quad \text{— (iii)}$$

$$Y + S = O + 10 \cdot X_2 \quad \text{— (iv)}$$

$$X_2 + K + O = T \quad \rightarrow \text{(v)}$$

1. Here $A = 0$, Because $O + A = O$, so Any other solution for A is Not Possible.

2. $X_1 + O + A = K$. Since $A = 0$, the only possible solution is $0 + 1 = K$.

lets put $O = 3$.

Thus.

$3 + 1 = K$

$\therefore K = 4$.

3. from eqn 5.

we have $O = 3$ and $K = 4$, so.

$X_2 + 3 + 4 = T$. $[X_2 + 7 = T]$.

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From eqn (ii)

$T + K = y + 10 \cdot x_1$.

$K_2 + 7 + 4 = y + 10 \cdot x_1$. $[x_1 = 1]$.

$x_2 + 11 = y + 10$.

$\therefore x_2 = y - 1$

Since carry is only 1 or 0.
y is either 2 or 1.
let $y = 1$.

So. $x_2 = 0$
and
$T = 7$.

4. From eqn (iv).

$y + S = 0 + 10 \cdot 0$.

$1 + S = 3 + 0$

$\therefore S = 2$.

This is required Answer.

$T = 7$
$y = 1$
$O = 3$
$K = 4$
$S = 2$
$A = 0$. //

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APPLE + GRAPE = CHERRY.

A	P	P	L	E	A	—	6
	6	6	3	7	P	—	3
G	R	A	P	E	L	→	7
	0	8	6	7	E	→	4
C H	E	R	R	Y.	G	→	9
1	7	0	0	4	R	→	0
	contradic				C	—	1
					H	→	5
					Y.	→	8

A	P	P	L	E
	7	7	3	4
G	R	A	P	E
	0	2	7	4
C H	E	R	R	Y
1	4	0	0	6

A	P	P	L	E	6	3	3	7 4
6	3	3	7	4	9	0	6	3 4
G	R	A	P	E	5	4	0	0 8
9	0	6	3	4				
C	H	E	R	R	Y			
1	5	4	0	0	8			

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Equations:

$$E + E = Y + 10 \cdot x_1 \quad \text{— (i)}$$
$$x_1 + L + P = R + 10 \cdot x_2 \quad \text{— (ii)}$$
$$x_2 + P + A = E + 10 \cdot x_3 \quad \text{— (iii)}$$
$$x_3 + P + R = M + 10 \cdot x_4 \quad \text{— (iv)}$$
$$x_4 + A + G = C + 10 \cdot x_5 \quad \text{— (v)}$$
$$x_5 = C \quad \text{— (vi)}$$

1. $C = 1$, Because the sum of Two digits and its carry is always less than 19.

2. Since R is repeated most lets put $R = 0$. Then we get.

$$x_3 + P + 0 = E + 10 \cdot x_4.$$

It gives $P = E - 1$.

and

$$x_3 = 1 \quad \text{and} \quad x_4 = 0$$

as. $x_4 + A + G = M + 10 \cdot x_5$.

$$0 + A + G = M + 10 \cdot 1$$

Thus $A + G > 10$.

3. let from eqn (i).

$$E + E = Y + 10 \cdot x_1$$

let $E = 4$.

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$2 \times 4 = Y + 10 \times 1$. [Thus $X_1 = 0$].
$\therefore Y = 8$.

4. from Eq^n (iv)
As we got value of ~~a + L + P =~~ E we know $P = E - 1$.
$\therefore P = 4 - 1 = 3$.

5. from eq^n (ii), putting $P = 3$ and $R = 0$.

$L + 3 = 0 + 10 \times 2$.
$L = 10 - 3$
$\therefore L = 7$.

6. The used Numbers are (0, 1, 4, 8, 3, 7, 2)

from eq^n (iii).

$1 + 8 + A = 0 + 10 \times 3$.
$4 + A = 10$.
$A = 6$. [$\because X_3 = 1$].

7. As we know value of A we can use.
$0 + 6 + G = H + 10$.
$6 + G = H + 10$.
we ~~co~~ G is either 5 or 9
since putting $G = 5$ we will

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not get required solution let pick
$G = 9$.

$0 + 9 + 6 = 5 + H + 10$.
$\therefore H = 5$.

Since All alphabets are assigned unique value the required solution is obtained

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