BCS Programming Competition Heat 2005

1 Cribbage Scores

A "hand" in a game of cribbage comprises five playing cards: four in the player's hand and one communal card. The hand may score between 0 and 29 points, depending on the combination of cards held therein.

Terminology

Each card is named by a two-character string. The first character is the card's rank, and will be one of: A (Ace), 2, 3, 4, 5, 6, 7, 8, 9, J (Jack), Q (Queen) and K (King). The second character is the suit, and will be one of H (Hearts), C (Clubs), D (Diamonds) and S (Spades). So, for example, the Ace of Clubs would be "AC" and the Jack of Diamonds would be "JD".

Scoring system

The score of a cribbage hand is simply the sum of the combinations of cards therein. The scores for each combination of cards are:

Name	**Description**	**Score**
Pair	Two cards of the same rank	2
Run	Three or more cards of consecutive rank	The number of cards in the run (e.g. a run of four cards scores 4)
Fifteen	Any combination of cards whose face values add up to 15	2

For the above scoring system, all five cards (i.e. the four in the player's hand and the communal cards) may be used. Note that for the purposes of calculating combinations that add up to 15, the Ace scores 1, and the Jack, Queen and King all score 10.

Note that there are two "derived" multiples. Three of a kind scores 6, because in a set of three cards of the same rank, there are three possible pairs. Similarly, a set of four cards with the same rank scores 12, since there are six possible pairs. In fact, these derived multiples are merely a shorthand method used by Cribbage players when counting mentally - the correct score will always be reached by evaluating all the various combinations of pairs.

There are also some special, extra facets of scores.

Name	**Description**	**Score**
Flush	All four cards in the player's hand are of the same suit, but the communal card is not the same suit	4
Flush	All four cards in the player's hand and the communal card are in the same suit	5
One for His Nob	The player's hand contains a Jack which is the same suit as the communal card	1

Let us look at an example. Assume we have a hand containing AH, AD, 2H and 3H, and that the communal card is KC. The scoring is as follows:

- AH + AD + 3H + KH = 15, so score 2
- 2H + 3H + KH = 15, so score 2
- AH and AD are a pair, so score 2
- AH, 2H, 3H is a run of three, so score 3
- AD, 2H, 3H is a run of three, so score 3

The score for this hand is therefore 12.

Let's now look at a second example, which scores the highest possible figure of 29. The hand is 5D, 5H, 5S and JC and the communal card is 5C:

- 5D + 5H + 5S = 15, so score 2
- 5D + 5H + 5C = 15, so score 2
- 5D + 5S + 5C = 15, so score 2
- 5H + 5S + 5C = 15, so score 2
- 5D + JC = 15, so score 2
- 5H + JC = 15, so score 2
- 5S + JC = 15, so score 2
- 5C + JC = 15, so score 2
- 5D, 5H, 5S and 5C are four of a kind, so score 12

The communal card is a Club and we hold the Jack of Clubs, so score 1

Input Data

You will be given a set of lines, with each line representing a hand. The cards in the hand will be separated by one or more spaces, and the last card will be the communal card. The end of the file while be after the final line of input.

Output Data

You should output the score for each hand, one per line. There is a tradition among Cribbage players that dictates that a hand containing no points whatsoever is said to score 19. This is because there is no combination of cards in a Cribbage hand that adds up to 19. You should follow this tradition.

Sample Input

```
AH AD 2H 3H KC
2H 4D 6C 8D 10S
4H 6C 4S 4D 5C
5D 5H 5S JC 5C
```

Sample Output

```
12
19
21
29
```

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2A John Humphrys' Clock

Regular listeners to BBC Radio 4's "Today" programme will know that the presenters frequently state what time it is, using a traditional notation ("Sixteen minutes to nine") rather than the more modern approach familiar to digital watch users ("Eight forty-four").

Regular listeners will also know that the presenters get it wrong from time to time - for example saying "Nine minutes to eight" when the time is 8:51 - because when combined with the busy nature of presenting the programme, the additional workload of mentally translating the time from the studio clock occasionally results in human error.

Your task is to write a program to translate a digital clock into the language that John Humphrys and his colleagues use on the Today programme.

There are three main classifications of time:

1. Quarter-hours

On the hour, on the half-hour, and at fifteen minutes past/to the hour, the time is simply stated using the following pattern:

- Seven o'clock
- Quarter past seven
- Quarter to nine
- Half past eight

2. Five minutes

If the number of minutes past the hour is divisible by five, and is not covered by one of the quarter-hour options mentioned in (1) above, the time is simply stated as the number of minutes past the hour (if the number of minutes is less than 30) or the number of minutes to the hour (if the number of minutes is more than 30). The word "minutes" is omitted. Examples are:

- Twenty-five past six
- Twenty to eight

3. The rest

For times not covered by the above two options, the time is read as per option (2), but with the word "minutes" included (or "minute" if the number of minutes is one). For example:

- Eight minutes past seven
- Four minutes to nine

Input Data

The input data will comprise a set of times in digital notation, one per line. You may assume that times will be from 1:00 to 11:59 inclusive (with no leadig zeros), and that there is no need to deal with am/pm. The end of file will be after the final line of data.

Output Data

The output should contain one line for each input line, with each line containing the appropriate time (as per the method described in (1)-(3) above) in words. The first letter of each line should be capitalised (as per the sample output), hyphenation and pluralisation should be used correctly, and all numbers must be correctly spelt.

Sample Input

```
7:00
9:21
8:42
10:39
4:05
```

Sample Output

```
Seven o'clock
Twenty-one minutes past nine
Eighteen minutes to nine
Twenty-one minutes to eleven
Five past four
```

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2B John Humphrys' Clock

In part A, you wrote a program to translate digital times into words. There was, however, no need to cater for times later than 11:59.

In this part of the question, your task is to extend your program to cater for all possible times on the 24-hour clock.

Input Data

The format of the input data is as per part A, except that times will be from 0:00 to 23:59 inclusive.

Output Data

The form of the output is as per part A, except for two additional cases that should be applied before case (1) of part A:

- 0:00 should be output as "midnight"
- 12:00 should be output as "noon".

There is no need to stipulate am or pm.

Sample Input

```
17:00
0:01
21:21
18:42
10:39
14:05
12:00
```

Sample Output

```
Five o'clock
One minute past twelve
Twenty-one minutes past nine
Eighteen minutes to seven
Twenty-one minutes to eleven
Five past two
Noon
```

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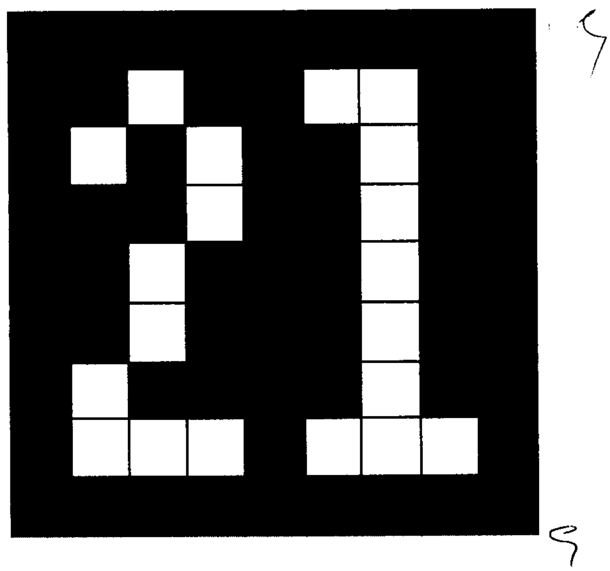
4 Jigsaw 21

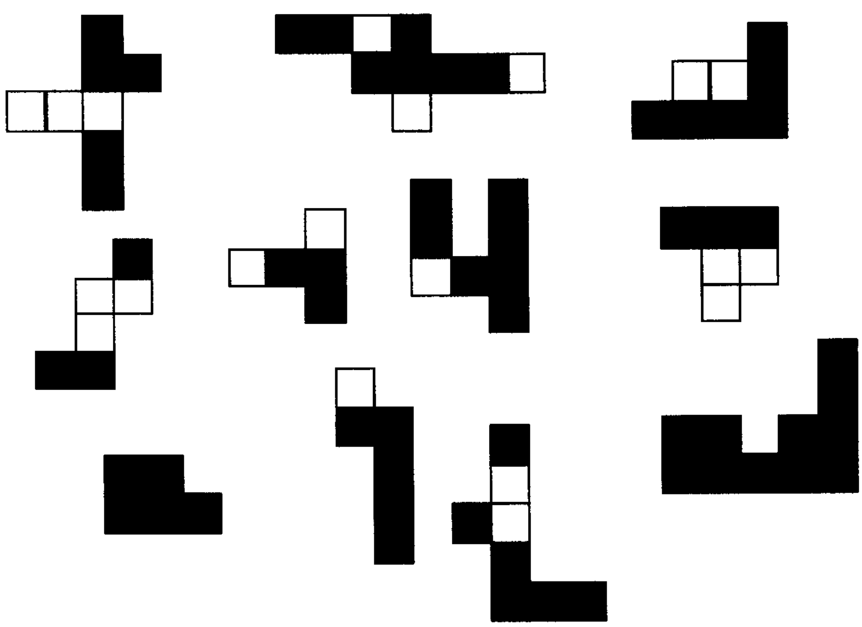
Your task is to re-assemble the pieces of a jigsaw.

Each jigsaw when reconstructed is in the form of a 9x9 grid of blocks, as in the example below:



It will be split into a number of distinctly shaped pieces, each comprising at least 5 continguous blocks. Each of these pieces may have been rotated through 90 or 180 degrees but will not be mirrored.

For example:



Input

Input will consist of several sets of jigsaw pieces. Within each set, the pieces will be represented by O for a blue block and X for a white block. Pieces will occupy several lines but there will be no more than one piece on any line.

Lines will not contain trailing spaces and all pieces will be left-aligned.

You may assume that it is always possible to reconstitute the jigsaw from the pieces you are given.

There will always be one blank line between pieces and no two pieces will be identical.

After all pieces have been described, there will be a single line beginning with "21" which signifies the end of that jigsaw puzzle. After the final jigsaw there will be a line consisting solely of "##"

Output

For each jigsaw, you are required to output the position of each of the pieces, using letters to represent each one.

As you read the pieces in, the blocks in the first piece you come to should be labelled "A", the next "B" and so on.

Thus, the output will be nine lines of nine characters where each is a letter representing the piece to which it belongs.

There must be a single blank line after each jigsaw you output.

The jigsaw must always be reconstructed with the "21" vertical, as in the example and you may assume that there will only be one possible output for each jigsaw.

Sample Input

```
  O
  OO
XXX
  O
  O

OOXO
  OOOOX
   X

   O
 XXO
OOOO

O O
O O
XOO
  O

  X
XOO
  O

OOO
 XX
 X
```

```
   O
  XX
  X
 OO

    O
    O
OO OO
OOOOO

X
OO
 O
 O
 O

 O
 X
OX
 O
 OOO

OO
OOO
21
##
```

Sample Output

```
DJJJGHHHH
DDDJGGGHH
DEDJJKGGH
DEDJKKAHH
EEEJKKAHH
BBBBAAAAA
FFBBBBBAC
FFFBIICCC
FIIIICCCC
```

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3A Lagrangian Points

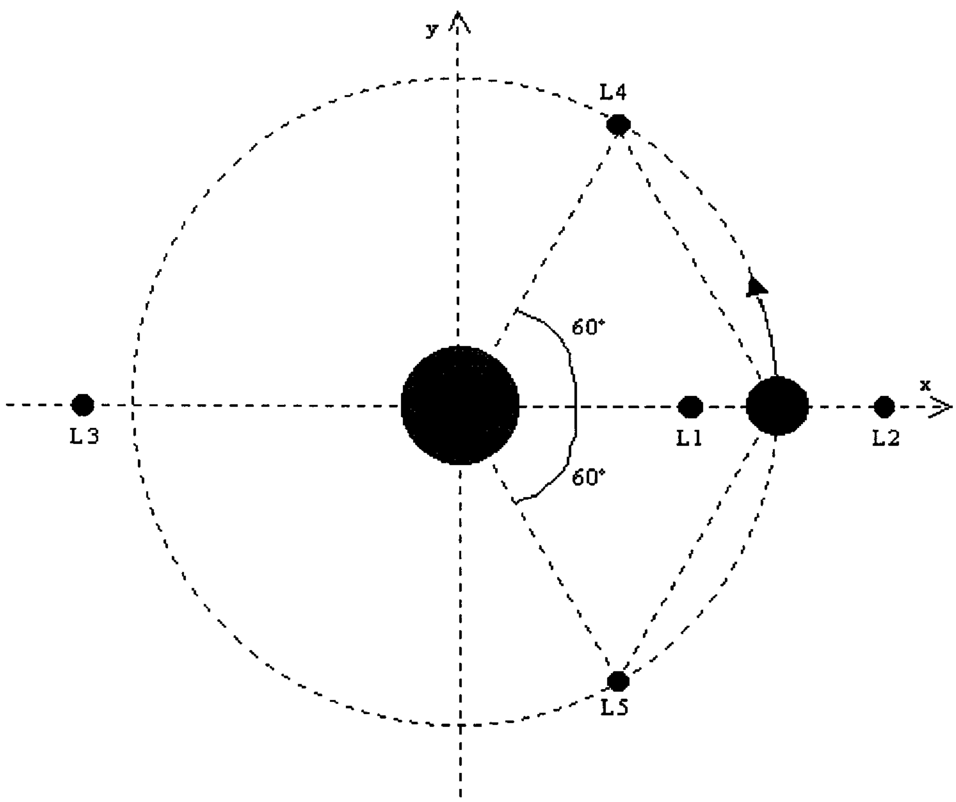
Given two bodies (of large mass) in circular orbit about their common centre of mass, there are five positions where a third object, of negligible mass, could be placed that would maintain its position relative to the other two.

These are known in celestial mechanics as Lagrangian points (or L-points), after the eighteenth-century French mathematician Joseph Louis Lagrange who discovered them in 1772.

A Lagrangian point is thus the place at which the gravitational forces between the two bodies balance, leaving the spacecraft almost completely still in space.

The orbits of the two bodies are normally assumed to be circular. If the orbits of the two bodies are elliptical, the positions are no longer points but form elliptical orbits themselves, similar to the bodies.

The five Lagrangian points are defined as follows:



L1

Between the two bodies.

For example, if A is the Sun and B the Earth, at the L1 point, the time it would take a body such as a spacecraft located at the L1 point to complete an orbit (its "period") would be exactly the same as that of Earth. NASA's Solar and Heliospheric Observatory is stationed currently stationed there, as it can maintain continuous sight of the sun and communication with Earth.

L2

Beyond the smaller of the two bodies.

Example: On the other side of the Earth, further away from the Sun where the orbital period of an object would normally be greater than that of the Earth, the extra pull of the Earth's gravity decreases the period, and at the L2 point that orbital period becomes equal to the Earth's.

L2 is a commonly used spot for space-based observatories as it will maintain the same orientation with respect to the Sun and Earth, offering uninterrupted observations, since the Earth, Moon and Sun remain 'behind' the telescope all the time.

The Wilkinson Microwave Anisotropy Probe is already in orbit around the Sun-Earth L2, the proposed James Webb Space Telescope will be placed there and "Darwin" will also operate from there.

L3

Beyond the larger of the two bodies.

With the Sun and the Earth as the two bodies, the L3 point has been a popular place to site a fictional hidden planet or alien attack formation.

L4

This occurs at the third point of an equilateral triangle with the base of the line defined by the two bodies, such that the point is ahead of the smaller body in its orbit around the larger one.

L5

This also occurs at the third point of an equilateral triangle with the base of the line defined by the two bodies, but such that the point is behind the smaller body in its orbit around the larger one.

L4 and L5 are sometimes called Trojan points.

The first three Lagrangian points are stable only in the plane perpendicular to the line between the two bodies.

By contrast, L4 and L5 are stable equilibria, provided the ratio of the masses ml/ms is > 24.96.

In the Sun-Jupiter system several thousand asteroids, collectively referred to as Trojan asteroids, are in such orbits. Other bodies can be found in the Sun-Saturn, Sun-Mars, Jupiter-Jovian satellite, and Saturn-Saturnian satellite systems. Very faint clouds of dust are present in the Earth-Moon L4 and L5 points.

The Earth's companion object 3753 Cruithne is sometimes referred to as Earth's second moon. It is in a somewhat Trojan-like orbit around the Earth, but not in the same manner as a true Trojan.

The Saturnian moon Tethys has two smaller moons in its L4 and L5 points, Telesto and Calypso. The Saturnian moon Dione has the moon Helene in its L4 point.

The L5 Society is a precursor of the National Space Society, and promoted the possibility of establishing a colony and manufacturing facility in orbit around the L4 and/or L5 points in the Earth-

Moon system.

Task

Given the mass of the two bodies in kilogrammes, your task is to determine the co-ordinates of the L1, L2 and L3 points relative to the centre of the larger body and to determine the velocity of an craft or other body of negligible mass that might exist there.

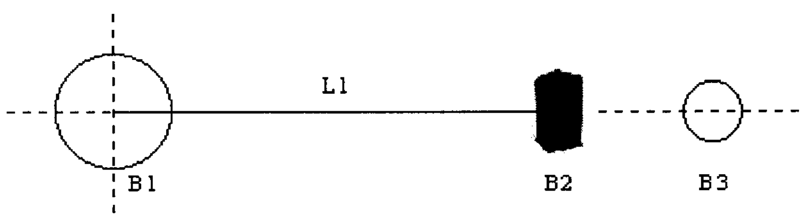
The x-axis is defined to run through the centre of the two objects with the y-axis at right-angles to this. The positive x-axis is in the direction of the smaller object. All 5 Lagrange points lie in the x-y plane.

There are several ways of presenting the formulae for determining the positions of the L1, L2 and L3 Lagrangian points but all derive from Lagrange's Quintic Equation. For the purpose of this question the detailed derivation of the formula is not relevant, but may be expressed as:

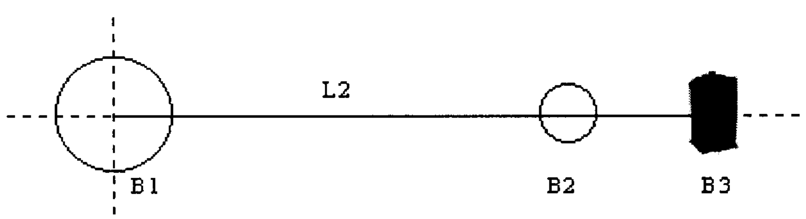
$$f(k) = (m_1 + m_2)k^5 + (3m_1 + 2m_2)k^4 + (3m_1 + m_2)k^3 - (m_2 + 3m_3)k^2 - (2m_2 + 3m_3)k - (m_2 + m_3) = 0$$

where:

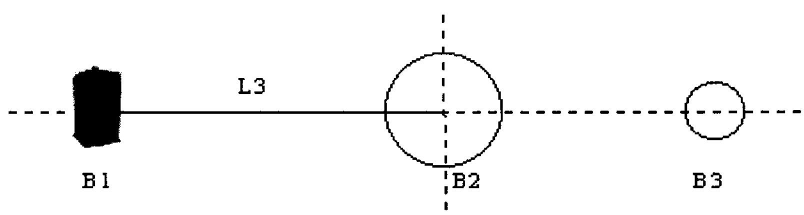
m_1, m_2 and m_3 represent the masses (in kg) of the bodies B1, B2 and B3 respectively in the diagrams below.
d represents the distance (in km) between the centres of the large and small bodies.



B_1 = large body, B_2 = craft (effectively of zero mass), B_3 = smaller body
L1 = d/(1+k)



B1 = large body, B2 = smaller body, B3 = craft (effectively of zero mass)
L2 = d(1+k)



B1 = craft (effectively of zero mass), B2 = large body, B3 = smaller body

L3 = -d/k

The Quintic Equation has no exact formulation for the solution but it can be shown that k has exactly one solution ($0<k<1$) in each of the three cases: L1, L2 and L3.

Thus, given any (valid) initial estimate for k, it is possible to determine a very close approximation to the value by applying Newton's method of successive iterations of an approximate formula for k.

The polynomial equation for k above can be approximated by using the first two terms of the Taylor series expansion:

$$f(k) = f(estimatedk) + (k - estimatedk) * f'(estimatedk) + ...$$

which can be expressed as an iterative formula:

$$k_{n+1} = k_n - f(k_n) / f'(k_n)$$

Applying this to the Lagrange Quintic gives the approximate formula:

$$k_{n+1} = k_n - \frac{[(m_1 + m_2)k_n^5 + (3m_1 + 2m_2)k_n^4 + (3m_1 + m_2)k_n^3 - (m_2 + 3m_3)k_n^2 - (2m_2 + 3m_3)k_n - (m_2 + m_3)]}{[5(m_1 + m_2)k_n^4 + 4(3m_1 + 2m_2)k_n^3 + 3(3m_1 + m_2)k_n^2 - 2(m_2 + 3m_3)k_n - (2m_2 + 3m_3)]}$$

(You may take π to be 3.141592654) .

Example

In the Earth-Moon system, we are looking for the L1 point.

m1 = Earth's mass = 5.98e24 kg,
m2 = 0,
m3 =The Moon's mass = 7.35e22 kg

If we start with an inital estimate of k (k_0) of, say 0.5, we get:

$$k_1 = k_0 + 3.31175e24 / 2.385275e25 = 0.3611585666$$

Putting this value of k into the formula again, we get:

$$k_2 = k_1 + 1.00518443e24 / 1.05294326e25 = 0.2656943123$$

and after a few iterations, we get a convergent answer for k of:

k = 0.17771701 (8 d.p.)

Hence the craft at L1 = 326327 km (from the centre of the Earth).

To calculate the velocity of the craft, we use:

$$v = 2\pi(r-c) / T$$

where:

> r = the radius of orbit of the craft (in metres from the centre of the large body)
> c = the centre of mass of the system (in metres from the centre of the large body)
> = ms * d / (ml + ms)
> where ml is the mass of the large body and ms the mass of the small body
> T = period of orbit of the smaller body (in seconds)

In our example,

$$v = 2\pi (L1 - m_3 d / (m_1 + m_3)) / T$$
$$= 2 * \pi * 1000 * (326327 - 7.35e22 * 384321 / (5.98e24 + 7.35e22)) / 2352900$$
$$= 859 \text{ metres/second}$$

Input Data

For each system, the input will consist of two lines. The first will be the name of the larger body (1-21 alphanumeric characters) followed by a space and the mass of that body (in kg), in standard form. The second line will begin with the name of the smaller body followed by a space and its mass also in standard form, a space, the distance between the centres of mass of the two bodies, then a space and its period of orbital rotation about the large body in seconds.

There will be a single blank line between systems and a single '#' after the final one.

Output Data

The first line of output for each system should begin with its description in the form:

<larger-body-name> - <smaller-body-name> `Lagrange Points:`

This should be followed by the distance in km to each of the points L1, L2 and L3 in turn as shown in the sample below, followed by the velocity of any craft placed at each of the points, then a single blank line.

Although, in the example above, interim values have been shown to 8 decimal places, maximum accuracy should be maintained throughout your calculataions until your final answers.

All values should be output in full (i.e. not in standard form) rounded to the nearest integer.

Sample Input

```
Earth 5.98e24
Moon 7.35e22 384321 2352900
#
```

Sample Output

```
Earth-Moon Lagrange Points:
L1 at x = 326327 km
L2 at x = 448806 km
L3 at x = -381599 km
At L1, craft velocity = 859 m/s
At L2, craft velocity = 1186 m/s
```

```
At L3, craft velocity = -1031 m/s
```