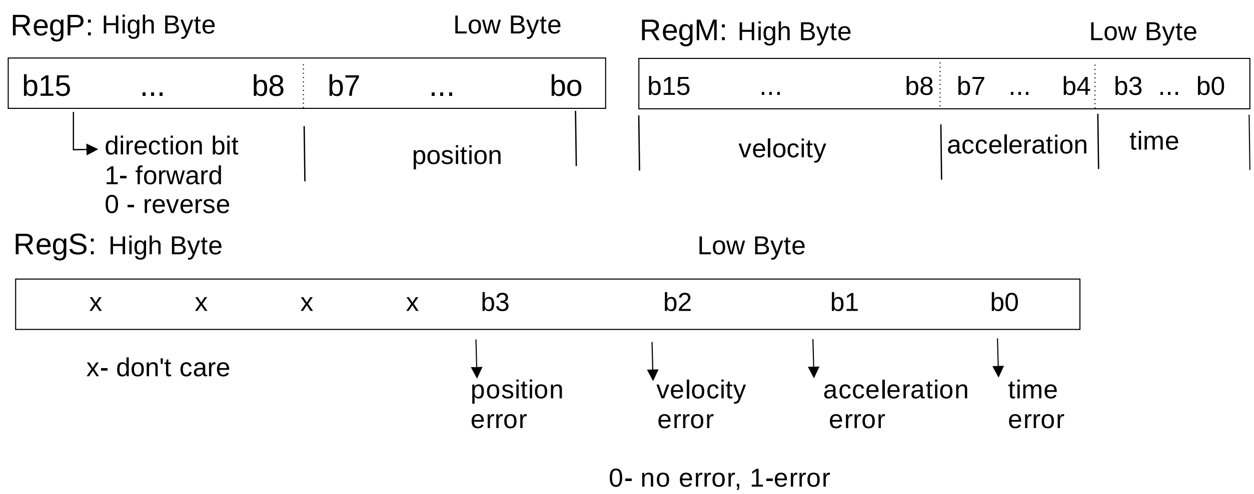
Challenge 2

A hypothetical CNC machine with **one axis of travel** has three registers labelled as RegP, RegM and RegS, where RegP & RegM are 16-bits and RegS is 8-bts. Data in Reg P and RegM define the type of motion a cutting tool is to follow. RegS indicates errors in position, velocity, acceleration or time.



Position, velocity, acceleration, and time define a **motion.** RegS indicates **errors**.

0<**position**<=255, final position to move to starting from rest in cm (8-bits)

0<**velocity**<= 255, in cm/sec (8-bits)

0< **acceleration**<= 15, in cm/sec^2(4-bits)

0<**time**<=15, total time of travel in seconds (4-bits)

0<=**s**<=15, value of the status register indicating errors

Note:

(1) **set bn ->** bit **bn** is replaced by **1**, **reset bn** -> bit **bn** is replaced by 0
(2) Registers data is to be transferred to **program 8-bits variables p, v, a, and t**
(3) Errors in **p, v, a, or t** are to be corrected using the following rules:

Error in **p**: reset b0 of p

Error in **v**: replace v by bitwise NOT v

Error in **a**: set b3 of a

Error in **t**: exchange bits b0 and b1 of t

Program Output:

(1) Values comments in brackets are optional
(2) Use the **same names** for variables described above - helps with discussion
(3) Keeping score? Two points for each output.
(4) **Input Data: 33009,9002,11** (initial values - RegP, RegM, RegS)
(5) **Final Test Data:** End of November

Output #1: 241 (value of p, transferred from RegP)

Output #2: 35 (value of v, transferred from RegM)

Output #3: 2 (value of a, transferred from RegM)

Output #4: 10 (value of t, transferred RegM)

Output # 5 to #8 – values of p, v, a, and t with corrections

Output #5: 240 (p)

Output #6: 35 (v)

Output #7: 10 (a)

Output #8: 9 (t)

Output #9: 6.63, 66.33 (time, velocity) see note (1)

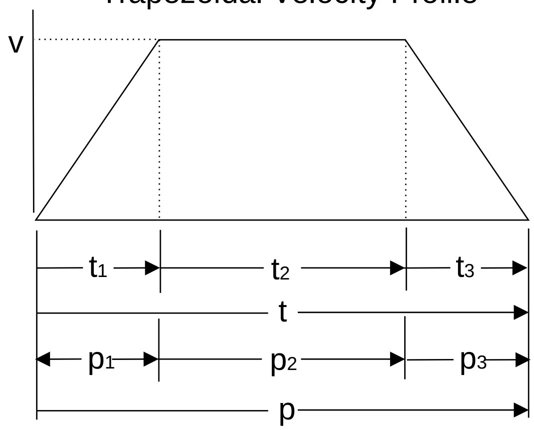
Output #10: 1.32, 7.68 (t1, t2) or “no solution” – see note (2)

Notes:

(1) In Output # 9 the tool moves, with **no profile**, from rest to position p with acceleration a. 6.6 (sec) is the time taken for the tool to reach position p and 66.33 (cm/sec) is the velocity at that point in time.

(2)

Trapezoidal Velocity Profile



since $t_1 = t_3$ & $p_1 = p_3$, then $t = 2t_1 + t_2$,$p = 2p_1 + p_2$
a: acceleration cm/sec^2
v: velocity in cm/sec after t_1 seconds
t_1: time travelling with constant acceleration a
t_2 time travelling with constant velocity v
t_3 time travelling with constant deceleration a
p_1, p_2, p_3 distances covered in cm
p: total distance travelled

In Output #10 the **tool is to move** from rest to final position, **p**, using the trapezoidal "velocity profile" defined by the parameters p, v, a and t. Movement may not be possible if p, v, a and t define a **non existing tool path**.

The starting point is to **solve for t1** (use the starting equations shown below). The result will be a **quadratic equation in t1** of the form: $ax^2 + bx + c = 0$ whose solution is $x = \frac{-b \pm \sqrt{b^2-4ac}}{2a}$

Substituting p, v, a and t will yields either **two** values for t1 or **no values** for t1 (roots are complex- not real numbers).

In Output #10,

(a) if t1, t2 do not exist output "**no solution**"
(b) if t1, t2 each have two values (indicting **two mathematical tool paths),** one set of t1, t2 will be inadmissible. Output the **admissible values of t1, t2**.

Bonus! Output #11: **phrase or statement** (necessary condition for the inadmissible set of t1, t2 in part (b) to be a tool path)

Solution of profile:

In the profile **a, v, p** and **t** are **positive** known (given) quantities leaving t_1 and t_2 as unknown. Solving for first for t_1:

$p_1 = \frac{1}{2}at_1^2$ ----(1), where t1 >0

$p_2 = vt_2$ ------(2), where t2 >0, $p = 2p_1 + p_2$, $t = 2t_1 + t_2$

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