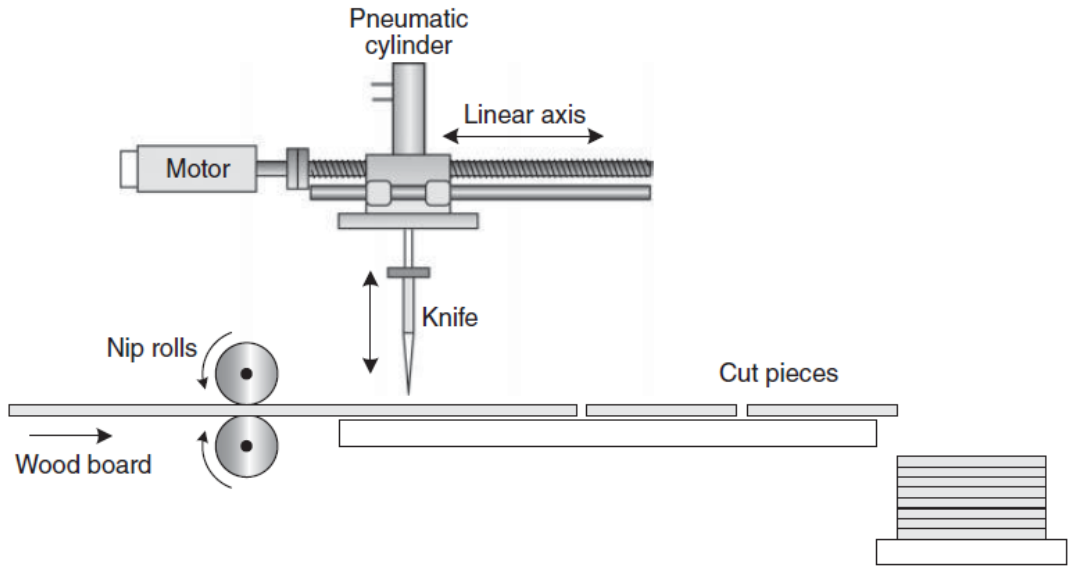
Robot Control

Multi-Axes motion

Multi-axes coordination

- Multi-axes machines require coordination of the motion of individual axes to complete a task.
- Consider a CNC milling machine with a two-axis table and a vertical *Z*-axis with the spinning cutter.
- By coordinating the two axes of the table, we can create circular cuts in a part.
- Coordinating all three axes enables complex 3D cuts.



Moving the axes of the machine

- There are three basic approaches we can take in moving the axes of the machine

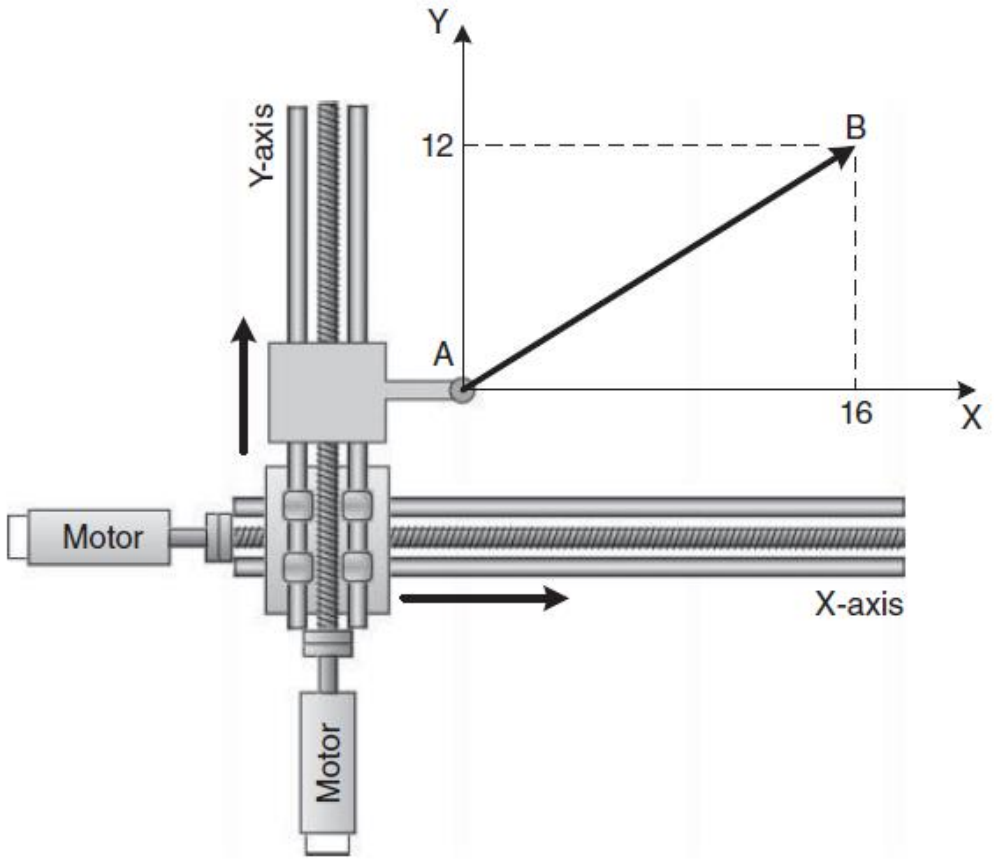
1. Move one axis at a time
2. Start moving all axes at the same time (slew motion)
3. Start and finish at the same time (interpolated motion).

Slew Motion

In slew motion, all axes start moving with the same speed and at the same time but each axis finishes its motion at a different time.

Example

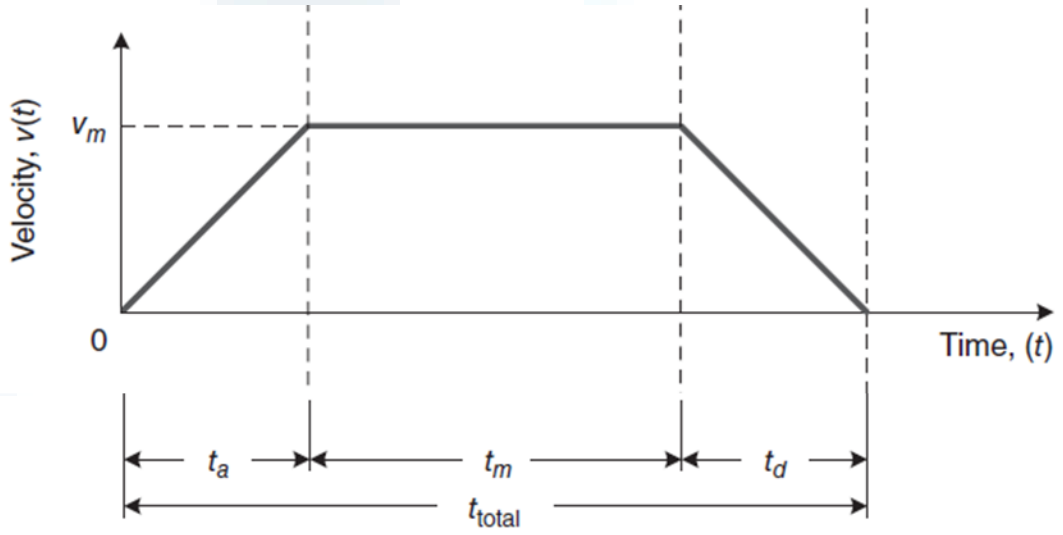
- Consider the machine shown in Figure beside.
- If both axes are moving at the speed of 4 cm/s using trapezoidal velocity profile with $ta = td = 0.2$ sec,
- how long will it take each axis to complete its move?



Solution

- The *X*-axis motion parameters are:

$$v_x = 4\frac{cm}{sec}$$
$$L = 16\ cm$$
$$t_a = 0.2\ sec$$



Solution

The X-axis move time is:

$$t_{m/x} = \frac{L}{v_m} - t_a = \frac{16}{4} - 0.2$$

$$t_{m/x} = 3.8\ sec$$

The Y-axis move time is:

$$t_{m/y} = \frac{L}{v_m} - t_a = \frac{12}{4} - 0.2$$

$$t_{m/y} = 2.8\ sec$$

The total time for the *X*-axis to complete its motion

$$t_{total/x} = t_{m/x} + 2t_a = 4.2\ sec$$

The total time for the *Y*-axis to complete its motion

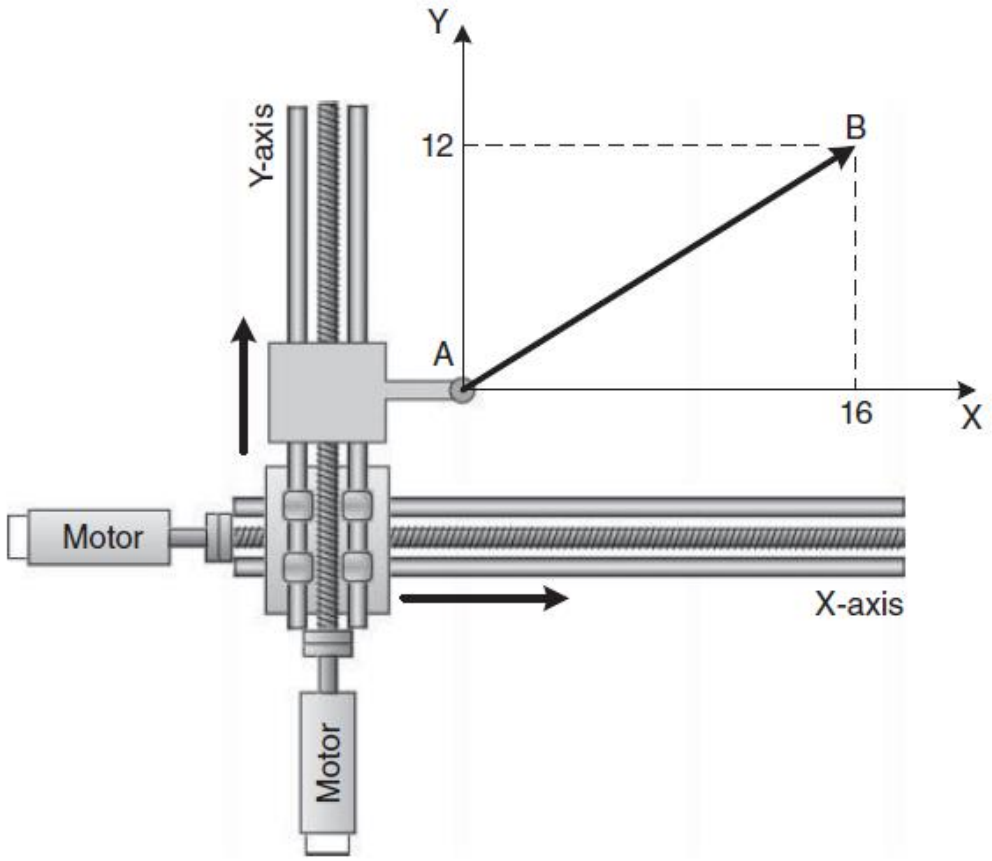
$$t_{total/y} = t_{m/y} + 2t_a = 3.2\ sec$$

Note:

The *Y*-axis finishes its motion 1 s

before the *X*-axis.

As a result, the tool tip will not follow the straight line shown in the figure beside.



Interpolated Motion

In this mode, the motions of the axes are coordinated by the controller.

Linear and circular interpolation can generate lines and circular segments.

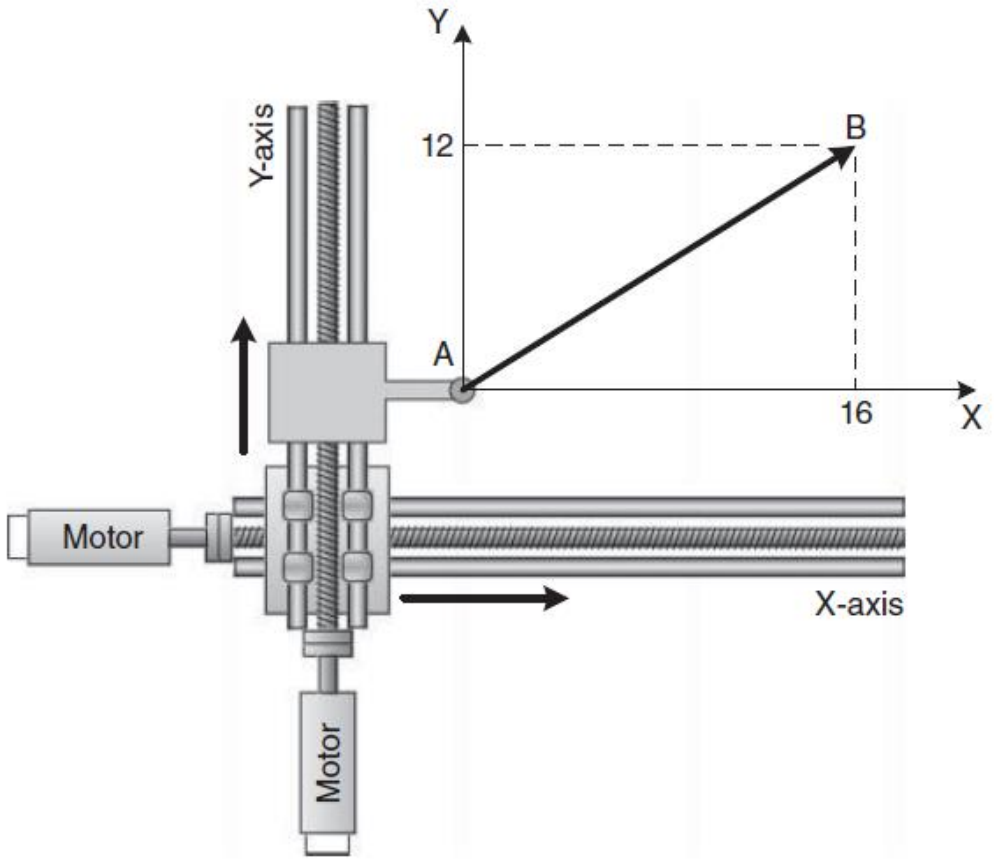
Interpolated Motion

- There are two approaches to achieve this:

1. Slow down the faster axes while keeping the acceleration time, *ta*, the same as the axis that takes the longest time to complete its motion
2. Slow down the faster axes while keeping the acceleration, *a*, the same as the axis that takes the longest time to complete its motion.

Example

- To make the tool tip follow the straight line between points “A” and “B”, we can tell the controller to interpolate the motion.
- In this case, it will execute the motion of the longer move as programmed (*X*-axis) and slow down the shorter move (*Y*-axis) so that they both finish their moves at the same time.

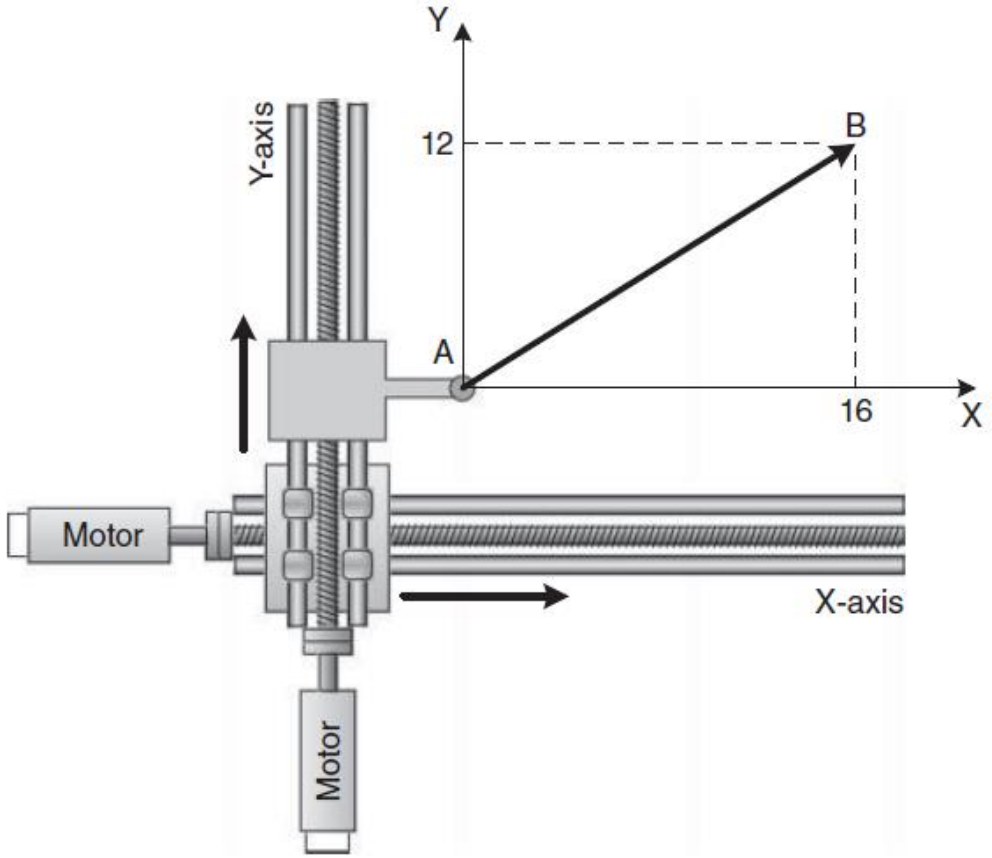


Example

- Given

$$v_x = 4\frac{cm}{sec}$$
$$L = 16\ cm$$
$$t_a = 0.2\ sec$$

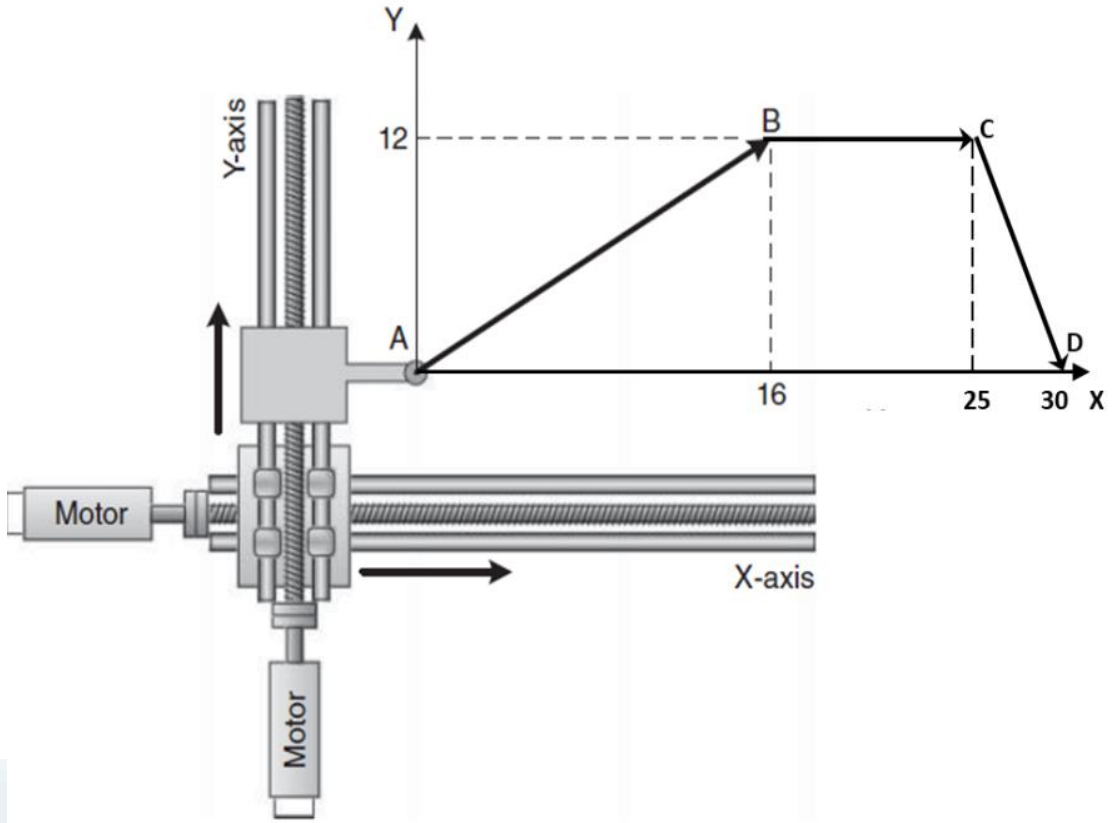
- what should be the new speed of the *Y*-axis v_y, so that both axes finish their moves at the same time?
- Keep t_a the same for both axes.



Solution

- we found that the *X*-axis will take 4.2 s to finish its move.
- Therefore, the total motion time for the *Y*-axis will also be
- $t_{total/y} = 4.2\ sec$
- $t_{total/y} = t_{m/y} + 2t_a \rightarrow t_{m/y} = 3.8\ sec$
- $v_y = \frac{L}{t_{m/y}+t_a} = \frac{12}{3.8+0.2} = 3\frac{cm}{sec}$

Homework



يبين الشكل المجاور آلة تتحرك نهايتها المؤثرة في المستوي XY بحركتين خطيتين. فإذا علمت أن :

المحركات متماثلة، تتحرك بمخطط سرعة بشكل شبه منحرف في كل مرحلة، و زمن التسارع و التباطؤ لكليهما ٠,١ ثانية.

السرعة البدائية و النهائية في كل مرحلة معدومة.

سرعة المحرك الأفقي أثناء الحركة المنتظمة في المراحل الثلاث هي على الترتيب: (٤،٣،٢,٥) سم/ثانية

- ارسم بدقة مخططات السرعة لكلا المحركين في المراحل الثلاث (مخطط واحد لكل محرك)، موضحاً النقاط الأساسية و القيم عند كل نقطة.

جَامعة
المَنارة
MANARA UNIVERSITY

Thanks