$\qquad$

1) A machined block is resting on a ramp feeder on a small table in a robot work cell as shown below. Determine the location and attitude of block 8 with respect to global coordinate frame 1 . Ensure that your attitude matrix is positive orthonormal.


$$
\operatorname{det}\left[\mathrm{A}_{8}\right]=
$$

$\qquad$



Top view of work cell (not to scale)


Side view of table (not to scale)
2) Extract Euler parameters from $\quad[\mathrm{A}]=\left[\begin{array}{ccc}0.6538 & 0.3609 & 0.6650 \\ -0.7507 & 0.1998 & 0.6297 \\ 0.0944 & -0.9109 & 0.4016\end{array}\right]$
$\{\mathrm{p}\}=\{$ $\qquad$
$\qquad$
$\qquad$
Download and run "make_ega.m" from our class web page to check your work.
3) Perform the following cross product by hand.

$$
\begin{aligned}
& \{\mathrm{a}\}=\left\{\begin{array}{llll}
0.6538 & -0.7507 & 0.0944
\end{array}\right\}^{\mathrm{T}} \quad\{b\}=\left\{\begin{array}{llll}
0.3609 & 0.1998 & -0.9109
\end{array}\right\}^{\mathrm{T}} \\
& \{\mathrm{a}\} \times\{\mathrm{b}\}=\left\{\begin{array}{lll}
- & -
\end{array}\right\}^{\mathrm{T}}
\end{aligned}
$$

Download "skew_sym.m" from our class web page and calculate $[\tilde{a}]\{b\}$ to check your work.
$\qquad$

## EXTRA CREDIT

Local coordinates of five landmarks A,B,C,D,E on rigid body 7 are given below. Unfortunately, landmark labeling was scrambled when global pose of this object was measured, and the five global locations $1,2,3,4,5$ shown below cannot be associated sequentially with the landmarks (i.e. global location 2 may refer to landmark D). Further, there was a measurement error, and one of the global locations is completely wrong.

| LANDMARK | local $\mathrm{x}_{7}{ }^{\prime}$ | local $\mathrm{y}_{7}{ }^{\prime}$ | local $\mathrm{z}{ }^{\prime}$ |
| :--- | :--- | :--- | :--- |
| A | 0 | 0 | 0 |
| B | 0 | 0 | 3 |
| C | 2 | 0 | 0 |
| D | 0 | 1 | 0 |
| E | 0 | 0 | -4 |


| LOCATION | global $\mathrm{x}_{1}{ }^{\prime}$ | global $\mathrm{y}_{1}{ }^{\prime}$ | global $\mathrm{z}_{1}{ }^{\prime}$ |
| :--- | :--- | :--- | :--- |
| 1 | 2.574 | -3.482 | 2.146 |
| 2 | 2.000 | -3.000 | 4.000 |
| 3 | 2.510 | -2.142 | 3.935 |
| 4 | -1.244 | -1.184 | 2.524 |
| 5 | 4.433 | -4.362 | 1.107 |

a) Match the global locations to their respective landmarks.
local landmark $\quad$ A $\quad$ B $\quad$ C $\quad$ D $\quad$ E
global location $\qquad$
b) Identify the incorrect global location and state why.
c) Using the correct global locations, describe the pose of object 7 in global coordinates.

$$
\left\{\mathrm{r}_{7}\right\}=\left\{\begin{array}{l}
\square \\
\square
\end{array}\right\}
$$

$$
\left[\mathrm{A}_{7}\right]=\left[\begin{array}{lll}
\square & \square & \square \\
\square & \square & \square
\end{array}\right]
$$

