- Write your matriculation number and your seat number on every page

- The number of points should correspond the max. number of minutes that you should spend for this problem, e.g, 2 points ≈ 2 minutes

- Littler answer box size means less words expected. Be succinct.

This exam has 4 questions, for a total of 18 points and 0 bonus points.

Page	Points	Bonus Points	Score
1	9	0	
2	7	0	
3	2	0	
Total:	18	0	

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Please include your calculation steps and thoughts where applicable. Your professor wants to understand and check how you came to your conclusion.

1. You are designing a cheap, autonomously driving robot which should help you to clean you floor to save you some precious time. The robot should not damage your precious furniture by colliding with them.

   (a) (2 points) Which of the following components would be absolutely necessary?

   Yes or **N**o:
   ___ bumpers
   ___ GPS
   ___ inertial measurement unit
   ___ motors

   (b) (4 points) Give for every component the reason in a single sentence why this component would be absolutely necessary or not.

2. Think about holonomic locomotion

   (a) (1 point) Which of the following vehicles is holonomic?
   - ○ train on a track
   - ○ lawnmower on a garden
   - ○ car on a flat road
   - ○ differentiallu driven vacuum cleaner robot on a floor

   (b) (2 points) Think about the non-holonomic vehicles in the previous choices. Which disadvantage do they have regarding locomotion? Explain using an example in a single sentence.

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3. (5 points) Complete the following function which takes the four components x, y, z, w of a quaternion and converts them to Euler angles. Try to use a library.

```python
def quaternion2euler(x, y, z, w):
    # returns rotation_around_x, rotation_around_y, rotation_around_z
    return ### YOUR CODE HERE

euler = quaternion2euler(0, 0, 0, 1)
```

Write your code here:

4. For which purpose you use the following ROS concepts on Turtlebot3? Give one example for each concept.

   (a) (1 point) topic

   (b) (1 point) action

(c) (1 point) service

(d) (1 point) node