

# Medical Robotics - Coursework

## Key information

Module name	Medical Robotics
Unit of Assessment	Coursework
Unit of Assessment weighting	40%
Submission date	02/12/2024 by 16:00 on SurreyLearn
Feedback release date	Not after 13 <sup>th</sup> January 2024

## Learning Outcomes

The learning outcomes for this coursework and for the module can be found at the following link: <https://catalogue.surrey.ac.uk/2024-5/module/ENGM300/SEMR1/1>.

The particular learning outcomes being assessed in the coursework are:

1. Understand fundamental concepts in robotics and robotic control.
2. Implement the principles of robotics and robotic control in solving practical problems.

## Task

The coursework submission should take the form of a three-part report with a brief introduction and conclusion.

The report should be **2,000 ± 500 words** long and include a word count with your submission. The word count does not include equations, figure captions and/or table captions. Reports should be submitted as .pdfs and will be subject to the usual Turnitin checks.

### Part 1:

In the practical sessions you have been familiarised with the Trossen robot. Using the engineering drawings at the end of this briefing document (Appendix A), identify the link parameters and joint variables. Present these parameters using the Denavit-Hartenberg [D-H] notation. Finally, show the individual link transformation matrices for the robot. You should provide an explanation of your process but do not need to calculate  ${}^B_WT$  or  ${}^B_TT$ . **(25%)**

### Part 2:

In terms of the subspace, reachable workspace and dextrous workspace, discuss the Trossen robot's potential kinematic limitations. What are those limitations and how may they impact a robot sharing those limitations in surgical applications?

Taking a healthcare robot [either a research or commercial device], explain its kinematic differences from the Trossen robot. With illustrations, you should also show how the robot's design exploits different features to improve its kinematics. You should not use the PUMA robots as these have already been covered in depth during classes. **(25%)**

### **Part 3:**

With the robot you have identified in Part 2, firstly, present its medical application. You should outline what that application is and why the application is particularly suited to robotic delivery or assistance. You should then discuss any tooling that the robot requires to do its job and why its kinematics help to perform the task so effectively. **(30%)**

**Introduction and Conclusions:** In the introduction, briefly outline the context for using healthcare robots and the aim of the report that follows. Finish the body of the report by drawing the main conclusions from your work. **(5% each)**

**Presentation:** As with any technical report, make sure that your work is presented correctly. Please make use of figures, tables, equations and references to aid the reader. All elements should be formatted using the conventions and standards expected from a scientific paper. Take care to use concise, precise and correct language and grammar for the best possible communication. **(10%)**

### **Some notes on the requirements:**

The word count begins with the first word of the introduction and ends with the last word of the conclusions. It does not include references, citations, equations, and figure/table captions and content. You are encouraged to use figures to illustrate concepts and, as there is no limit on pages, any figures and tables should be presented at a sensible size. It is not anticipated that you would need an appendix for this report. However, if you feel that there is content suited to appendices, i.e., supplementary information not for assessment, you may include this.

Healthcare robot is specified in the brief as opposed to surgical robot. You may use any robot with a medical application, which includes those robots used for surgery. You may also use a robot that has been covered in the course to-date – though not the PUMA series. However, it is anticipated that the robot has kinematic interest; deliberately choosing a robot with very few degrees of freedom or highly simplified mechanics should be avoided. Such a simple robot would limit the depth and substance that you can provide in many areas of this coursework!

**Please do not include your name on submissions.** The coursework will be marked anonymously.

### **Group work**

Not applicable. This is an individual assignment.

### **Feedback opportunities**

Formative feedback opportunities exist in lectures, tutorials and practical sessions throughout the module. You may also contact the module leader at any time with specific queries [[m.oldfield@surrey.ac.uk](mailto:m.oldfield@surrey.ac.uk)]. Following submission, each report will receive written comments with a completed rubric – see Table 1. Any mark provided on the feedback form will still be subject to approval in the relevant board of examiners.

### **Any specific conditions**

Not applicable.

### **Feedback form**

The format of the feedback rubric is included below in Table 1. Free-form comments will also be provided to supplement the more generic content of the rubric.

**Table 1. Feedback form and rubric for Human Movement and Rehabilitation Coursework assignment**

**ENGM300 Coursework Feedback Form 2024-25**

**Student Name:**

<b>Criteria</b>	<b>Mark</b>	<b>Outstanding to Exceptional 80-100%</b>	<b>Excellent 70-79%</b>	<b>Good 60-69%</b>	<b>Adequate (Pass) 50-59%</b>	<b>Below Expectations (Fail) 40-49%</b>	<b>Well Below Expectations (Fail) 0-30%</b>
<b>Structure and Presentation</b> <ul style="list-style-type: none"> <li>Layout/structure</li> <li>Coherence and writing style</li> <li>Grammar, spelling and vocabulary</li> <li>Formatting of figures and tables</li> </ul>	<b>/10</b>	<ul style="list-style-type: none"> <li>Outstanding presentation reflecting professional norms.</li> <li>Outstandingly clear, concise and fluent</li> <li>No grammar and language mistakes</li> <li>Figures, tables and equations presented and formatted with no errors</li> </ul>	<ul style="list-style-type: none"> <li>Excellent presentation reflecting professional norms.</li> <li>Clear, concise and fluent.</li> <li>Occasional grammar and language mistakes</li> <li>Figures, tables and equations presented and formatted with very few minor errors</li> </ul>	<ul style="list-style-type: none"> <li>Good presentation reflecting professional norms.</li> <li>Mostly clear, concise and fluent</li> <li>Some grammar and language mistakes</li> <li>Figures, tables and equations presented with consistent but small errors</li> </ul>	<ul style="list-style-type: none"> <li>Presentation mostly reflecting professional norms</li> <li>Limited clarity and fluency</li> <li>Significant number of grammar and language mistakes</li> <li>Figures, tables and equations presented and formatted with some errors</li> </ul>	<ul style="list-style-type: none"> <li>Poor presentation showing little understanding of professional norms</li> <li>Unclear, incoherent use of language</li> <li>Many grammar and language mistakes – difficult to understand</li> <li>Figures and tables presented with many errors</li> </ul>	<ul style="list-style-type: none"> <li>Poor presentation showing no understanding of professional norms</li> <li>Unclear, incoherent and difficult to understand</li> <li>Many grammar and language mistakes leading to difficulty in understanding</li> <li>Poor handling of figures and tables</li> </ul>
<b>Introduction</b> <ul style="list-style-type: none"> <li>Context of the work</li> <li>Aims of the report</li> </ul>	<b>/5</b>	<ul style="list-style-type: none"> <li>Highly efficient and focussed distillation of background and context</li> <li>Outstanding articulation of aim</li> </ul>	<ul style="list-style-type: none"> <li>Background and context covered thoroughly and very clearly.</li> <li>Excellent articulation of aim.</li> </ul>	<ul style="list-style-type: none"> <li>Good description of the context of the work</li> <li>Good articulation of aim but maybe lacking particular focus of assignment</li> </ul>	<ul style="list-style-type: none"> <li>Functional Introduction</li> <li>Context is adequate</li> <li>Aim of the report is present and adequately captures the overall purpose</li> </ul>	<ul style="list-style-type: none"> <li>Introduction included</li> <li>Some elements of are missing. These elements include an adequate context and/or, aim</li> </ul>	<ul style="list-style-type: none"> <li>Poor or missing Introduction.</li> <li>Most requested elements are missing. These elements include context and/or aim</li> </ul>
<b>Part 1</b> <ul style="list-style-type: none"> <li>Identification and presentation of D-H parameters for Trossen robot</li> <li>Derivation of link transformation matrices</li> <li>Explanation of processes to derive the kinematics and the kinematics themselves</li> <li>Presentation of kinematics</li> </ul>	<b>/25</b>	<ul style="list-style-type: none"> <li>Identification of D-H parameters is faultless</li> <li>Derivations of the link transformation matrices of the Trossen robot are faultless and highly resolved</li> <li>Explanations are extremely thorough and coherent</li> <li>Explanations contain all important details</li> <li>Kinematics presented clearly and with no errors</li> <li>Accepted conventions are used throughout</li> </ul>	<ul style="list-style-type: none"> <li>Identification of D-H parameters contains no significant errors</li> <li>Derivations of the link transformation matrices of the Trossen robot are without errors</li> <li>Explanations relate well to theory</li> <li>Explanations contain important details</li> <li>Kinematics presented clearly and with few errors</li> <li>Accepted conventions are used in the majority of circumstances</li> </ul>	<ul style="list-style-type: none"> <li>Identification of D-H parameters contains few minor errors</li> <li>Derivations of the link transformation matrices of the Trossen robot contain few minor errors</li> <li>Explanations are sensible and relate to theory</li> <li>Explanations contain most important details</li> <li>Kinematics presented clearly and with some small errors</li> <li>Accepted conventions are mostly used</li> </ul>	<ul style="list-style-type: none"> <li>Identification of D-H parameters contains some minor errors</li> <li>Derivations of the link transformation matrices of the Trossen robot contain some minor errors</li> <li>Explanations are superficial but relate to theory</li> <li>Explanations contain several important details</li> <li>Kinematics presented clearly and with some errors</li> <li>Accepted conventions are used in some situations</li> </ul>	<ul style="list-style-type: none"> <li>Identification of D-H parameters contains several significant errors</li> <li>Derivations of the link transformation matrices of the Trossen robot contain several significant errors</li> <li>Explanations contain errors but have some relation to theory</li> <li>Explanations lack many important details</li> <li>Kinematics not presented clearly</li> <li>Limited use of accepted conventions</li> </ul>	<ul style="list-style-type: none"> <li>Poor, incorrect or missing identification of D-H parameters</li> <li>Poor, incorrect or missing derivations of the link transformation matrices of the Trossen robot</li> <li>Explanations containing substantial errors and lacking any coherence</li> <li>Kinematics not presented in an accessible or structured way</li> <li>No use of accepted conventions</li> </ul>

<b>Part 2</b> <ul style="list-style-type: none"> <li>• Selection of a healthcare robot for comparative purposes</li> <li>• Effective description of the healthcare robot and its kinematics</li> <li>• Links between qualitative description of healthcare robot and its kinematics</li> <li>• Substantive comparison between healthcare robot and Trossen robot</li> </ul>	/25	<ul style="list-style-type: none"> <li>- Healthcare robot has been selected and outstanding analysis is provided</li> <li>- Healthcare robot has great kinematic interest</li> <li>- All aspects of the healthcare robot kinematics are identified</li> <li>- All links of any note are drawn between description and theory of the healthcare robot kinematics</li> <li>- A comprehensive discussion is made on healthcare robot and Trossen robot kinematics with all distinctions identified</li> </ul>	<ul style="list-style-type: none"> <li>- Healthcare robot has been selected and an excellent analysis has been made</li> <li>- Healthcare robot has considerable kinematic interest</li> <li>- All important aspects of the healthcare robot kinematics are identified</li> <li>- All important links are drawn between description and theory of the healthcare robot kinematics</li> <li>- An excellent critical discussion is made on healthcare robot and Trossen robot kinematics with many distinctions identified</li> </ul>	<ul style="list-style-type: none"> <li>- Healthcare robot has been selected and good analysis has been made of it</li> <li>- Healthcare robot has substantial kinematic interest</li> <li>- Many important aspects of the healthcare robot kinematics are identified</li> <li>- Several links are drawn between description and theory of the healthcare robot kinematics</li> <li>- A substantial discussion is made on healthcare robot and Trossen robot kinematics with many distinctions identified</li> </ul>	<ul style="list-style-type: none"> <li>- Healthcare robot has been selected and there is some useful analysis of it</li> <li>- Healthcare robot has been deliberately chosen to for its kinematic simplicity</li> <li>- Some important aspects of the healthcare robot kinematics are identified</li> <li>- Some essential links drawn between description and theory of the healthcare robot kinematics</li> <li>- A comparison is made between healthcare robot and Trossen robot kinematics with some important distinctions made</li> </ul>	<ul style="list-style-type: none"> <li>- Healthcare robot has been selected but subsequent analysis is very limited</li> <li>- Healthcare robot has been deliberately chosen to for its kinematic simplicity</li> <li>- Only superficial description of the healthcare robot kinematics</li> <li>- Limited links drawn between description and theory of the healthcare robot kinematics</li> <li>- Superficial comparison between healthcare robot and Trossen robot kinematics</li> </ul>	<ul style="list-style-type: none"> <li>- Very poor or missing selection of healthcare robot</li> <li>- Healthcare robot has been deliberately chosen to limit its kinematic interest, i.e., a 1 degree of freedom manipulator</li> <li>- Very poor or missing presentation of the healthcare robot kinematics</li> <li>- Very poor or missing links between description and theory of the healthcare robot kinematics</li> <li>- Very poor or missing comparison between healthcare robot and Trossen robot</li> </ul>
<b>Part 3</b> <ul style="list-style-type: none"> <li>• Description of the medical condition that robot addresses</li> <li>• Description of how the robot addresses the medical condition</li> <li>• Critical analysis of the robot's mechanical design and how it addresses the medical condition</li> <li>• Critical analysis of the robot's kinematics and their suitability to its purpose</li> </ul>	/30	<ul style="list-style-type: none"> <li>- Outstanding description of the medical purpose of the robot with great insightful detail</li> <li>- A comprehensive and clear description of how the robot and tooling is used</li> <li>- All links between the robot's mechanical design and its suitability are identified and discussed</li> <li>- Outstanding critical analysis of the purpose of the robot's kinematic design</li> </ul>	<ul style="list-style-type: none"> <li>- Excellent description of the medical purpose of the robot with much useful and insightful detail</li> <li>- Very substantial description of how the robot and tooling is used</li> <li>- All but most minor links between the robot's mechanical design and its suitability are identified and discussed</li> <li>- Excellent critical analysis of the purpose of the robot's kinematic design</li> </ul>	<ul style="list-style-type: none"> <li>- Good description of the medical purpose of the robot with useful and insightful information</li> <li>- Thorough description of how the robot and tooling is used</li> <li>- Most of the significant links between the robot's mechanical design and its suitability are identified and discussed</li> <li>- Considerable critical analysis of the purpose of the robot's kinematics</li> </ul>	<ul style="list-style-type: none"> <li>- Adequate description of the medical purpose of the robot with some useful information</li> <li>- Superficial description of how the robot and/or tooling is used</li> <li>- Some of the most significant links between the robot's mechanical design and its suitability are identified</li> <li>- Some useful analysis of the purpose of the robot's kinematics</li> </ul>	<ul style="list-style-type: none"> <li>- Limited description of the medical purpose of the robot</li> <li>- Superficial description of how the robot and/or tooling is used to address the medical condition</li> <li>- Limited links between the robot's mechanical design and its suitability</li> <li>- Superficial analysis of the purpose of the robot's kinematics</li> </ul>	<ul style="list-style-type: none"> <li>- Very poor or missing description of the medical purpose of the robot</li> <li>- Very poor or missing description of how the robot or tools is used to address the medical condition</li> <li>- Very poor or missing links between the robot's mechanical design and its suitability</li> <li>- Very poor or missing analysis of the purpose of the robot's kinematics</li> </ul>
<b>Conclusions</b>	/5	<ul style="list-style-type: none"> <li>- Outstanding conclusions identifying all substantial outcomes</li> <li>- Presentation is very clear, concise and structured</li> <li>- Links to aims and objectives are established explicitly and identifiably</li> </ul>	<ul style="list-style-type: none"> <li>- Excellent conclusions identifying substantial outcomes</li> <li>- Presentation is very clear, concise and structured</li> <li>- Links to aims and objectives are established explicitly and well</li> </ul>	<ul style="list-style-type: none"> <li>- Good distillation of many substantial outcomes</li> <li>- Findings are presented clearly and with structure</li> <li>- Reference made to the aims and objectives of the report and degree to which they have been met</li> </ul>	<ul style="list-style-type: none"> <li>- Adequate identification of some key points in the report</li> <li>- Limited structure and/or reference to the aims and objectives of the report</li> </ul>	<ul style="list-style-type: none"> <li>- Limited attempt to identify the main outcomes of the report</li> <li>- Substantial new discussion points introduced</li> </ul>	<ul style="list-style-type: none"> <li>- Very poor or missing synopsis of the main outcomes of the report</li> <li>- Conflicting information introduced.</li> </ul>
<b>Lateness penalty</b>	0						
<b>Wordcount penalty</b>	0						

**Mark: /100      Additional Comments:**

Appendix A

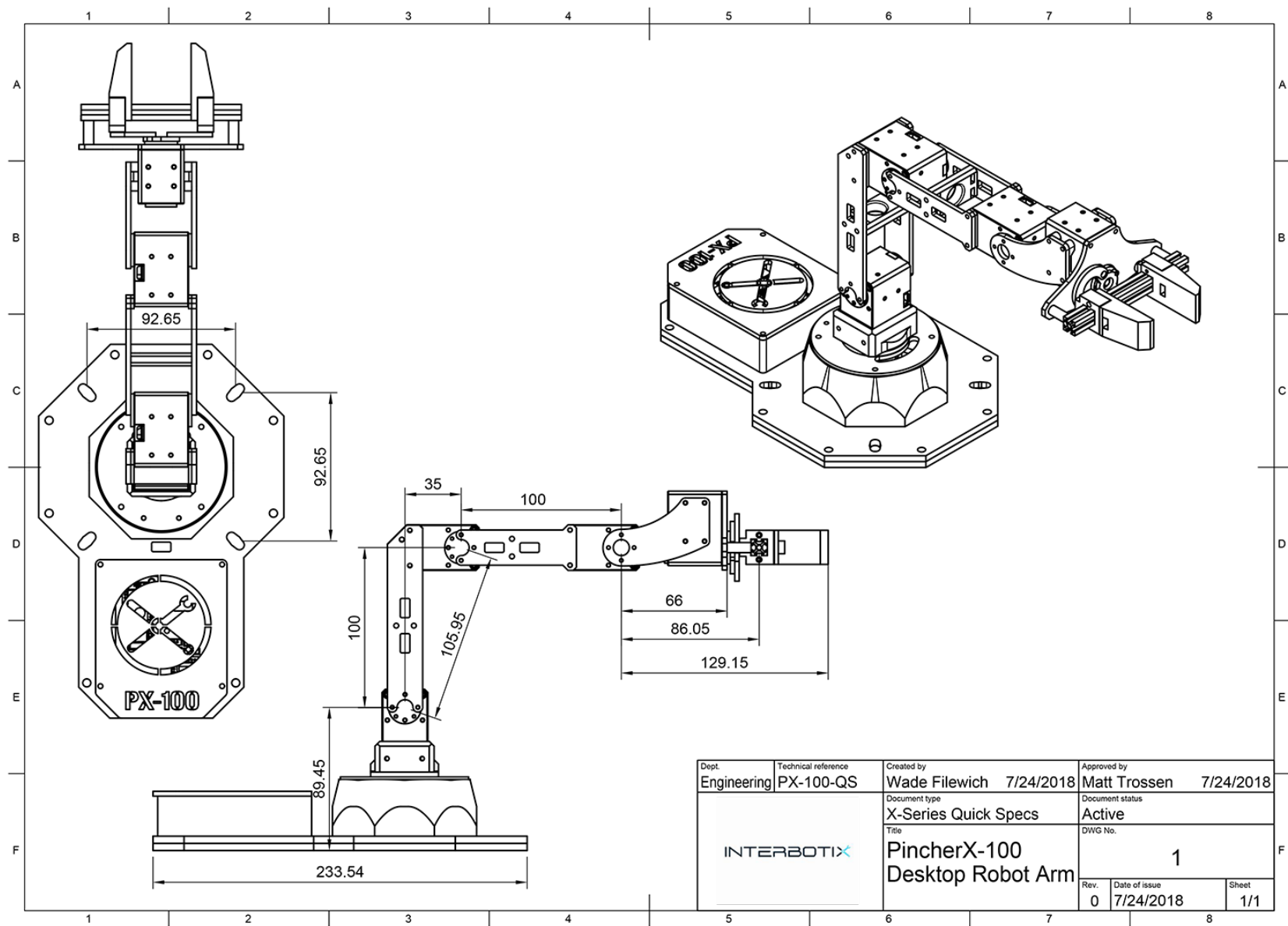


Figure A1. Critical dimensions of the Trossen Robotics PincherX-100 robot arm [Taken from <https://www.trossenrobotics.com/pincherx-100-robot-arm.aspx>]