Milestone 4 (Team) – Cover Page

Team Number: 06

Please list full names and MacID's of all *present* Team Members

Full Name:	MacID:
Ronav Roy Chowdhury	roychr2
Safana Al-Emara	alemaras
David Segal-Pillemer	segalpid
Olivia Dmitrovich	dmitrovo
Marco Tan	tanm27

Any student that is ***not*** present for Design Studio will not be given credit for completion of the worksheet and may be subject to a 10% deduction to their DP-2 grade.

MILESTONE 4 (STAGE 2) – MATERIALS SELECTION GROUP DISCUSSION

Team Number:	06

You should have already completed **Stage 1** of Milestone 4 individually *prior* to Design Studio 10.

1. Copy-and-paste each team member's **Preliminary Materials Selection** research from the individual worksheets in the tables on the following pages
   → Between the 4-5 team members, all tables should include a minimum of 4 candidate materials
2. Recalling that each team member only needed to consider **TWO** of the three criteria (structure, properties, processing) for **Stage 1**, your team should now fill in any tables not completed for each unique candidate material
   → For example, if a team member proposed *cobalt chrome* and *titanium*, researching the **structure** and **properties** of each, the *team* should then research the **processing** of each of these materials, filling in the appropriate table.

Implant Component:	Acetabular Liner

MILESTONE 4 (STAGE 2) – MATERIALS SELECTION GROUP DISCUSSION
STRUCTURE

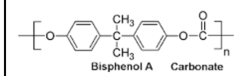
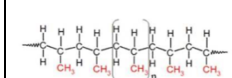
Team Number: 06

Fill in the Materials Selection table below related to the **STRUCTURE** of the material by *copy-and-pasting* each team members individual research. Discuss your findings as a team.

→ Note: some columns include headers (to help get you started) and some are left blank
  - Add additional column headers as you feel are appropriate
  - You only have to fill in the columns you think are relevant

→ If a candidate material proposed in one of the other tables is not included below, you should add it to this table and fill out the appropriate fields as a *team*

Material	Class	Atomic Arrangement	Interatomic Bonding	Polarity	Description	
Polyethylene	Polymer	Crystalline	Covalent	Non-polar	A chain of hydrocarbon (C_2H_4) monomers, that is saturated. Molecules packed tightly. Dense	
polycarbonate	polymer	amorphous	Mostly covalent bonding but also van Der	Polar (attractive & hydrophilic)	Bisphenol A (2 aromatic rings with carbon in between)	

			Waals and hydrogen bonds		Carbonate group All forming a chain of n repetitions 	
Silicone	Polymer	Crystalline	Covalent		Made up of siloxane bonds (-Si-O-Si-) with organic groups attached to the silicon. Big molecule once small monomers are packed tightly	
polypropylene	polymer	Semi-crystalline	Mostly covalent bonding but also van Der Waals and hydrogen bonds	Non-polar (neutral & hydrophobic)	Backbone of single bond carbons with hydrogens branching off and a single carbon branching in each monomer 	

Zirconia Toughened Alumina	Zirconium oxide and aluminum oxide – composite ceramics called AZ composites	Zr-Al2O3 grains of this material are sintered together.	2 aluminum atoms bonded to 3 oxygen atoms and 1 zirconium atom bonded to 2 oxygen atoms. It is a giant covalent bond.			
Polyether ether ketone	Polymer – specifically semi-crystalline thermoplastic	Poly (oxy-1, 4-phenyleneoxy-1, 4-phenylenecarbonyl-1, 4-phenylene) -$C_{19}H_{14}O_{3}$	3 6 carbon rings where 2 of the carbon atoms are bonded to oxygen and 2 other carbon atoms are bonded to another carbon atom which is subsequently bonded to an oxygen atom.			

Cobalt-Chromium (CoCr)	Metal	Crystalline	Metalic			Chromium and cobalt single bonded to oxygen.
Yttria stabilized zirconia	Ceramic	ZrO2 + Y2O3	Covalent in a monoclinic crystal structure	Non-polar	A crystal lattice of ZrO2 in cubic form made stable using Y2O3 to maintain the cubic structure.	

MILESTONE 4 (STAGE 2) – MATERIALS SELECTION GROUP DISCUSSION

PROPERTIES

Team Number: 06

Fill in the Materials Selection table below related to the **PROPERTIES** of the material by *copy-and-pasting* each team members individual research. Discuss your findings as a team.

→ Note: some columns include headers (to help get you started) and some are left blank
  - Add additional column headers as you feel are appropriate
  - You only have to fill in the columns you think are relevant

→ If a candidate material proposed in one of the other tables is not included below, you should add it to this table and fill o ut the appropriate fields as a *team*

Material	Elastic Modulus	Ultimate Strength	Toughness, Fracture	Wear	Corrosion Resistance	Biocompatibility
Polyethylene	1.07 - 1.09 GPa	22.1 – 31.0 MPa	1.52 - 1.82 $MPam^{1/2}$	Very resistant to wear, low coefficient of friction	Very corrosion resistant	High biocompatible because they do not contain toxins. Chemically inert and are not soluble in water, so no ions to enter the bloodstream
polycarbonate	2.4 GPa stiff material will not bend or stretch easily	65 MPa stronger than polyethylene (common material for	3.0 MPa*sqrt(m)	Unavailable information but studies using material indicated no changes in material following 5 years so	This material is resistant to acids, oxidizing/reducing agents & alcohols (excluding methyl alcohol)	Approved & used for many medical devices due to its biocompatibility

		liners) by >200 times		greater than 5 years.		No toxicity associated with material
polypropylene	1.68 GPa Less stiff material will bend or stretch more easily	29.2 MPa	1.4 kJ/m^2	Unavailable	This material is resistant to non-oxidizing acids & bases, fats & most organic solvents	Used for treatment in pelvic floor conditions, biocompatible and does not trigger inflammatory response
Silicone	0.0793	7.24 MPa	0.7 MPa/m$^{1/2}$	Poor wear resistance, but when coupled with other materials can be much improved	Except for sulphuric acid, hydrofluoric acid, silicone is corrosion resistant	High biocompatibility, non-toxic, insoluble in body fluids. Used in cardiovascular system
Yttria stabilized zirconia	200 – 210 GPa	0.55 GPa	0.01 Gpa/m^0.5	Very high wear resistance	Strong corrosion resistance, especially at excessively high temperatures.	Strong biocompatibility, supports strong adhesions of cells on surfaces and promotes cell proliferation (used in dental already).
Cobalt-Chromium (CoCr)	220 MPa	145-270 MPa	-low ductility, can potentially cause component fracture	- does not wear easily, also has great resistance to fatigue	-shows a high degree of corrosion resistance even in chloride surroundings.	448-1606 MPa

Zirconia Toughened Alumina	360 GPa	2750 MPa	7.2 MPa/m^1/2	Very high wear resistance	Very corrosion resistant	High biocompatibility as there are no grains formed over time.
Polyether ether ketone	3.7-4.0 GPa	170 MPa	2.733 - 4.296 MPa/m^1/2	Very high wear resistance.	Very corrosion resistant	It has a high biocompatibility as the elastic modulus is similar to that of bone.

MILESTONE 4 (STAGE 2) – MATERIALS SELECTION GROUP DISCUSSION

PROCESSING

Team Number: 06

Fill in the Materials Selection table below related to the **PROCESSING** of the material by *copy-and-pasting* each team members individual research. Discuss your findings as a team.

→ Note: some columns include headers (to help get you started) and some are left blank
- Add additional column headers as you feel are appropriate
- You only have to fill in the columns you think are relevant

→ If a candidate material proposed in one of the other tables is not included below, you should add it to this table and fill out the appropriate fields as a *team*

Material	Coatings	Drug Delivery Options	Corrosion Resistance	Cost	Additive Manufacturing	
Zirconia Toughened Alumina	A bioactive coating to improve bone integration and bonding with the implant could be implemented (e.g. a layer of covalently bonded	The material is sintered meaning that it is one solid mass making it more reliable.	Has a high corrosion and wear resistance as a result of sintering.	Relatively Inexpensive		

	phosphonate molecules (CM))					
Polyether ether ketone	This implant can be coated with hydroxyapatite (HA) to allow for the deposition of new bone from adjacent living bone.	PEEK plastic is processed through an injection molding machine and unique molds to form raw plastic materials into the parts you need. The plastic is melted into the injection molding machine and then into your customized mold.	Has a high corrosion resistance as very concentrated nitric and sulfuric acids are the only acids that can attack PEEK.	Quite expensive		
Yttria-stabilized zirconia	N/A	N/A	Strong corrosion resistance, especially at excessively	Pricy.	A silicon carbide interlayer may be used to increase strength and	

			high temperatures.		corrosion resistance (but SiC has health effects)	
Polyethylene	N/A	N/A	-fairly resistant to corrosion to most mineral acids including sulfuric up to 70% concentrations	Usually inexpensive but it depends on the type of polyethylene employed.	-for high density polyethylene, it contains undesirable thermal properties which cause the material to shirk and not adhere to printing bed	
Cobalt-chromium (CoCr)	Electrodeposition has versatility relating to large variety of component shapes which can be precision-coated.	N/A	-also relatively resistant to corrosion	more expensive compared to polyethylene, however still less expensive than		
Silicone	silicon can be coupled with a nitrogen compound to create silicon nitride. Increases	N/A	Except for sulphuric acid, hydrofluoric acid, silicone is corrosion resistant	Expensive		

	strength and wear.					
Polycarbonate	N/A	N/A	This material is resistant to acids, oxidizing/reducing agents & alcohols (excluding methyl alcohol)	\$5,469.60 per 6 kg Expensive but doable	N/A	
polypropylene	N/A	N/A	This material is resistant to non-oxidizing acids & bases, fats & most organic solvents	\$1,714.25 per 6 kg Less expensive	N/A	

MILESTONE 4 (STAGE 3) – PROPOSED MATERIAL

Team Number:	06

Based on the previous tables, identify the material you consider as being most appropriate for this component

Proposed Material:	Polycarbonate

Explain why you selected this material based on the structure, properties and processing:

Structure: It is amorphous and a polymer, which means it will be flexible and comfortable for Jackie Chiles.

Properties: It has a relatively high UTS for polymers which means it will be strong and not break down with movement, which still being flexible. Processing: Not very expensive for the amount of material needed for the liner.

Comment on why the material selected makes the most sense ***for your patient***

- Material is very biocompatible as there is no toxicity or graining associated with it. - Polycarbonate is also a very flexible material as opposed to being very stiff making it comfortable for Jackie Chiles. - Adds a little bit of height to balance out the height difference between his two legs. - Addresses the issue involving lack of cartilage - Does not make it too strong or overcompensate the other hip that does not require a hip replacement but isn't perfect.