Solenoids will be utilised in both the robot keyboard and robot xylophone as shown in **Section X and Section X (insert reference for keyboard and xylophone section).** They are common electronic components that come in various forms, electromechanical, pneumatic and hydraulic [1]. The solenoids used in this project are electromechanical, they were selected as they were cheap to purchase and were simple to implement in the robot keyboard and xylophone. A significant amount of force would not be needed so pneumatic and hydraulic (which are more expensive as well) were not considered.

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Figure Pull action solenoid from Solentec Ltd. (left) corresponding force/stroke characteristic (right) Invalid source specified.

Electromechanical solenoids consist of two main components: a coil and plunger or slug that is placed inside the coil (this is usually made out of steel) [1]. According to Ampere’s Law [2] when a current is passed through the solenoid a magnetic field is created in and around the coil which forces the plunger to be drawn in. As can be seen in Figure 1 a spring is used to hold the plunger in place, this is so that when a current is not being passed through the solenoid and no force is acting on the plunger it returns to its normal position outside of the coil, this is typical of a ‘Pull’ type solenoid. ‘Push’ type solenoids are also available where the spring holds the plunger inside the coil when the coil is not energised, when a current is passed through the plunger is forced out of the coil.

A solenoid is dictated by two parameters, the duty cycle of the solenoid and the force produced according to the duty cycle. The duty cycle is calculated by the following formula:

Equation Duty Cycle of a Solenoid [3]

In this case the “On Time” refers to the amount of time that the coil is energised and the “Off Time” refers to the time that it is not. Figure 1 shows how the force exerted by the solenoid reduces as the duty cycle increases i.e. as the rate at which the solenoid is energised and de-energised increases the force exerted by the plunger decreases. This is because as the solenoid is energised and de-energised it begins to gain heat which increases the losses in the solenoid, so less force is delivered. The stroke is the amount of the plunger that is outside of the coil when it is energised. It can be seen that as the duty cycle decreases the force that can be exerted by the solenoid increases, this means that if the solenoid is not switched on and off very quickly then more force can be expected to be produced.

# Bibliography

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| [1] | Society of Robots, “Actuators - Solenoids,” Soceity of Robots, 9 August 2006. [Online]. Available: http://www.societyofrobots.com/actuators\_solenoids.shtml. [Accessed October 2017]. |
| [2] | H. A. Radi and J. O. Rasmussen, Principles of Physics For Scientists and Engineers, Berkley, CA, USA: Springer, Berlin, Heidelberg, 2013. |
| [3] | BICRON Electronics Company, “Standard & Customer Solenoids for OEM Application,” BICRON Electronics Company, Connecticut, 2011. |