# ASEE ETD MINI-GRANT PROJECT REPORT

# Development of Apparatus for Enhanced Experiential Learning in the UNH ET Automation and Control Systems Courses

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## I. INTRODUCTION

The University of New Hampshire offers Bachelor's Degrees in both Electrical Engineering Technology (EET) and Mechanical Engineering Technology (MET). Both the MET and EET majors take common courses in the areas of control systems and automation as part of their degree requirements. These courses have classroom lecture and laboratory components.

One of the challenges in these courses is to provide students with relevant and engaging opportunities for hands-on learning. The hands-on component is especially important for ET students, as it has been found that they tend to have a stronger preference for courses that emphasize practical applications when compared to their counterparts in more traditional Engineering programs (Thomas, 2014). It has also been observed by instructors at UNH that students entering the ET program are likely to have less familiarity with mechanical devices through hobbies and jobs than earlier generations of students. The UNH ET Program is currently working on improving lab capabilities for teaching control systems, automation, and robotics. This initiative is part of the UNH ET Program's ABET continuous improvement plan (LeBlanc et al, 2016).

Complete implementation of these plans is expected to be rather costly and will take some time to implement fully. Therefore, development of hardware is being carried out in stages, building upon initial experience gained with a few small projects. The ASEE Mini-Grant was sought in order to provide support for one of the components of this initial effort. Securing the Mini-Grant served as a catalyst to get the larger effort underway by getting the design and fabrication of one mechanism completed.

The first set of projects that UNH is focusing on involves the design and construction of a walking beam conveyor combined with Geneva mechanism driven parts feeder for the conveyor. Both the walking beam conveyer and the Geneva mechanism are examples of machinery used in industrial automation that pre-dates the development of electronic control systems. While they can be operated as strictly mechanical systems, their application can be expanded by implementation of electronic control provided by an industrial Programmable Logic Controller (PLC) or even by an inexpensive hobby-grade microcontroller such as an Arduino (Arduino, 2021).

Potential uses of electronic control include activation of the machinery and controlling its speed to suit process requirements. Other uses would include implementation of safety measures such as an emergency stop of the process. More sophisticated use of the PLC is envisioned for the future, including integrating industrial robotics equipment with the walking beam conveyer and Geneva mechanism. An additional advantage of the mechanisms chosen is that the kinematics and dynamics are amenable to analysis using techniques taught in the ET program.

## II. DESCRIPTION OF PROJECT WORK

The project got underway with design of the walking beam conveyor and the Geneva stop mechanism as a Senior Capstone Project by a team of two students in the Academic Year 2019-2020. As will be described below, the Geneva stop mechanism was also fabricated and made operational during the period of the Mini-Grant. Therefore, Mini-Grant funds are being used specifically to partially defray expenses associated with Geneva stop mechanism.

Work on the walking beam conveyor is proceeding using other sources of funding. However, since both mechanisms are designed for the possibility of operating together, some discussion of the work on the walking beam conveyer is included for the sake of providing perspective.

The two devices share the common characteristic that they produce intermittent motion from constant speed rotational motion of a driver by purely mechanical means. In an automated production environment the intermittent motion of the objects being handled allows for manufacturing operations (for example machining, finishing, coating or inspections) to be performed during the intervals that the parts are stationary.

### II.A Capstone Project Work

Development of the walking beam conveyor and the Geneva stop mechanism was undertaken by a team of two students in the Academic Year 2019-2020 as a Senior Capstone Project. The original scope of work included design, and at least partial fabrication of components as part of the Capstone.

However, in March 2020 UNH pivoted to remote operations for the remainder of the spring semester due to the COVID-19 pandemic. The restrictions put in place due to COVID meant that no work on fabrication could be performed in the campus machine shop be either students or staff. Upon review of the progress the students had made up to March 2020, it was decided to have them concentrate their efforts on further development and documentation of the CAD solid models and drawings (Ferry, 2020; Heino, 2020). Sample images of the work produced by the students is shown in Figures 1 and 2.

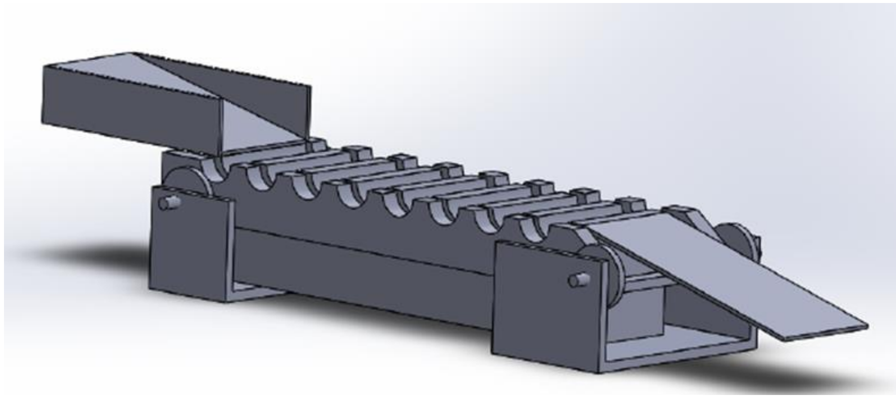

***Figure 1.*** CAD model of assembled walking beam conveyor component. Parts are to be to the chute at left by the feeder mechanism operated by the Geneva mechanism. The outer rack is stationary while the inner rack is moved by an eccentric drive mechanism. This motion moves the parts intermittently to the right.

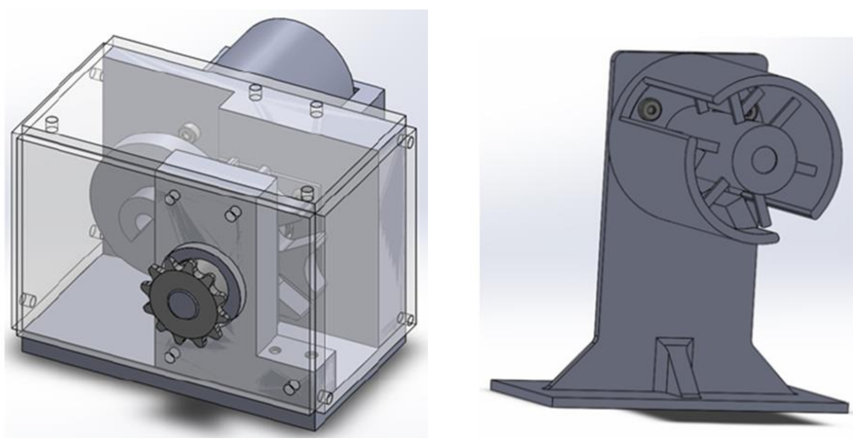

***Figure 2.*** Left: CAD model of assembled Geneva device. Case of driver motor is shown at rear. Gear wheel on front of case is provided to drive application requiring timed intermittent application such as loader mechanism for walking beam conveyer. Right: CAD model of loader mechanism to load parts on walking beam at specified feed rate.

### II.B Fabrication of the Geneva Stop Mechanism

During the fall semester of 2020, work in the ET Program's machine shop was allowed to resume. The Capstone students had graduated, so the work on the project was taken over by ET program staff (machine shop technician) assisted by faculty. It was decided to focus on fabricating the Geneva mechanism as there was interest in using it initially as a standalone demonstration piece in the automation course. The design work from the students was reviewed and modified where it was thought to be desirable. For example, one of the goals is to demonstrate the operation of the equipment in a classroom, and for this purpose it is desirable to have the components be large enough to be easily observed by students in a classroom. For this reason, the dimensions of the Geneva mechanism were scaled up by 50% relative to the original design. This yielded a diameter of 3 inches for the 6-lobe driven Geneva wheel. Another modification was to relocate the drive shaft from the driven wheel to the back side of the case. This allows an unobstructed view of Geneva wheel components for better demonstration of the operating principles.

Fabrication and testing of the Geneva Mechanism was completed in February 2021. Photos of the completed mechanism are shown in Figures 3 and 4. Figure 3 shows the front side of the mechanism. The moving parts are completely enclosed for safety during demonstrations. Four of the sides of the enclosure are made of clear acrylic plastic to allow the operating principles to be easily observed.

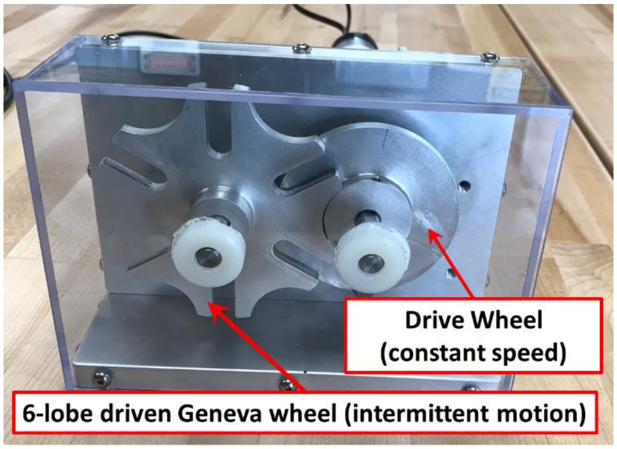


***Figure 3.*** Front view of the completed Geneva mechanism. Drive wheel at right is connected to the electric motor drive mounted at the back and rotates at a constant rate. The six-lobe driven wheel at left moves intermittently.

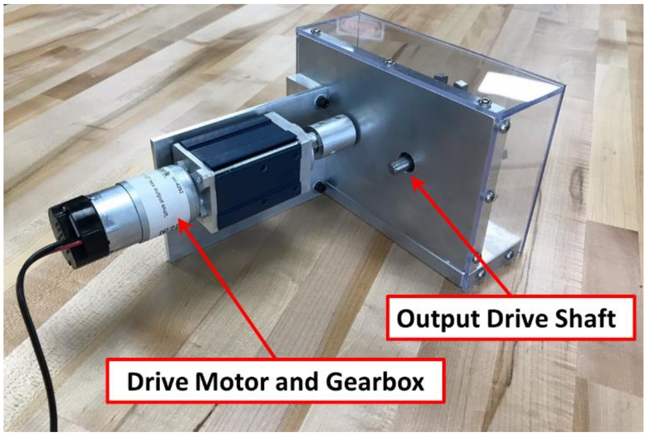


***Figure 4.*** Rear view of the completed Geneva mechanism showing mounting of electric motor drive and stub shaft that can be used to harness the intermittent motion of the Geneva wheel.

Figure 4 is a rear view which shows the drive motor and gearbox. The keyed output drive shaft allows for the intermittent motion provided by the Geneva mechanism to be used to drive a parts feeder or other equipment.

CAD models and other documents are being archived with the intention of sharing them with other parties who may be interested in replicating the Geneva mechanism for their academic programs.

## III. USE OF FUNDS

The total award from the Mini-Grant is $1300. Funds equal to this sum were used for the following purposes:

- Purchase of DC Drive Motor and Gearbox; $150.
- Metal stock, plastic stock, and hardware. $250.
- UNH Technician Labor for CAD work and machining; $900.

The UNH ET program has provided goods and services to match the Mini-Grant award. The value of these exceed $1300 and include:

- Siemens Simatic HMI Industrial Programmable Logic Controller; $400 (est. value).
- Two Sparkfun Arduino Microcontroller Tinker kits; $100.
- DC Power supply; $80.
- UNH Technician Labor for CAD work and machining; $900.

## IV. ACKNOWLEDGEMENTS

The support of this work by the ASEE ETD Mini-Grant program, and the matching contributions by the UNH Engineering Technology Program is gratefully acknowledged.

## V. REFERENCES

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