Teacher's Guide –
TECHNOLOGY at Wilton Windmill

SYSTEMS ~ Wilton Windmill is basically a **'System'** which performs the task of converting wheat into flour.

INPUT ⟹ **PROCESS** ⟹ **OUTPUT**

Within the mill are a number of **'Subsystems'** that contribute towards this outcome, for example the entire mill and floors housing the machinery are a structural subsystem; the rotating millstones are a mechanical subsystem; within the cap there is a braking subsystem. Only **'Batch Production'** was possible as the wind did not always blow!

MECHANISMS ~ There are many **'Mechanical Subsystems'** within the mill that contain various mechanisms to transform an **'Input Motion and Force'** into a desired **'Output Motion'** and **'Force'.** They are designed to give some advantage from using them, known as **'Mechanical Advantage'.** For example, the sack hoist effortlessly lifts sacks of wheat up to the top of the mill.

All four types of **'Motion'** are employed when the mill is in operation, **'Linear', 'Reciprocating', 'Rotating'** and **'Oscillating'** and there are many fascinating **'Mechanisms'** that students can find which convert one form to another. Examples of the following mechanisms can be seen within the mill:

- **Gear Trains** ~ where the **'Driver Gear'** turns the **'Driven Gear'** in the opposite direction and usually speeds it up as they have varying numbers of teeth and this relationship is known as the **'Gear Ratio'**. For example, if the driver gear has 20 teeth and rotates clockwise once when meshed with a driven gear containing 10 teeth, the driven gear will rotate twice in an anticlockwise direction and the gear ratio is 1:2.
- **Worm and Wheel** ~ An excellent mechanism for reducing gear ratios quickly and it is used to turn the whole cap of the windmill so that the sails always face the wind. Gear ratios are easily calculated because the worm is in effect a one-toothed gear and so the ratio is always 1:the number of teeth on the wheel. Unusually, this mechanism does not work in reverse and so the worm always has to move the wheel – the wheel cannot rotate the worm.
- **Rack and Pinion** ~ This mechanism is used to convert rotary motion into linear motion. From the balcony, pulling the chain hanging down outside the mill rotates a small **'Pinion'** which in turn moves a **'Rack'**, connected to a **'Striking Rod'.** Then, via a series of **'Levers'** known as a **'Spider'**, it opens or closes the shutters in the sails while they are rotating. As such it is a **'Control Mechanism'.**
- **Bevel Gears** ~ This type of gearing has the teeth angled at 45º and is used to change the direction through 90º. The **'Brake Wheel'** meshes with the **'Wallower'** in such a way, but at a lesser angle than 90º as the **'Wind Shaft'** is at a 15º angle.

BELT DRIVES ~ There are several examples within the mill where belt drives have been used to transfer **'Power'** and **'Movement'** from one rotating shaft to another. Look out for the leather belt dive to the **'Centrifugal Governors',** a control device which helps to achieve **'Quality Control'** with the quality of the flour being produced in fluctuating and gusty winds.

VELOCITY RATIO ~ Is used to calculate speeds and for **'Belt Drives'** the **'Revolutions Per Minute'** can be determined with the following formula:

$$\textbf{RPM of the driven pulley} = \frac{\textbf{RPM of driver pulley x diameter of driver pulley}}{\textbf{diameter of driven pulley}}$$

MISCELLANEOUS MECHANISMS ~ There are a number of other interesting mechanisms used within the windmill, including an **'Inclined Plane'** (the **'Shoe'** over the millstones) and **'Screw Threads'** used to adjust and control the quality of the flour. Be sure to look at the bevelled wooden **'Friction Clutch'** used to control the **'Sack Hoist'** along with a **'Pulley System'**. A **'Damsel'** a type of **'Cam'** is used in the centre of the millstones to shake the grain down at a constant speed.

LEVERS and LINKAGES ~ Many examples exist in the mill, such as the huge wooden system used to operate the **'Brake'** and this is combined with a type of **'Ratchet'** to control it. Smaller examples can be found elsewhere, try looking at the **'Sails'** or around the **'Tentering System'.** Levers give a **'Mechanical Advantage'**, reducing the **'Effort'** needed and **'Links'** can transfer **'Forces'** and change the **'Direction of Motion'**. There are three **'Classes'** of Levers – can you find an example of each type during your visit?

First Class Lever ~ 'Pivot' in the Middle
Second Class Lever ~ 'Load' in the Middle
Third Class Lever ~ 'Effort' in the Middle

Self-Dispensing Grease Canister

Friction ~ An interesting **'Force'** that is necessary to mill the flour, yet there are numerous accounts of too much friction between rotating millstones igniting flour and burning many a mill to the ground. Friction needs to be reduced on moving parts and this is achieved with **'Grease'** and **'Bearings'**. At Wilton Windmill, to ensure the mill is always ready to mill, we use a modern invention to ensure that bearings are always greased, **'Self Dispensing Grease Canisters'** which work over a period of months. Grease is applied to gear teeth to reduce wear and friction. In 1821, the mill was the height of windmill technological development and in a pair of meshed gears, one had cast iron teeth and the other had wooden (Hornbeam or Apple) teeth to reduce noise and wear – the wooden teeth could be easily replaced if need be. Gears always had an odd number of teeth to minimise wear and vibration by reducing the frequency with which two individual teeth meshed together.