Clutches, Latches, Ratchets, Oh My!

This morning, my brain finally sent back to the main portion of my mind an answer that I had been trying to get across regarding the task of designing a latch/clutch for the potato throwing catapult.

This design has two functional requirements … strictly speaking …

1. one-way, non-back-drivable torque transmission from the motor/gearbox
2. holding the bail in place until the user is ready to release

Based on the Principles of Design, it is desirable to have one Design Feature for each Functional Requirement.

In class, a student presented an interesting idea, and I had a senior moment. So, the two functional requirements were merged (at the discretion of the student) and the discussion proceeded to coming up with one Design Feature to satisfy both Functional Requirements. This really cannot be done.

Consider the functional requirements satisfied by each of the devices in this section: clutches, latches, and ratchets.

A ratchet provides free motion in one direction and blocks motion in the opposite direction until a release is actuated.

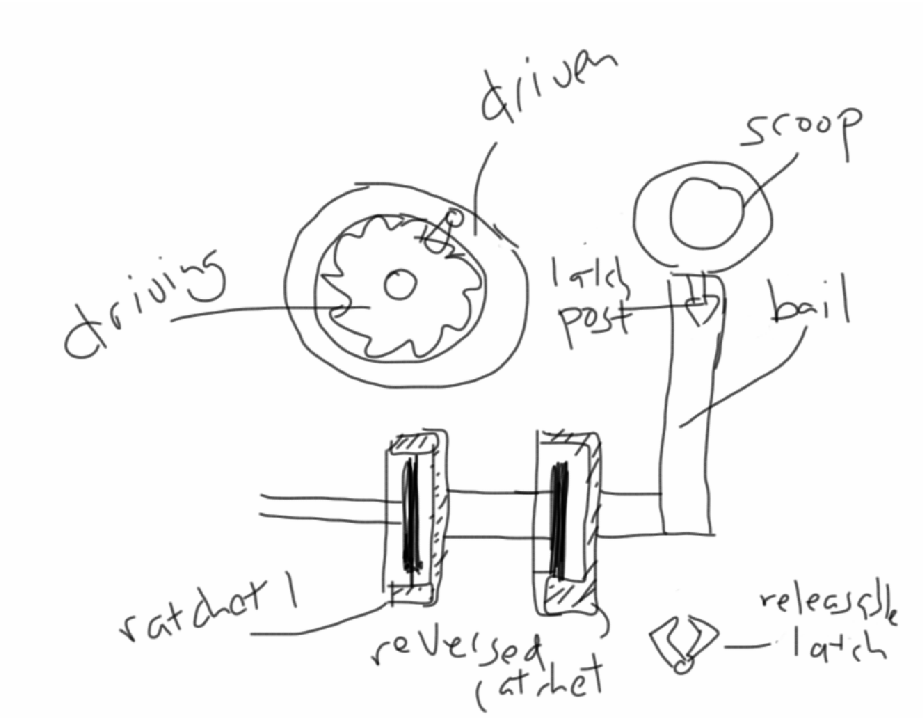

Figure 1. Double Ratchet and Latch

A latch prohibits any motion until a release is actuated, but only after it has been engaged.

There are two functional descriptions of a clutch.

One style of clutch (encountered in a manual transmission) decouples torque transmission when actuated.

Another style of clutch (encountered in the automatic transmission) stops rotary motion when actuated.

In the catapult design, Functional Requirement 2 is most easily satisfied by a conventional latch.

However, Functional Requirement 1 might be rewritten as

1. one-way torque transmission from the motor/gearbox
2. bail may not back-drive the motor/gearbox

Seen in this light, an obvious solution presents itself …

1. free-wheel (as seen on bicycles)
2. ratchet (as seen on a come-along)

Since a come-along ratchet also usually has a release mechanism, the Functional Requirements for the clutch/latch can be rewritten as

1. one-way torque transmission from the motor/gearbox

2. bail may not back-drive the motor/gearbox until the user is ready to release

If the designer realizes that a sprag clutch is a form of free-wheel that might be better incorporated into the gearbox, Functional Requirement 1 could actually be absorbed into the gearbox Functional Requirement (probably a good idea).

Another Functional Requirement which should be part of this discussion is to decouple or interrupt gearbox power when the latch has been actuated. Otherwise, the gearbox could damage the latch mechanism. So, Functional Requirements for the clutch/latch could be

1. one-way torque transmission from the motor/gearbox
2. bail may not back-drive the motor/gearbox until the user is ready to release
3. notify control system when latch is engaged and protect against damage

or

1. bail may not back-drive the motor/gearbox until the user is ready to release
2. notify control system when latch is engaged and protect against damage

The big difference in thought about this problem is that the solution requires TWO ratchets, not one (see Figure 1). The first ratchet disallows the gearbox from changing load direction and the second disallows the bail to change direction.

Another solution to this problem would be to use a clutch as from a manual transmission (see Figure 2). Such a clutch would use the gearbox to hold the bail in place until the

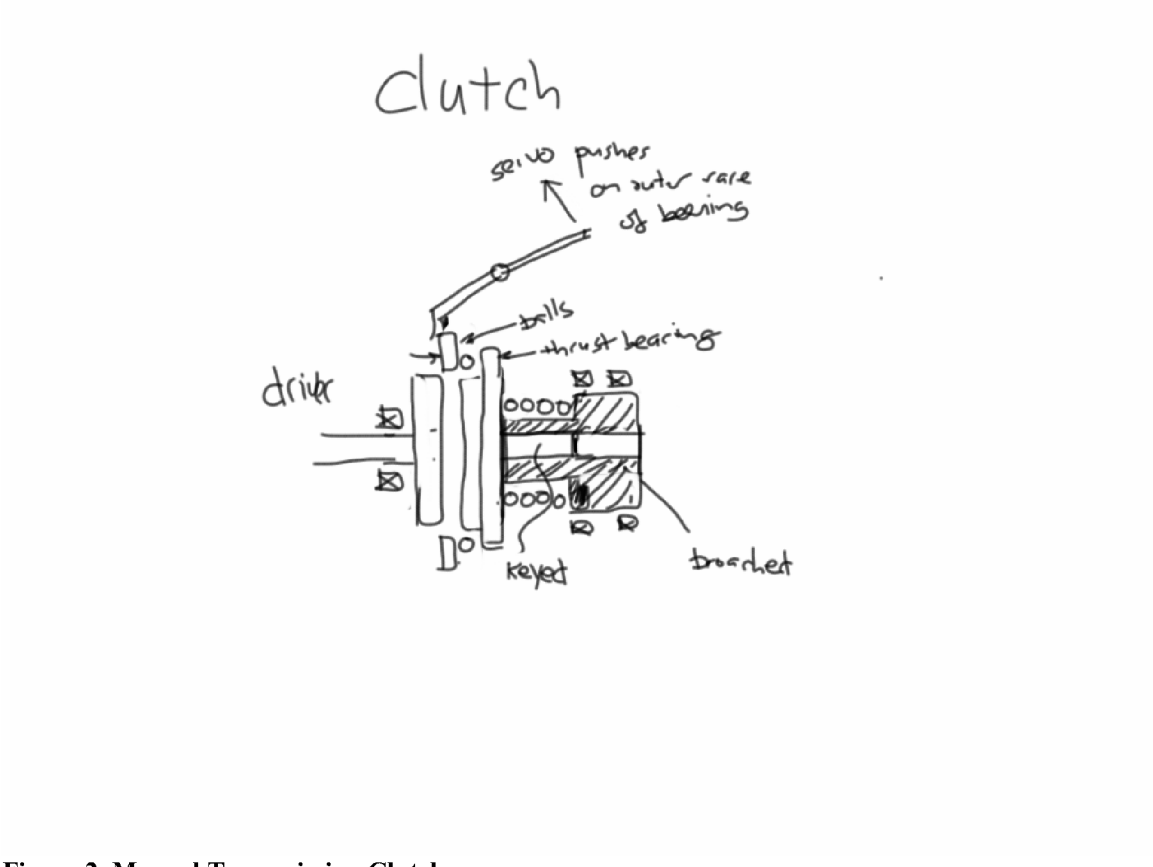

Figure 2. Manual Transmission Clutch

user was ready to release. A control system could use feedback on a potentiometer to maintain the desired cocked position until such a time as the user should disengage the clutch.

The functional requirements for this device would be

1. controllably engage/disengage torque transmission from the gearbox
2. maintain cocked position and protect gearbox from damage

The problem with this solution is that the gearbox would be active all the time and a power failure could cause a premature release.

So, if the functional requirement were added "maintain latched position during a power failure" this clutch design would eventually be forced into a clutch latch. The complexity of the latter solution is much higher than the complexity of the first solution.

A specific latch might be what you see on your trunk or hood (see Figure 3).

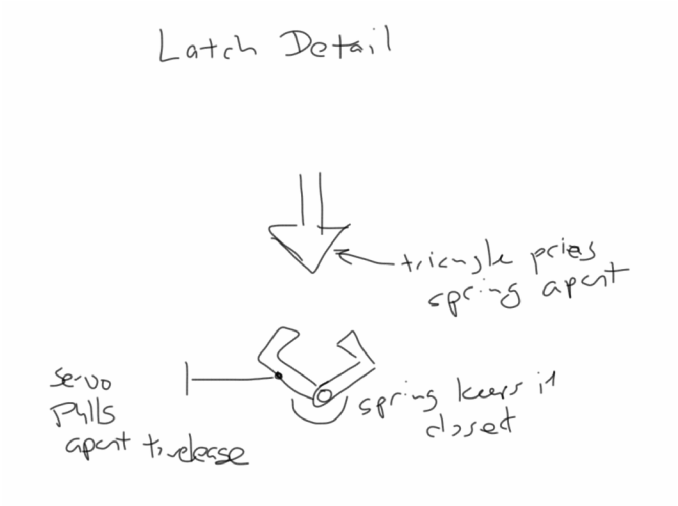

Figure 3. Latch Detail