EVALUATING
ACADEMIC READINESS
FOR APPRENTICESHIP TRAINING
Revised for
ACCESS TO APPRENTICESHIP

SCIENCE SKILLS
FRICTION

AN ACADEMIC SKILLS MANUAL
for
The Industrial Maintenance Mechanic Trades

This trade group includes the following trades:
Boiler Maker,
Facilities Maintenance Mechanic & Technician, and
Industrial Mechanic (Millwright)

Workplace Support Services Branch
Ontario Ministry of Education and Training

Revised 2011

In preparing these Academic Skills Manuals we have used passages, diagrams and questions similar to those an apprentice might find in a text, guide or trade manual.

This trade related material is not intended to instruct you in your trade. It is used only to demonstrate how understanding an academic skill will help you find and use the information you need.

SCIENCE SKILLS
FRICTION

An academic skill required for the study of the Industrial Maintenance Mechanic Trades

INTRODUCTION

Machines work according to scientific principles or laws. Often we are aware of the effects of these laws, even when we don't know the exact principle involved. For example, when you want to stop a moving vehicle, you apply the brakes. However, you might not be aware that brakes rely on the force of friction to stop a vehicle.

As an industrial maintenance mechanic, you have to be aware of the different effects of friction on the machines and parts you will be installing and replacing. Sometimes, friction is beneficial. It helps keep parts in their proper place and it is used by gears and brakes to slow things down. At other times, friction is a hindrance that has to be overcome. It causes wear and heat in connected moving parts, resulting in costly replacements. It requires extra energy to overcome the resistance caused by friction when you move heavy loads.

Knowing how to reduce the effects of friction is an essential part of your job. If you understand what causes friction, you can develop techniques to control it. This skills manual on friction covers the following topics:

- Definition of friction
- Friction between solid objects
- Limiting the effects of friction
- Making the most of friction

DEFINITION OF FRICTION

Friction is a basic force that has an effect on everything in our world. ***Friction*** *is the force that opposes motion between two surfaces*.

- Whenever one object moves over the surface of another, or when an object moves through water or air, the object meets a resistance force that tends to slow it down.
- Since all objects have some contact either with another object or with the air, all objects feel some effect of friction.

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Why Friction Happens
There are several reasons why friction happens:

- Objects are made from molecules. No matter how smooth a surface looks to our eyes, at the molecular level irregular projections grip each other resisting movement. The more closely two surfaces press together, the stronger the grip.
- There is also a force of attraction between molecules of different materials that causes them to resist moving apart. The strength of this attraction depends on the structure of the materials in contact

The exact reasons for why friction varies with different surfaces are not fully understood. In general, the rougher the two surfaces are and the more closely they press together, the stronger the force of friction becomes.

- Objects slide more easily on a surface such as ice or Teflon than on a concrete floor.

An object that is moving has a certain amount of kinetic energy. Friction causes some of the kinetic energy to be converted to heat energy. As the amount of kinetic energy becomes smaller, the object slows down. If two objects rub together as they quickly move back and forth, they can get hot because of the transfer of energy from motion to heat.

When you run a machine using electricity, you put energy into it. However, you never get the same amount of energy back out of the machine as you put into it. Friction steals some of the energy along the way. That energy is experienced as heat and sound.

- Whenever friction limits the efficiency of a machine in this way, you try to reduce friction as much as possible.
- At the same time, you need friction to make brakes, clutches and gears work. Here you work with friction, strengthening its effect.
- So friction can be both a help and a hindrance, an ever-present force you have to learn to control.

Static and Kinetic Friction
When you push a heavy machine across the floor, it is usually harder to start it moving than to keep it moving. If two objects are in contact, a resistance is created by the bonds of attraction between the two objects. This attraction, along with gravity, prevents objects from moving across each other unless they are given a push. It also tends to slow down a moving object.

Energy must be applied to overcome friction when we start something moving and also when we want to keep it in motion. But more force is needed to start an object moving in the first place than to keep it going. We describe these different effects as static friction and kinetic friction.

- ***Static friction*** *makes it difficult to start an object moving.*
- ***Kinetic friction*** *opposes the motion of an object that is already moving.*

Static friction is a stronger force than kinetic friction. There is a stronger attraction between objects that are resting against each other than between objects that are moving past each other.

FRICTION BETWEEN SOLID OBJECTS

Solid objects have differently shaped surfaces. They may be flat, spherical or cylindrical. The surfaces of solid objects also vary in how rough or how smooth they are. Both the shape and the surface smoothness of an object affect the amount of force needed to overcome friction.

Sliding friction

Say a solid object slides over the flat surface of another solid object. This type of movement creates a large amount of friction called ***sliding friction***. Sliding friction creates heat and noise, and causes surfaces to wear out quickly.

The smoother the surfaces in contact, the less force is needed to overcome sliding friction. When the surface areas in contact are narrow, sliding friction is also reduced. It is easier to drag a load on runners than when it is flat on the ground.

Rolling friction

If a solid object moves over a spherical or cylindrical surface such as a ball bearing or a roller, there will be less friction than when two flat surfaces move over each other. Rolling motion creates less friction than sliding motion. This reduced friction of rolling motion is called ***rolling friction***.

If the contact area of a roller or a wheel is made narrower, there is less rolling friction. However, the roller or wheel has to be large enough to support the load it is carrying.

Friction in a wheel and axle

Both sliding and rolling friction are present in a wheel and axle. When a wheel rotates around its axle, the two surfaces are in contact and they rub together.

- This creates sliding friction in the area of contact, which causes heat and wear in this area.
- At the same time, the outer surface of the wheel experiences rolling friction. This reduces the amount of friction considerably compared to if you were pulling the load without wheels. There is less resistance to motion and so less effort is required to move a load.

Even with these two frictions at work, using wheels connected to an axle is a much more efficient way to transport a load than sliding it over the ground.

The next step in efficiency is to reduce the sliding friction between the wheel and the axle. There are two primary methods of doing this.

1. The first way is to coat the area of contact with some kind of ***lubrication***.
2. The second way is to change the sliding friction to rolling friction. This is done by using ***bearings*** that roll, instead of sliding, in the contact area between the wheel and axle.

LIMITING THE EFFECTS OF FRICTION

Friction causes heat and noise in moving parts. When parts get overheated, they can warp or wear out quickly. The excess noise in machinery caused by friction can create a potential hearing problem for the people working nearby. It is calculated that friction adds at least 5% to the force needed to move a load up an incline. Working against the force of friction requires energy, which can be expensive. For these reasons it is important to limit the effects of friction.

To avoid using too much energy in order to overcome friction, engineers look for ways to decrease the amount of friction. The following are methods used on a job site to help reduce friction:

- the use of suitable materials (for example, steel creates less friction than rubber),
- polishing surfaces so they are as smooth as possible,
- the use of a lubricant which flows between parts to create a fluid surface that creates less friction than solid surfaces,
- the use of wheels or rollers to move objects,
- making sure that moving parts which are in contact are fitted precisely so there are no uneven areas to rub together, and
- the use of ball bearings in machines – steel balls that roll on another steel surface create only 1/100 the friction of flat steel that slides on steel.

Lubrication

The most common method of reducing friction between moving solid parts is lubrication. When a solid object moves over a fluid surface such as oil or water, less friction is created compared to when the object moves over another solid surface. *The molecules forming liquids naturally flow over each other because they have more kinetic energy.* Friction is reduced to a much lower level when lubrication creates fluid friction where originally there was dry friction.

- It is much easier to push a boat when it is in the water than when it is on land. The fluid friction of the water is much less than the friction of the boat bottom on a solid surface.

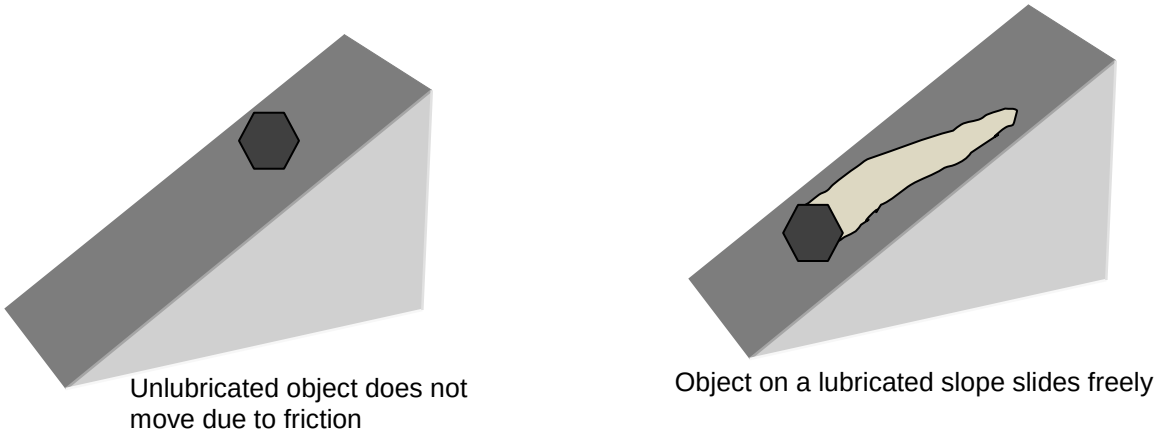

FIGURE 1: Effect of Lubrication on Friction

When a layer of oil is placed between two solid surfaces, the oil sticks to the solids. As one lubricated solid surface moves over the other, it is actually the oil molecules that slide over each other. In this way, lubrication works to lessen friction.

In a motor that runs machinery such as a drill or an assembly line, the surfaces of moving parts that are in close contact must be protected from wear and overheating. This is provided by coating the surfaces with a thin film of oil. The molecules of the oil act like miniature ball bearings.

Oil is a liquid substance that has a smooth, flowing feel. It is extracted from petroleum. All oils flow, but they do so at different rates depending on their viscosity. ***Viscosity*** *is the resistance of a liquid to flow.* Viscosity of an oil determines in what situations that oil can be used as a lubricant.

In an engine, oil must be thin enough to flow to the areas it is needed while still being thick enough to coat the surfaces. Viscosity increases in cold weather. Winter oil must be thin enough to flow at cold starting temperatures. Although you need to use the right oil for each situation, you probably do not have to figure out what type of oil is required. Usually the type of lubrication needed is specified on each machine.

Oil has other functions in an engine besides lubrication. It traps particles of dirt, which can be removed when the oil flows through an oil filter.

Oil helps create a pressure seal between the piston and cylinder. It contains the pressure created by the combustion explosion so that all of the pressure is used to drive the piston. Oil also helps cool the engine by absorbing heat and carrying it to a cooler area.

Grease is an oil thickened with soap. Grease is used if the lubricant needs to stay in place, if there is a heavy load at low speeds and if a good level of rust protection is required.

Bearings

Bearings reduce friction because they have a smooth surface. They roll instead of sliding and, because of their round shape, they have a small surface area of contact. In a wheel, bearings can reduce friction between the housing of the wheel and the shaft of the axle. See Figure 2.

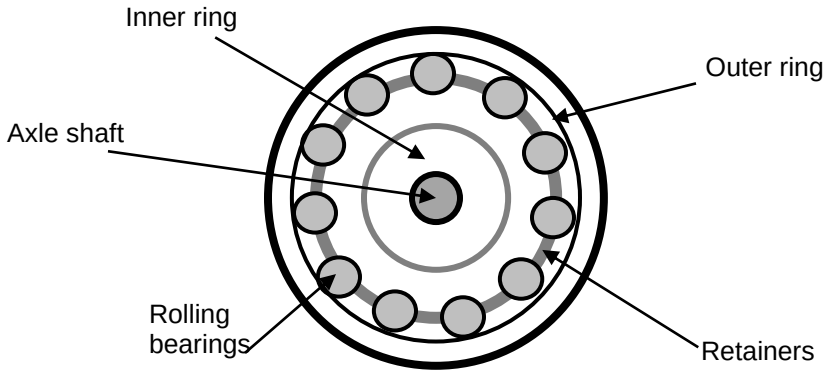

FIGURE 2: Parts of a Wheel Bearing

When the shaft rotates, it imparts its rotational motion to the wheel. To increase the efficiency of this transfer of energy, friction between the housing of the wheel and the shaft of the axle must be reduced. This is done by the use of lubrication and the use of bearings.

The bearings in a wheel are designed to work in the circular path between the wheel housing and the shaft. They are evenly spaced by retainers and contained within an inner ring and an outer ring.

MAKING THE MOST OF FRICTION

Excess friction must be limited in machines and when moving heavy objects. However, we also rely on friction to get a grip on things. Friction helps hold in place close fitting parts such as screws. Sometimes a machine needs insulation to keep heat from moving to sensitive parts or to dampen noise. Usually the insulation can be kept in place by friction between the wall of the machine and the insulation.

Machines depend on the force of friction in order to function. Gears, clutches and brakes would not work without it. It is the friction of the brake linings on the drums that enables brakes to slow a conveyor belt or a vehicle.

Some machinery requires material with polished surfaces to work well. Friction is used in grinders and sanders to create a smooth surface. The friction between the rough sandpaper and the surface being sanded results in particles being broken off until only a smooth surface remains.

CONCLUSION

Friction is a crucial force that has an influence on everything you use on the job. Since friction is always with us, industrial mechanics must find ways to both take advantage of and to control the effects of friction. Too much friction wastes energy as heat and noise and causes parts to wear out quickly. Lubrication and bearings are two ways of reducing friction between moving parts. At the same time, friction is needed in these machines to make brakes and gears work. Friction between the linings and the drums in brakes enables the brakes to slow a vehicle. The friction between the tires and the road allows vehicles to steer straight ahead or negotiate a turn. Friction is also used to create smooth surfaces and to hold objects in place.

Understanding why friction occurs can help you predict its effects, both positive and negative. This can enable you to either limit these effects or to work with them.

Underline the correct word to answer these questions. Answers are on the next page.

1. The force that causes resistance to movement when one object moves over the surface of another is called (energy or friction).

2. It is harder to start an object moving than to keep it moving. This is because static friction is (greater or lesser) than kinetic friction.

3. Friction acts to (slow down or speed up) a moving object.

4. Overcoming friction in machinery requires the use of (more or less) energy.

5. The use of rollers and bearings are two ways to (increase or decrease) the effects of friction.

6. It is (easier or harder) to slide an object on a flat surface than to roll it on wheels.

7. An object moving on a fluid surface meets (more or less) friction compared to a dry surface.

8. Lubricants such as oil create a (fluid or dry) surface for solids to move on.

9. Friction in moving parts can cause (cooling or overheating).

10. The molecules of a lubricant act as (ball bearing or brakes) on the surfaces that are moving over each other.

11. The force of (friction or gravity) helps hold screws in place.

12. Friction between the brake linings and the drums in a vehicle is used to (speed up or slow down) the vehicle.

Answer page

1. friction
2. greater
3. slow down
4. more
5. decrease
6. harder
7. less
8. fluid
9. overheating
10. ball bearings
11. friction
12. slow down