DESIGN AND FABRICATION OF EASILY MOVABLE STEPS FOR LIBRARY USAGE

A PROJECT REPORT

Submitted by

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ABSTRACT

Many students who are having short personality facing problems in picking books from upper racks in our library. So we thought of changing the design of the existing steps and making it more convenient for the users.

The problem discussed above can be rectified by introducing wheel attached steps. But main problem with introducing wheels is whenever user steps on the movable step, it may roll and he may fall down from the step. So there should be a mechanism that will make the system stable and to support the system with ground when user is stepping in.

The project aims to invent a new mechanism for that a spring type mechanism is introduced The improved model will not only be useful in our library but also in other places, especially school libraries where younger children face problem in getting books from library upper racks.

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CHAPTER 1

INTRODUCTION

1.1 OUR IDEA

The height of upper rack in our KCT library is about 225 cm from ground, and many other libraries it is still higher. People shorter than 164 cm height especially girls face problems in getting books from upper racks by using existing steps, which are also not easily movable. So there is necessity of redesigning the existing steps. Present steps, which short students are using, are highly uncomfortable; particularly lifting them to places wherever required in big library space is a difficult task. Also the existing step lacks safety features and hence students are reluctant to use them. There are many solutions for this problem, one of them is not putting books in upper racks, but this makes library authorities to search for new space for putting these books. A better option is changing the design of steps and introducing the new features The improved model will not only be useful in our library but also in other places, especially school libraries where younger children face problem in getting books from library upper racks.

The problem discussed above can be rectified by introducing wheel-attached steps. But main problem with introducing wheels is whenever user steps on the movable step, it may roll and he may fall down from the step. So there should be a mechanism that will make the system stable and stick to ground when user is stepping in. For that a Helical Spring mechanism is introduced

The total movable step system is planned with 5 major parts. Those are

1) Wheel frame
2) Helical spring
3) Inner frame
4) Wooden step structure
5) Extra step.

The wheel frame is attached to inner frame with a helical spring. Wooden step structure along with extra step will be attached to the inner frame. So whenever there is no load on the wooden structure the Helical spring will lift the inner frame along with wooden structure up to 1 cm from ground. As there is clearance we can move the system on wheels easily. Whenever student steps on, and shifts one third of his weight, the leaf spring sinks and inner frame along with wooden structure touches ground and system will become stable. Another important feature in the present design is the provision for incrementing a step. For this, an extra step is attached to right hand side of second step which is merged with the second step in normal condition, but can be operated with leg to form a third step whenever required.

1.2 CONVENTIONAL PROCESS IN LIBRARY

Today in the entire library, mostly they use the Ladder for both taking the books and to left where it has been taken. Every one feels that it is very high and also it is very low of cost, but actually they don't know the risk involved in it. Since it is too high there is a chance for slipping down. It may also break when the load increases, it also retain its strength for some few years only after that it looses its strength due to crack formation (Creep failure). The Library is a big place where large numbers of collections are available, so for searching a particular book it takes quite a long time and also we have to move here and there along with ladder. This system is very difficult for a short person, even for an elder person. So if we use more number of ladders it also increase in the total cost that is allotted for this purpose.

1.3 VARIOUS SYSTEM FOLLOWED AT PRESENT

1) LADDER TYPE – This is one of the commonly used systems in all the libraries as we have discussed above itself.

2) LADDER WITH WHEEL TYPE – This type of ladder is being used now only. The major drawback of this type is that when we go on increasing the height of the ladder the possibility of slip is more and also this type is not stable because the system is not balanced due to the additional forces (when we shake, move etc.) the only advantage is that it can be easily moved to all places.

3) BENCH TYPE – This type is the oldest method but still now also there are place where it is used. It is one of the simplest method but the height parameter can not be varied it is a fixed one. This one also has the same disadvantage of carrying it along with us for all places.

1.4 SOLUTION

Hence for all the above said problems a redesigning has to be done. Our project deals with this problem and brings a solution to this buy using a Spring above the wheels. When a load acts on the system the springs gets in contact with the wheels and the friction between the wheels and ground is improved so the possibility of slip is very less. It is also very easy to take all over the place. Here we are using a step type arrangement so there is no fear of falling down and it is very easy to carry all the books.

CHAPTER 2

SPRINGS

2.1 HISTORY OF SPRINGS

Very simple, non-coil springs have been used throughout history. Even a resilient tree branch can be used as a spring. More sophisticated spring devices date to the Bronze Age, when eyebrow tweezers were common in several cultures. During the third century B.C., Greek engineer Ctesibius of Alexandria developed a process for making "springy bronze" by increasing the proportion of tin in the copper alloy, casting the part, and hardening it with hammer blows. He attempted to use a combination of leaf springs to operate a military catapult, but they were not powerful enough. During the second century B.C., Philo of Byzantium, another catapult engineer, built a similar device, apparently with some success. Padlocks were widely used in the ancient Roman empire, and at least one type used bowed metal leaves to keep the devices closed until the leaves were compressed with keys.

The next significant development in the history of springs came in the Middle Ages. A power saw devised by Villard de Honnecourt about 1250 used a water wheel to push the saw blade in one direction, simultaneously bending a pole; as the pole returned to its unbent state, it pulled the saw blade in the opposite direction.

Coiled springs were developed in the early fifteenth century. By replacing the system of weights that commonly powered clocks with a wound spring mechanism, clockmakers were able to fashion reliable, portable timekeeping devices. This advance made precise celestial navigation possible for ocean-going ships.

In the eighteenth century, the Industrial Revolution spurred the development of mass-production techniques for making springs. During the 1780s, British locksmith Joseph Bramah used a spring winding machine in his factory. Apparently an adaptation of a lathe, the machine carried a reel of wire in place of a cutting head. Wire from the reel was wrapped around a rod secured in the lathe. The speed of the lead screw, which carried the reel parallel to the spinning rod, could be adjusted to vary the spacing of the spring's coils.

Common examples of current spring usage range from tiny coils that support keys on cellular phone touchpads to enormous coils that support entire buildings and protect them from earthquake vibration.

2.2 INTRODUCTION ABOUT SPRINGS

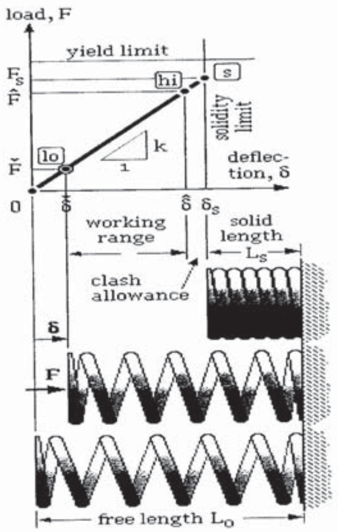
A spring is a device that changes its shape in response to an external force, returning to its original shape when the force is removed. The energy expended in deforming the spring is stored in it and can be recovered when the spring returns to its original shape. Generally, the amount of the shape change is directly related to the amount of force exerted. If too large a force is applied, however, the spring will permanently deform and never return to its original shape.

Springs are unlike other machine/structure components in that they undergo significant deformation when loaded - their compliance enables them to store readily recoverable mechanical energy. In a vehicle suspension, when the wheel meets an obstacle, the springing allows movement of the wheel over the obstacle and thereafter returns the wheel to its normal position. Another common duty is in cam follower return - rather than complicate the cam to provide positive drive in both directions, positive drive is provided in one sense only, and the spring is used to return the follower to its original position.

Springs are common also in force- displacement transducers, eg. in weighing scales, where an easily discerned displacement is a measure of a change in force. The simplest spring is the tension bar. This is an efficient energy store since all its elements are stressed identically, but its deformation is small if it is made of metal. Bicycle wheel spokes are the only common applications which come to mind.

Beams form the essence of many springs. The deflection d of the load F on the end of a cantilever can be appreciable - it depends upon the cantilever's geometry and elastic modulus, as predicted by elementary beam theory. The shortcoming of most metal springs is that they rely on either bending or torsion to obtain significant deformations; the stress therefore varies throughout the material so that the material does not all contribute uniformly to energy storage.

2.3 SPRINS CHARACTERISTIC



The performance of a spring is characterised by the relationship between the loads (**F**) applied to it and the deflections (**d**) which result, deflections of a compression spring being reckoned from the unloaded free length as shown in the animation.

The F-d characteristic is approximately linear provided the spring is close- coiled and the material elastic. The slope of the characteristic is known as the **stiffness** of the spring $k = F/d$ (aka. spring 'constant', or 'rate', or 'scale' or 'gradient') and is determined by the spring geometry and modulus of rigidity as will be shown. The yield limit is usually arranged to exceed the solidity limit as illustrated, so that there is no possibility of yield and consequent non-linear behaviour even if the spring is solidified whilst assembling prior to operation. Sometimes a spring is deliberately yielded or **pre-set** during manufacture as will be explained later.

The animation illustrates the spring working between a minimum operational state (F_{lo}, d_{lo}) and a maximum operational state (F_{hi}, d_{hi}) { **nomenclature explanation**}. If the total number of cycles is small - say less than 10^4 - then loading may be treated as static, otherwise fatigue considerations apply.

The largest working length of the spring should be appreciably less than the free length to avoid all possibility of contact being lost between spring and platen, with consequent shock when contact is re-established. In high frequency applications this may be satisfied by the design constraint $F_{hi}/F_{lo} = 3$.

As the spring approaches solidity, small pitch differences between coils will lead to progressive coil- to- coil contact rather than to sudden contact between all coils simultaneously. Any contact leads to impact and surface deterioration, and to an increase in stiffness.

To avoid this, the working length of the spring should exceed the solid length by a **clash allowance** of at least 10% of the maximum working deflection - that is $d_s - d_{hi} = 0.1d_{hi}$, though this allowance might need to be increased in the presence of high speeds and/or inertias.

2.3.1 Hooke's law

Springs that are not stretched or compressed beyond their elastic limit obey Hooke's law, which states that the force with which the spring pushes back is linearly proportional to the distance from its equilibrium length:

$$\mathbf{F = -kx,}$$

where

x is the displacement vector - the distance and direction in which the spring is deformed

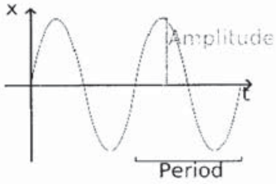
F is the resulting force vector - the magnitude and direction of the restoring force the spring exerts

k is the spring constant or force constant of the spring.

Simple harmonic motion

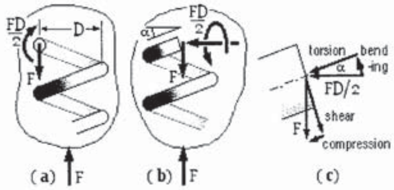
Since force is equal to mass, m, times acceleration, a, the force equation looks like:

$$\mathbf{F = -kx = ma}$$



The displacement, x, as a function of time. The amount of time that passes between peaks is called the period.

2.4 STRESS INDUCED IN SPRINGS



The free body (**a**) of the lower end of a spring whose mean diameter is D :

- embraces the known upward load F applied externally and axially to the end coil of the spring, and
- cuts the wire transversely at a location which is remote from the irregularities associated with the end coil and where the stress resultant consists of an equilibrating force F and an equilibrating rotational moment FD/2.

The wire axis is inclined at the helix angle a at the free body boundary in the side view (**b**) (Note that this is first angle projection). An enlarged view of the wire cut conceptually at this boundary (**c**) shows the force and moment triangles from which it is evident that the stress resultant on this cross-section comprises four components - a shear force (F cosa), a compressive force (F sina), a torque ($^{1}/_{2}$FD cosa) and a bending moment ($^{1}/_{2}$FD sina).

Assuming the helix inclination a to be small for close- coiled springs approaching solidity (when working loads are critical) then sina ˜ 0, cosa ˜ 1, and the significant loading reduces to **torsion plus direct shear.** The maximum shear stress at the inside of the coil will be the sum of these two component shears :

$$t = t_{torsion} + t_{direct} = Tr/J + F/A$$
$$= (FD/2)\,(d/2)/(pd^4/32) + F/(pd^2/4) = (1 + 0.5d/D)\ 8\ FD/pd^3$$

$$t = K\ 8FC\ /pd^2$$

in which the **stress factor, K** assumes one of three values, either

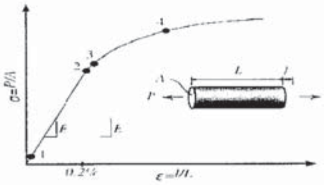
. . .

- K = 1 when torsional stresses only are significant - ie. the spring behaves essentially as a torsion bar, or
- K = K_s = 1 + 0.5/C which accounts approximately for the relatively small direct shear component noted above, and is used in **static applications** where the effects of stress concentration can be neglected, or
- K = K_h ˜ (C + 0.6)/(C - 0.67) which accounts for direct shear and also the effect of curvature- induced stress concentration on the inside of the coil (similar to that in curved beams). K_h should be used in **fatigue applications**; it is an approximation for the **Henrici factor** which follows from a more complex elastic analysis as reported in **Wahl** op cit. It is often approximated by the Wahl factor $K_w = (4C - 1)/(4C - 4) + 0.615/C$.

Standard tolerance on wire diameters less than 0.8mm is 0.01mm, so the error of theoretical predictions for springs with small wires can be large due to the high exponents which appear in the equations. It must be appreciated also that flexible components such as springs cannot be manufactured to the tight tolerances normally associated with rigid components. The spring designer must allow for these peculiarities. Variations in length and number of active turns can be expected, so critical springs are often specified with a tolerance on stiffness rather than on coil diameter.

2.4.1YEILD THEORY

YEILD STRENGTH CURVE



Elastic limit

Beyond the elastic limit, permanent deformation will occur. The lowest stress at which permanent deformation can be measured. This requires a manual load-unload procedure, and the accuracy is critically dependent on equipment and operator skill. For elastomers, such as rubber, the elastic limit is much larger than the proportionality limit.

Offset yield point (yield strength or proof stress)

This is the most widely used strength measure of metals, and is found from the stress-strain curve as shown in the figure to the right. A plastic strain of 0.2% is usually used to define the offset yield stress, although other values may be used depending on the material and the application. The offset value is given as a subscript, e.g. $R_{p0.2}$=310 MPa. In some materials there is essentially no linear region and so a certain value of strain is defined instead. Although somewhat arbitrary, this method does allow for a consistent comparison of materials.

Upper yield point and lower yield point

Some metals, such as mild steel, reach an upper yield point before dropping rapidly to a lower yield point. The material response is linear up until the upper yield point, but the lower yield point is used in structural engineering as a conservative value.

2.4.2 Yield Criterion

A yield criterion, often expressed as yield surface, or yield locus, is an hypothesis concerning the limit of elasticity under any combination of stresses. There are two interpretations of yield criterion:

one is purely mathematical in taking a statistical approach while other models attempt to provide a justification based on established physical principles. Since stress and strain are tensor qualities they can be described on the basis of three principal directions, in the case of stress these are denoted by , and .

The following represent the most common yield criterion as applied to an isotropic material (uniform properties in all directions). Other equations have been proposed or are used in specialist situations.

Maximum Principal Stress Theory - Yield occurs when the largest principal stress exceeds the uniaxial tensile yield strength. Although this criterion allows for a quick and easy comparison with experimental data it is rarely suitable for design purposes.

$$\sigma_1 \leq \sigma_y$$

Maximum Principal Strain Theory - Yield occurs when the maximum principal strain reaches the strain corresponding to the yield point during a simple tensile test. In terms of the principal stresses this is determined by the equation:

$$\sigma_1 - \nu(\sigma_2 + \sigma_3) \leq \sigma_y.$$

Maximum Shear Stress Theory - Also known as the Tresca criterion, after the French scientist Henri Tresca. This assumes that yield occurs when the shear stress exceeds the shear yield strength :

$$\tau = \frac{\sigma_1 - \sigma_3}{2} \leq \tau_{ys}.$$

Total Strain Energy Theory - This theory assumes that the stored energy associated with elastic deformation at the point of yield is independent of the specific stress tensor. Thus yield occurs when the strain energy per unit volume is greater than the strain energy at the elastic limit in simple tension. For a 3-dimensional stress state this is given by:

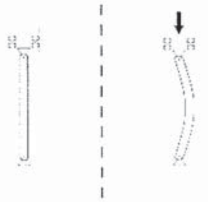
$$\sigma_1^2 + \sigma_2^2 + \sigma_3^2 - 2\nu(\sigma_1\sigma_2 + \sigma_2\sigma_3 + \sigma_1\sigma_3) \leq \sigma_y^2.$$

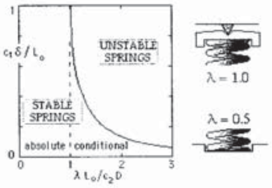
Distortion Energy Theory - This theory proposes that the total strain energy can be separated into two components: the volumetric (hydrostatic) strain energy and the shape (distortion or shear) strain energy. It is proposed that yield occurs when the distortion component exceeds that at the yield point for a simple tensile test. This is generally referred to as the Von Mises criterion and is expressed as:

$$\frac{1}{2}\left[(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2\right] \leq \sigma_y^2.$$

Based on a different theoretical underpinning this expression is also referred to as **octahedral shear stress theory**.

2.5 BUCKLING EFFECT





Compression springs are no different from other members subject to compression in that they will buckle if the deflection (ie. the load) exceeds some critical value d_{crit} which depends upon the slenderness ratio L_o/D rather like Euler buckling of columns,

$c_1 d_{crit}/L_o = 1 - v[1 - (c_2 D/ ?L_o)^2]$ in which the constants are defined

$c_1 = (1 + 2?/(1 + ? = 1.23$ for steel ; $c_2 = p\,v[(1 + 2?/(2 + ?] = 2.62$ for steel

The end support parameter ? reflects the method of support. If both ends are guided axially but are free to rotate (like a hinged column) then ? = 1. If both ends are guided and prevented from rotating then ? = 0.5. Other cases are covered in the literature. The plot of the critical deflection is very similar to that for Euler columns.

A rearrangement of suitable for evaluating the critical free length for a given deflection is :

$L_{o.crit} = [1 + (c_2D/c_1?d)^2]\, c_1d/2$

2.6 TYPES OF SPRING

Springs are classified according some of its properties.Depending on load it can classifies as:

- Tension/Extension spring
- Compression spring
- Torsional spring

In tension/extension and compression there is axial load. On the other hand in the torsional spring there is torsional force.

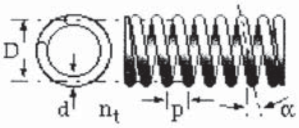
Depending on spring material it can be classified as:

- Wire/Coil spring
- Flat spring

The most common types of spring are:

- Helical spring
- Torsion spring
- Leaf spring
- Belleville spring

HELICAL SPRING



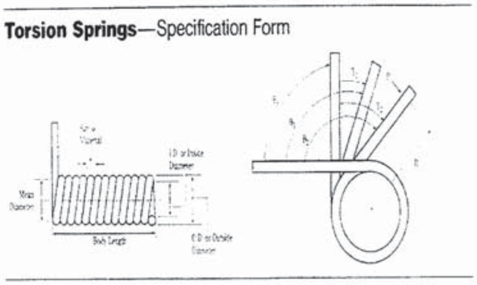
Helical spring geometry

A type of spring designed to compress and become smaller when presented with compressive load. Helical spring normally refers to a coil compression spring, but there are other types of springs and spring-like objects used as compression springs in special applications.

These are in turn of two types:

- Compression springs are designed to become shorter when loaded. Their turns are not touching in the unloaded position, and they need no attachment points.
  - A volute spring is a compression spring in the form of a cone, designed so that under compression the coils are not forced against each other, thus permitting more legnth to be shortened.
- Tension springs are designed to become longer under load. Their turns are normally touching in the unloaded position, and they have a hook, eye or some other means of attachment at each end.

TORSION SPRING


Torsion Springs—Specification Form

A **torsion spring** is a spring that works by torsion or twisting; that is, a flexible elastic object that stores mechanical energy when it is twisted. The amount of force (actually torque) it exerts is proportional to the amount it is twisted. A torsion spring is often made from a wire, ribbon, or bar of metal or rubber, while more delicate ones are made of silk, glass, or quartz fibers.

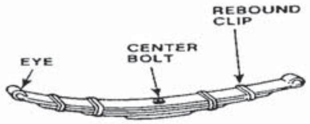
Torsion coefficient

As long as they are not twisted beyond their elastic limit, torsion springs obey an angular form of Hooke's law:

$$\tau = -\kappa\theta$$

where is the torque exerted by the spring in newton-meters, and is the angle of twist in radians. is a constant with units of newton-meters / radian, variously called the spring's **torsion coefficient**, **torsion elastic modulus**, or just **spring constant**, equal to the torque required to twist the spring through an angle of 1 radian. It is analogous to the spring constant of a linear spring.

LEAF SPRING

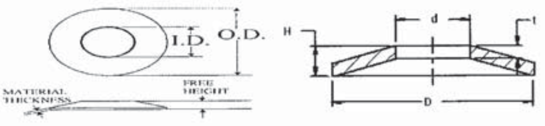


Originally called laminated or carriage spring, a **leaf spring** is a simple form of spring, commonly used for the suspension in wheeled vehicles. It is also one of the oldest forms of springing, dating back to medieval times

Sometimes referred to as a **semi-elliptical spring** or **cart spring**, it takes the form of a slender arc-shaped length of spring steel of rectangular cross-section. The center of the arc provides location for the axle, while tie holes are provided at either end for attaching to the vehicle body. For very heavy vehicles, a leaf spring can be made from several leaves stacked on top of each other in several layers, often with progressively shorter leaves. Leaf springs can serve locating and to some extent damping as well as springing functions.

A leaf spring can either be attached directly to the frame at both ends or attached directly at one end, usually the front, with the other end attached through a shackle, a short swinging arm. The shackle takes up the tendency of the leaf spring to elongate when compressed and thus makes for softer springiness.

Belleville Springs



Belleville springs are a type of disc-shaped washer with an extremely high tensile strength. Originally developed in the mid-19th century by Julian Belleville, belleville springs are used in a variety of environments in which a heavy load bearing ability is required. Many high performance cars use a type of belleville spring in their shock absorbing systems, and belleville springs are also used in manufacturing equipment, as well as electronics

Belleville springs can be made in a wide range of sizes, from very small washers to very large discs. In shape, they resemble a shallow soup bowl with the bottom cut out, and they are generally made from tempered steel and other similar metals that can stand up to immense pressures.

2.7 SPRING MATERIALS

This section will tell you about the different kinds of material that springs are made out of. It will also tell you where to get your wire -- make sure you read the Safety section so you know how to handle it safely once you've got it.

Types of Wire

Springs are usually made from alloys of steel. The most common spring steels are music wire, oil tempered wire, chrome silicon, chrome vanadium, and 302 and 17-7 stainless. Other materials can also be formed into springs, depending on the characteristics needed. Some of the more common of these exotic metals include beryllium copper, phosphor bronze, Inconel, Monel, and titanium.

The following table summarizes the more important properties of each material:

Material	Common Sizes	Properties and Uses
Music Wire	.003-.250	A high-carbon steel wire used primarily for applications demanding high strength, medium price, and uniformly high quality. Guitar and piano strings are made from this material, as are most small springs. Music wire will contract under heat, and can be plated.
Oil Tempered Wire (OT)	.010-.625	This is the workhorse steel spring wire, being used for many applications in which superior strength or uniformity is not crucial. Will not generally change dimensions under heat. Can be plated. Also available in square and rectangular sections.
Chrome Silicon, Chrome Vanadium	.010-.500	These are higher quality, higher strength versions of Oil Tempered wire, used in high-temperature applications such as automotive valve springs. Will not generally change dimensions under heat. Can be plated.
Stainless Steel	.005-.500	Stainless steels will not rust, making them ideal for the food industry and other environments containing water or steam. 302 series stainless will expand slightly under heat: 17-7 will usually not change. Cannot be plated.
Inconel, Monel, Beryllium Copper, Phosphor Bronze	.010-.125	These specialty alloys are sometimes made into springs which are designed to work in extremely high-temperature environments, where magnetic fields present a problem, or where corrosion resistance is needed in a high-temperature working environment. They are much more costly than the more common stocks and cannot be plated. Generally will not change dimensions under heat.
Titanium	.032-.500	Used primarily in air- and spacecraft because of its extremely light weight and high strength, titanium is also extremely expensive and dangerous to work with as well: titanium wire will shatter explosively under stress if its surface is scored. Generally will not change dimensions under heat. Cannot be plated.

Titanium is the strongest material, but it is very expensive. Next come chrome vanadium and chrome silicon.

The selection of the spring material is usually the first step in parametric spring design. Material selection can be based on a number of factors, including temperature range, tensile strength, elastic modulus, fatigue life, corrosion resistance, electrical properties, cost, etc. The Helical Spring Design module requires the following material properties as input:

- Elastic Modulus (E)
- Poisson's Ratio (n)
- Material Mass Density (r)

Nominal properties for materials commonly used in spring design can be accessed using the ETB Materials Database. A short description of common spring materials is given in the following paragraphs.

High-carbon spring steels are the most commonly used of all springs materials. They are least expensive, readily available, easily worked, and most popular. These materials are not satisfactory for high or low temperatures or for shock or impact loading. Examples include:

- Music Wire (ASTM A228)
- Hard Drawn (ASTM A227)
- High Tensile Hard Drawn (ASTM A679)
- Oil Tempered (ASTM A229)
- Carbon Valve (ASTM A230)

Alloy spring steels have a definite place in the field of spring materials, particularly for conditions involving high stress and for applications where shock or impact loading occurs. Alloy spring steels also can withstand higher and lower temperatures than the high-carbon steels. Examples include:

- Chrome Vanadium (ASTM A231)
- Chrome Silicon (ASTM A401)

Stainless spring steels have seen increased use in recent years. Several new compositions are now available to withstand corrosion. All of these materials can be used for high temperatures up to 650°F. Examples include:

- AISI 302/304 - ASTM A313
- AISI 316 - ASTM A313
- 17-7 PH - ASTM A313(631)

Copper-base alloys are important spring materials because of their good electrical properties combined with their excellent resistance to corrosion. Although these materials are more expensive than the high-carbon and the alloy steels, they nevertheless are frequently used in electrical components and in subzero temperatures. All copper-base alloys are nonmagnetic. Examples include:

- Phosphor Bronze (Grade A) - ASTM B159
- Beryllium Copper - ASTM B197
- Monel 400 (AMS 7233)
- Monel K500 (QQ-N-286)

Nickel-based alloys are especially useful spring materials to combat corrosion and to withstand both elevated and below-zero temperature application. Their nonmagnetic characteristic is important for such devices as gyroscopes, chronoscopes, and indicating instruments. These materials have high electrical resistance and should not be used for conductors of electrical current. Examples include:

- A286 Alloy
- Inconel 600 (QQ-W-390)
- Inconel 718
- Inconel X-750 (AMS 5698, 5699)

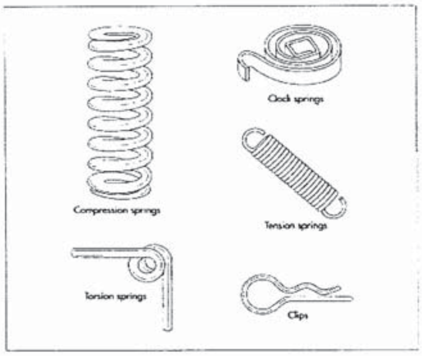
2.8 SPRING MANUFACTURING

The following description focuses on the manufacture of steel-alloy, coiled springs.

Coiling

- 1 Cold winding. Wire up to 0.75 in (18 mm) in diameter can be coiled at room temperature using one of two basic techniques. One consists of winding the wire around a shaft called an arbor or mandrel. This may be done on a dedicated spring-winding machine, a lathe, an electric hand drill with the mandrel secured in the chuck, or a winding machine operated by hand cranking. A guiding mechanism, such as the lead screw on a lathe, must be used to align the wire into the desired pitch (distance between successive coils) as it wraps around the mandrel.

Alternatively, the wire may be coiled without a mandrel. This is generally done with a central navigation computer (CNC) machine.



Examples of different types of springs.

The wire is pushed forward over a support block toward a grooved head that deflects the wire, forcing it to bend. The head and support block can be moved relative to each other in as many as five directions to control the diameter and pitch of the spring that is being formed.

For extension or torsion springs, the ends are bent into the desired loops, hooks, or straight sections after the coiling operation is completed.

- 2 Hot winding. Thicker wire or bar stock can be coiled into springs if the metal is heated to make it flexible. Standard industrial coiling machines can handle steel bar up to 3 in (75 mm) in diameter, and custom springs have reportedly been made from bars as much as 6 in (150 mm) thick. The steel is coiled around a mandrel while red hot. Then it is immediately removed from the coiling machine and plunged into oil to cool it quickly and harden it. At this stage, the steel is too brittle to function as a spring, and it must subsequently be tempered.

Hardening

- 3 Heat treating. Whether the steel has been coiled hot or cold, the process has created stress within the material. To relieve this stress and allow the steel to maintain its characteristic resilience, the spring must be tempered by heat treating it. The spring is heated in an oven, held at the appropriate temperature for a predetermined time, and then allowed to cool slowly. For example, a spring made of music wire is heated to 500°F (260°C) for one hour.

Finishing

- 4 Grinding. If the design calls for flat ends on the spring, the ends are ground at this stage of the manufacturing process. The spring is mounted in a jig to ensure the correct orientation during grinding, and it is held against a rotating abrasive wheel until the desired degree of flatness is obtained. When highly automated equipment is used, the spring is held in a sleeve while both ends are ground simultaneously, first by coarse wheels and then by finer wheels. An appropriate fluid (water or an oil-based substance) may be used to cool the spring, lubricate the grinding wheel, and carry away particles during the grinding.
- 5 Shot peening. This process strengthens the steel to resist metal fatigue and cracking during its lifetime of repeated flexings. The entire surface of the spring is exposed to a barrage of tiny steel balls that hammer it smooth and compress the steel that lies just below the surface.
- 6 Setting. To permanently fix the desired length and pitch of the spring, it is fully compressed so that all the coils touch each other. Some manufacturers repeat this process several times.
- 7 Coating. To prevent corrosion, the entire surface of the spring is protected by painting it, dipping it in liquid rubber, or plating it with another metal such as zinc or chromium. One process, called mechanical plating, involves tumbling the spring in a container with metallic powder, water, accelerant chemicals, and tiny glass beads that pound the metallic powder onto the spring surface.

Alternatively, in electroplating, the spring is immersed in an electrically conductive liquid that will corrode the plating metal but not the spring. A negative electrical charge is applied to the spring. Also immersed in the liquid is a supply of the plating metal, and it is given a positive electrical charge. As the plating metal dissolves in the liquid, it releases positively charged molecules that are attracted to the negatively charged spring, where they bond chemically. Electroplating makes carbon steel springs brittle, so shortly after plating (less than four hours) they must be baked at 325-375°F (160-190°C) for four hours to counteract the embrittlement.

- 8 Packaging. Desired quantities of springs may simply be bulk packaged in boxes or plastic bags. However, other forms of packaging have been developed to minimize damage or tangling of springs. For example, they may be individually bagged, strung onto wires or rods, enclosed in tubes, or affixed to sticky paper.

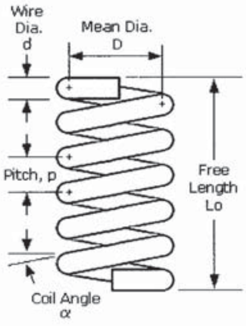
CHAPTER 3

SPRING DESIGN

3.1 SPRING GEOMETRY

The Helical Spring Design module calculates spring design parameters for close-coiled round wire helical compression springs, including spring rate, maximum force, maximum displacement, and maximum shear stress. It requires the following basic input:

- **Geometry** - Length, Wire Diameter, Coil Diameter
- **Material Data** - Elastic Modulus, Poisson's Ratio, Density
- **End Treatment** - Plain, Ground, Closed, Closed and Ground



Helical spring geometry

The primary spring geometric design parameters are:

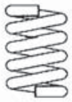
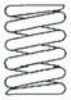
- ***Free Length*** **(L_o)** - The length of the unloaded spring.
- ***Wire Diameter*** **(d)** - The diameter of the wire that is wound into a helix.
- ***Coil Diameter*** **(D)** - The mean diameter of the helix, i.e., (D_{outer} + D_{inner})/2.
- ***Total Coils*** **(N_t)**- The number of coils or turns in the spring.

The following geometric parameters are derived by the module based on the specified end type:

- ***Active Coils*** **(N_a)** - The number of coils which actually deform when the spring is loaded, as opposed to the inactive turns at each end which are in contact with the spring seat or base.
- ***Solid Length*** **(L_s)** - The minimum length of the spring, when the load is sufficiently large to close all the gaps between the coils.
- ***Pitch*** **(p)** - The distance from center to center of the wire in adjacent active coils.

Typically, either closed ends or closed and ground ends are specified due to the greater area of contact between the spring and its base.

Table 1. Effect of end treatment.

	Plain Ends	**Closed Ends**	**Plain Ends Ground**	**Closed Ends Ground***
				
Active Coils, N_a	N_t	N_t-2	N_t-1	N_t-2
Free Length, L_o	N_ap+d	N_ap+3d	(N_a+1)p	N_ap+2d
Solid Length, L_s	(N_a+1)d	(N_a+1)d	(N_a+1)d	(N_a+2)d
Pitch, p	(L_o-d)/N_a	(L_o-3d)/N_a	L_o/(N_a+1)	(L_o-2d)/N_a

3.2 TERMS USED

- ***Outer Diameter*** **(D_o)** - The outer diameter of the spring coil,

$$D_O = D + d$$

- ***Inner Diameter*** **(D_i)** - The inner diameter of the spring coil,

$$D_i = D - d$$

- ***Spring Index*** **(C)** - The ratio of mean coil diameter to wire diameter. A low index indicates a tightly wound spring (a relatively large wire size wound around a relatively small diameter mandrel giving a high rate).

$$C = \frac{D}{d}$$

- ***Shear Modulus*** **(G)** - A material property calculated from the material's elastic modulus *E* and Poisson ratio n,

$$G = \frac{E}{2(1+\nu)}$$

- ***Slenderness Ratio*** **(L_o / D)** - The ratio of spring length to mean coil diameter.

- ***Spring Rate*** **(*k*)** - The force required to produce a unit deflection, F/d. For close-coiled helical springs the F-d characteristic is approximately linear and can be calculated from the geometry and shear modulus of the spring:

$$k = \frac{Gd^4}{8D^3 N_a}$$

- ***Maximum Deflection*** **(d_{max})** - The deflection required to go from the free length to the solid length of the spring,

$$\delta_{max} = L_O - L_s$$

- ***Maximum Load*** **(P_{max})** - The maximum force the spring can take occurs when the spring is deformed all the way to its solid height,

$$P_{max} = k \cdot \delta_{max}$$

- ***Uncorrected Maximum Shear Stress*** **(t_{max})** - The formula for uncorrected stress is obtained by dividing the torsion moment WD/2 acting on the wire, by the section modulus in torsion, p d^3/16, giving:

$$\tau_{max} = \frac{8DP_{max}}{\pi d^3}$$

- ***Wahl Correction Factor*** **(K_w) -** In addition to shear stress due to torque, there are two other sources of stress: the direct shear stress and the curvature stress. The stress due to curvature comes from the spring being unable to twist as its load is applied, thus contributing to the shear stress in the wire. To account for these additional sources of stress, the uncorrected shear stress t is multiplied by the Wahl correction factor K, which is a function of the spring index. The Wahl correction factor can be calculated from the following:

$$K_w = \frac{4C-1}{4C-4} + \frac{0.615}{C}$$

- ***Corrected Maximum Shear Stress*** **(t_{max}')** - The corrected stress is calculated by multiplying the Wahl correction factor K by the initial uncorrected stress t:

$$\tau_{max}' = K_w \cdot \tau_{max}$$

- ***Wire Length*** **(L_w)** - The length of wire needed to make the spring.

$$L_w = \pi D\left(\frac{N_a}{\cos(\alpha)} + N_{ia}\right)$$

- ***Spring Mass*** **(M)** - The mass of the spring.

$$M = \rho L_w \cdot \frac{\pi d^2}{4}$$

- ***Natural Frequency*** **(f_n)** - The lowest natural frequency of the spring in the axial direction.

$$f_n = \frac{1}{2}\sqrt{\frac{k}{M}}$$

3.3 SPECIFICATION AND MATERIALS USED

SPRING MATERIAL:

The most suitable material for springs are those which can store up the maximum amount of work or energy in a given weight or volume of spring material without permanent deformation. These steels should have a high elastic limit as well as high deflection value. The spring steel for loading applications should possess maximum strength against fatigue effects and shocks. The steel most commonly used for making springs are as shown below.

MATERIAL = CARBON STEEL

SPECIFICATION:

SLNO	MECHANICAL PROPERTIES	VALUE
1	Density	7870 KG / m ^{3}
2	Modulus of Elasticity	200X1E+9 N/m^2
3	Poisson's Ratio	0.290
4	Specific Heat Capacity	0.472 J/g-°C
5	Thermal Conductivity	43.6 W/m-K
COMPOSITION		
1	Carbon, C	0.320 - 0.380 %
2	Iron, Fe	98.73 - 99.18 %
5	Manganese, Mn	0.500 - 0.800 %
3	Phosphorous, P	<= 0.0400 %
4	Sulfur, S	<= 0.0500 %

3.4 SPRING SAFETY

Springs under load want to return to their original shape. The same goes for spring wire. Spring wire will try to straighten itself out if given the chance: don't let your body get in its way.

Small wire

Small wire (diameter less than about .025") will not hurt you if it hits you. On the other hand, small wire is nothing more than an edge, waiting for something to cut. Don't use your hand to try to stop wire that's moving, especially if it's moving under power (like being pulled by a lathe). Instead, wait till it stops moving. Gloves are an excellent idea, too.

Medium wire

Medium wire (diameter from about .025" - .312") is too wide to act as an edge, and usually not massive enough to break bones, but it can raise quite a knot if you get in its way. Again, always keep track of where the ends of the wire are, and if they start to move, get out of the way.

Heavy wire

Heavy wire (diameter greater than about .312") needs respect. If it gets loose, it can EASILY break bones, or worse.

Stainless steel

Stainless steel is a lot softer than other types of wire. When cut, the end of the wire is like a knife edge. Always keep track of where the end of the wire is, and keep your hands away from it while it's moving.

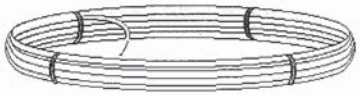
Handling Wire

The two most dangerous times are when you're breaking open a coil of wire and when you're actually winding a spring.

Breaking open coils

Once you have your wire, you'll need to take it out of its coil. The coil may be wrapped in paper — take that off first.

Under the paper, the wire will be tied. Light wire will be tied with string. Medium wire will be tied with tie wire. Large wire will be tied with metal bands. Whatever size wire you have, remember that the coil should have only two ends. One will be on the inside of the coil, and the other will be on the outside. You'll normally use wire from the inside, to avoid tangling. Always make a hook on the "inside" end so it's easy to find again:



Handling Small Wire in Coils

To break open a coil of small (up to about .125") wire, cut all the ties except two. Don't cut the closest tie holding the outside end of the wire, and the tie most directly opposite to that one.

To remove wire from the coil, start with the end on the inside of the coil: this will keep the coil from tangling. Grab the end of the wire and cut off the hook. Pull it slightly, until you can see the gap between it and the rest of the coil. Grab the wire at the gap and pull the end free from the tie holding it. Repeat this process, working around the coil, until you have the length you need.

Medium-sized wire

(.125 - .312") can be handled the same way, except that you should keep three ties instead of two. When uncoiling wire larger than .250", you should lay the coil flat on the ground and always stand in the center of the coil, for safety.

Large wire

(.312 - .625") needs special handling. First of all, you'll probably be using a hoist or forklift to move the coil, because of the weight. Lay the coil on top of something (a 2x4 or a pipe works great) to keep one end off the ground so that you can pick it up when you're done. Stand inside the coil from now on!

Then, take a length of tie wire and double it over. Loop it twice around the coil, right next to the second tie holding the inside end of the wire. Pull it tight and twist it so that you have a 'pigtail' and the tie wire is too tight to move by hand. Then, cut the first two original ties. Grab the end of the wire and flip it over the coil, so that it sticks out.

Go to the next tie and repeat this process, working your way around the coil until you have the length you need. You can use heavy bolt cutters or an acetylene torch to cut the wire.

If heavy wire gets away from you and starts to come undone all by itself, the very best thing to do is

- Run like hell, and
- Pray it doesn't hit you.

CHAPTER 4

SHEET METAL

4.1 SHEET METAL INTRODUCTION

Sheet metal is simply metal formed into thin and flat pieces. It is one of the fundamental forms used in metalworking, and can be cut and bent into a variety of different shapes. Countless everyday objects are constructed of the material. Thicknesses can vary significantly, although extremely thin pieces of sheet metal would be considered to be foil or leaf, and pieces thicker than 1/4 inch or a centimeter can be considered plate.

Sheet metal is generally produced in sheets less than 6 mm by reducing the thickness of a long work piece by compressive forces applied through a set of rolls. This process is known as rolling and began around 1500 AD. Sheet metals are available as flat pieces or as strip in coils. It is characterized by its thickness or gauge of the metal. The gauge of sheet metal ranges from 30 gauge to about 8 gauge. The higher the gauge, the thinner the metal is. There are many different metals that can be made into sheet metal. Aluminum, brass, copper, cold rolled steel, mild steel, tin, nickel and titanium are just a few examples of metal that can be made into sheet metal. Sheet metal has applications in car bodies, airplane wings, medical tables, roofs for building and many other things.

4.2 SHEET METAL PROCESS

A main feature of sheet metal is its ability to be formed and shaped by a variety of processes. Each process does something different to the metal giving it a different shape or size.

Various processes are

- Stretching
- Drawing
- Deep drawing
- Cutting
- Punching and shearing
- Spinning
- Roll-forming

Stretching

Stretching is a process where sheet metal is clamped around its edges and stretched over a die or form block. This process is mainly used for the manufacture of aircraft wings, automotive door and window panels. Stretching tools are very useful such as a kindilan.

Drawing

Drawing forms sheet metal into cylindrical or box shaped parts by using a punch which presses the blank into a die cavity. Drawing process can also be utilized to create arbitrary shapes with the help of soft punch.

Deep drawing

Deep drawing is a type of drawing process where the depth of the part is more than half its diameter. Deep drawing is used for making automotive fuel tanks, kitchen sinks, 2 piece aluminum cans, etc. Deep drawing is generally done in multiple steps called draw reductions. The greater the depth, the increased number of reductions required. Deep drawing may also be accomplished with fewer reductions by heating the workpiece, used in sink manufacture for example.

In many cases, special material that has been rolled at the steel mill in both directions can aid in the deep drawing process. Material that has been rolled in both directions has a more uniform grain structure and is referred to as "draw quality" material. Draw quality material will often improve deep drawing (limiting tearing).

Cutting

Cutting sheet metal can be done in various ways from hand tools called tin snips up to very large powered shears. With the advances in technology, sheet metal cutting has turned to computers for precise cutting.

Most modern sheet metal cutting operations are now based either on CNC Lasers cutting or multi-tool CNC punch press.

CNC laser involves moving a lens assembly carrying a beam of laser light over the surface of the metal. Oxygen or nitrogen or air is fed through the same nozzle from which the laser beam exits. The metal is heated and then burnt by the laser beam, cutting the metal sheet. The quality of the edge can be mirror smooth, and a precision of around 0.1mm can be obtained. Cutting speeds on thin (1.2mm) sheet can be as high as 25m a minute. Most of the laser cutting systems use a CO2 based laser source with a wavelength of around 10um; some more recent systems use a YAG based laser with a wavelength of around 1um.

Punching is performed by moving the sheet of metal between the top and bottom tools of a punch. The top tool (punch) mates with the bottom tool (die), cutting a simple shape (e.g. a square, circle, or hexagon) from the sheet. An area can be cut out by making several hundred small square cuts around the perimeter. A punch is less flexible than a laser for cutting compound shapes, but faster for repetitive shapes (for example, the grille of an air-conditioning unit). A typical CNC punch has a choice of up to 60 tools in a "turret" that can be rotated to bring any tool to the active punching position. A modern CNC punch can take 600 blows per minute.

A typical component (such as the side of a computer case) can be cut to high precision from a blank sheet in under 15 seconds by either a punch or a laser CNC machine.

Punching and shearing

During punching or shearing, the sheet metal is cut by using a punch and die. This process can allow many different shapes and patterns, by a computer numerically controlled (cnc) punch machine.

Spinning

Spinning is used to make axis-symmetric parts by applying a work piece to a rotating mandrel with the help of rollers or rigid tools. Spinning is used to make rocket motor casings and missile nose cones and satellite dishes for example.

Press brake forming

This is a form of bending, used for long and thin sheet metal parts. The machine that bends the metal is called a press brake. The lower part of the press contains a V shaped groove. This is called the die. The upper part of the press contains a punch that will press the sheet metal down into the v shaped die, causing it to bend. There are several techniques used here, but the most common modern method is "air bending". Here, the die has a sharper angle than the required bend (typically 85 degrees for a 90 degree bend) and the upper tool is precisely controlled in its stroke to push the metal down the required amount to bend it through 90 degrees. Typically, a general purpose machine has a bending force available of around 25 tonnes per metre of length. The opening width of the lower die is typically 8 to 10 times the thickness of the metal to be bent (for example, 5mm material could be bent in a 40mm die) the inner radius of the bend formed in the metal is determined not by the radius of the upper tool, but by the lower die width. Typically, the inner radius is equal to 1/6th of the V width used in the forming process.

The press usually has some sort of back gauge to position depth of the bend along the workpiece. The backgauge can be computer controlled to allow the operator to make a series of bends in a component to a high degree of accuracy. Simple machines control only the backstop, more advanced machines control the position and angle of the stop, its height and the position of the two reference pegs used to locate the material. The machine can also record the exact position and pressure required for each bending operation to allow the operator to achieve a perfect 90 degree bend across a variety of operations on the part.

Roll forming

Roll-forming is a continuous bending operation in which a long strip of metal (typically coiled steel) is passed through consecutive sets of rolls, or stands, each performing only an incremental part of the bend, until the desired cross-section profile is obtained. Roll-forming is ideal for producing parts with long lengths or in large quantities.

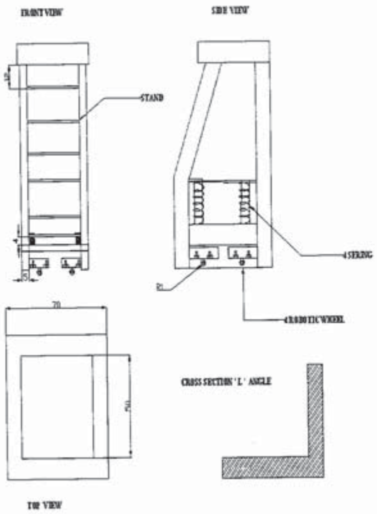
CHAPTER 5

DESIGN AND FABRICATION

5.1 3D REPRESENTATION OF THE PROJECT

Movable steps assembly

5.2 DESIGN OF OUR PROJECT



5.3 LIST OF PARTS

S.NO	NAME OF THE PARTS	QTY
1.	NYLON WHEELS	4
2.	SPRINGS	4
3.	SHEET METAL	1*1ft
4.	FRAME	8kg
5.	BOLTS & NUTS	25

5.4 COST ESTIMATION

S.NO	NAME OF THE PARTS	COST
1.	NYLON WHEELS	320
2.	SPRINGS	400
3.	SHEET METAL	500
4.	FRAME	600
5.	WELDING WORK	280
6.	BOLTS & NUTS	65
7.	LABOUR COST	150

TOTAL - Rs 2315 /-

CONCLUSION

Thus our project had overcome all the disadvantage which we have mentioned. Mainly we concentrated on the safety steps and moreover there is no struggle in carrying along with us, just one push is required. From a older people to the little children all of them can use this steps. Talking about the cost it is quite normal only and the materials used is available in all shops and also affordable.

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