Fbd for types of support and analysis mechanics essay

In any problem where you are considering the forces acting on an object – which is a large percentage of the problems in physics – one of the first steps is to create a free-body diagram to depict the situation.

Meaning

A free-body diagram is a picture of the physical situation you are analyzing, which depicts all of the relevant forces acting on the objects of interest.

Forces are vector quantities and should, therefore, be indicated with a magnitude and direction in the free-body diagram

Coordinate Systems & FBD

When creating a free-body diagram, you must orient it in a coordinate system, typically a two-dimensional one. This is almost always done so that the force of gravity is pulling straight down (in the negative-y direction). It's generally preferred to orient things so that any horizontal movement will be in the positive-x direction (i. e. to the right), although so long as you maintain the same orientation you will get physically identical results.

Types of Forces Acting on FBD

The majority of forces in free-body diagrams, at least as they relate to classical mechanics, come from the application ofNewton's Three Laws of Motionand the Law of Universal Gravitation.

Free-body diagrams of other situations can involve other forces. When creating the free-body diagram of an electron, for example, you would want to include electromagnetic forces acting on it.

1. Gravitational Force

You will almost always consider the gravitational force, or weight, in a free-body diagram. The magnitude of this force is calculated by mass (m) times the acceleration of gravity (g), typically treated as a constant of 9. 8 m/s2 on the Earth's surface.

In the case of an air born object, such as a basketball player who is jumping, the only force that is typically acting on it while in the air is the weight of the object.

2. Normal Force

The normal (or perpendicular) force is the contact force the surface an object rests or moves on against the object. It is directed perpendicular to the surface.

In most cases, these surfaces are depicted in a free-body diagram as horizontal, with gravity down, so the normal force is directed upwards and is equal to the total force into the surface.

3. Frictional Force

An object resting on a surface interacts with the surface. The force of this interaction is the frictional force, or just friction. Friction requires a bit more of an in-depth discussion than what I will present here, but for the moment I will state that friction is:

- Always parallel to the surface the object is interacting with.
- Always in the opposite direction of the force moving an object across the surface.
- Proportional to the normal force.

4. Tension

Often, free-body diagrams will depict one component of a larger system. When we discuss a man pulling a stone slab with a rope, and we're interested in the motion of the slab, we don't care about all the forces acting on the man. As such, what we really care about is the tension – the force that the rope is exerting on the stone slab. Tension at any point is the magnitude of the force at that point, so tension at the point where the rope meets the object is what we care about.

Assumptions

The free body diagram reflects the assumption and simplifications made in order to analyze the system. If the body in question is a satellite in orbit for example, and all that is required is to find its velocity, then a single point may be the best representation. On the other hand, the brake dive of a motorcycle cannot be found from a single point, and a sketch with finite dimensions is required.

Force vectors must be carefully located and labeled to avoid assumptions that presuppose a result. For example, in the accompanying diagram of a block on a ramp, the exact location of the resulting normal force of the ramp on the block can only be found after analyzing the motion or by assuming equilibrium.

Other simplifying assumptions that may be considered include two-force members and three-force members.

Steps for making FBD

Step 1: Identify the object or system and isolate it from other objects clearly specify its boundary.

Step 2: First draw non-contact external force in the diagram. Generally it is weight.

Step 3: Draw contact forces which acts at the boundary of the object or system. Contact forces are normal reaction, friction, tension and applied force.

In a Free Body Diagram, internal forces are not drawn, only external forces are drawn.

FBD EXAMPLE

These are simplified representations of an object (thebody) in a problem, and include force vectors acting on the object. This body isfreebecause the diagram will show it without its surroundings.

Let’s take Figure 1 to be a pictorial representation of our problem: a boat on the floor, with a rope pulling it. First we will represent the boat — the ‘ body’ in our problem — as a (really) simplified figure, a square

Gravity

The first force we will investigate is that due to gravity, and we’ll call it thegravitatior

We know that the acceleration due to gravity (if on Earth) is approximatelyg= 9. 8 m

force, by Newton’s Second Law is

F= mg

Wheregis the acceleration due to gravity. Let’s add this to our diagram. Note that the

vector, labeledFmg, points downward, as this is the direction in which the gravitatior acts.

Note that this force is commonly calledweight. This ‘ weight’ (mg) is different from ou everyday use of the word ‘ weight’ (which is known in physics as ‘ mass’).

Normal

Thenormal forceone which prevents objects from ‘ falling’ into whatever it is they are upon. It is always perpendicularto the surface with which an object is in contact. For if there is a crate on the floor, then we say that the crate experiences a normal force floor; and because of this force, the crate does not fall into the floor. The normal forc crate points upward, perpendicular to the floor.

It is called the normal force becausenormalandperpendicularmean the same thing. T normal force is always perpendicular to the surface with which a body is in contact. F body on a sloped surface (say a ramp), the normal force acting on that body is still perpendicular to the slope.

In the case of our problem, the ship, we will pretend the ship is being pulled on a floo is because on water there is the complication with another force, buoyancy. For simp sake, we will ignore buoyancy by putting the ship on the floor.) Let’s add the normal our FBD (Figure), and represent the normal force with the script ‘ N’,.

Friction

Related to the normal force is thefrictional force. The two are related because they a due to the surface in contact with the body. Whereas the normal force was perpendic the surface, the frictional force is parallel. Furthermore, friction opposes motion, and vector always points away from the direction of movement.

Friction is divided into two categories, static and kinetic. These are represented by th

F’, with a subscript ‘ s’ for static friction:, and a subscript ‘ k’ for kinetic friction,. As it suggests, static frictionoccurs when the body is not moving (i. e. “ static”). It is the fo which makes it difficult to start something moving. On the other hand, kinetic frictior when the body is in motion. This is the force which causes objects to slow down and eventually stop.

Friction is usually approximated as being proportional to the normal force. The propo constant is called the coefficient of (static or kinetic) friction. The constant is represe asfor static friction, andfor kinetic friction; it depends on the actual surface with whic body is in contact.

To summarize,

We’ve added (kinetic) friction to our free body diagram, Figure .

Push and Pull

Another force which may act on an object could be any physical push or pull. This co caused by a person pushing a crate on the floor, a child pulling on a wagon, or in the our example, the wind pushing on the ship.

We will label the push force caused by the wind withFpush

Tension

Tension in an object results if pulling force act on its ends, such as in a rope used to boulder. If no forces are acting on the rope, say, except at its ends, and the rope itse equilibrium, then the tension is the same throughout the rope.

We will use the letterTto represent tension in a free body diagram.

If we say that our ship is being pulled by a rope at its front end, then we can add this our FBD (Figure).

- And there we have it: all the forces acting on our ship has been labeled in Figure. This is the complete FBD for our problem of a ship being pulled along a floor by a rope

Types of supports

Structural systems transfer their loading through a series of elements to the ground. This is accomplished by designing the joining of the elements at their intersections. Each connection is designed so that it can transfer, or support, a specific type of load or loading condition. In order to be able to analyze a structure, it is first necessary to be clear about the forces that can be resisted, and transferred, at each level of support throughout the structure. The actual behaviour of a support or connection can be quite complicated. So much so, that if all of the various conditions were considered, the design of each support would be a terribly lengthy process. And yet, the conditions at each of the supports greatly influence the behaviour of the elements which make up each structural system.

SUPPORT TYPES

The three common types of connections which join a built structure to its foundation are: roller or frictionless, pinned andfixed. A fourth type, not often found in building structures, is known as asimple support. This is often idealized as a frictionless surface). All of these supports can be located anywhere along a structural element. They are found at the ends, at midpoints, or at any other intermediate points. The type of support connection determines the type of load that the support can resist. The support type also has a great effect on the load bearing capacity of each element, and therefore the system.

1. ROLLER SUPPORTS

Roller supports are free to rotate and translate along the surface upon which the roller rests. The surface can be horizontal, vertical, or sloped at any angle. The resulting reaction force is always a single force that is perpendicular to, and away from, the surface. Roller supports are commonly located at one end of long bridges. This allows the bridge structure to expand and contract with temperature changes. The expansion forces could fracture the supports at the banks if the bridge structure was “ locked” in place. Roller supports can also take the form of rubber bearings, rockers, or a set of gears which are designed to allow a limited amount of lateral movement.

2. FRICTIONLESS SUPPORTS

Frictionless surface supports are similar to roller supports. The resulting reaction force is always a single force that is perpendicular to, and away from, the surface. They too are often found as supports for long bridges or roof spans. These are often found supporting large structures in zones of frequent seismic activity. The representation of a frictionless support includes one force perpendicular to the surface.

3. PINNED SUPPORTS

Pinned support can resist both vertical and horizontal forces but not a moment. They will allow the structural member to rotate, but not to translate in any direction. Many connections are assumed to be pinned connections even though they might resist a small amount of moment in reality. It is also true that a pinned connection could allow rotation in only one direction; providing resistance to rotation in any other direction. The knee can be idealized as a connection which allows rotation in only one direction and provides resistance to lateral movement. The design of a pinned connection is a good example of the idealization of the reality. A single pinned connection is usually not sufficient to make a structure stable. Another support must be provided at some point to prevent rotation of the structure. The representation of a pinned support includes both horizontal and vertical forces.

4. FIXED SUPPORTS (CANTILEVER)

Fixed supports can resist vertical and horizontal forces as well as a moment. Since they restrain both rotation and translation, they are also known as rigid supports. This means that a structure only needs one fixed support in order to be stable. All three equations of equilibrium can be satisfied. A flagpole set into a concrete base is a good example of this kind of support. The representation of fixed supports always includes two forces (horizontal and vertical) and a moment.

5. SIMPLE SUPPORTS

Simple supports are idealized by some to be frictionless surface supports. This is correct in as much as the resulting reaction is always a single force that is perpendicular to, and away from, the surface. However, are also similar to roller supports in this. They are dissimilar in that a simple support cannot resist lateral loads of any magnitude. The built reality often depends upon gravity and friction to develop a minimal amount of frictional resistance to moderate lateral loading. For example, if a plank is laid across gap to provide a bridge, it is assumed that the plank will remain in its place. It will do so until a foot kicks it or moves it. At that moment the plank will move because the simple connection cannot develop any resistance to the lateral loal. A simple support can be found as a type of support for long bridges or roof span. Simple supports are often found in zones of frequent seismic activity.

IMPLICATIONS and REACTIONS

The following figure shows the analysis of the type of support condition on the deflection behavior and on the location of maximum bending stresses of a beam supported at its ends

Simple Beams that are hinged on the left and roller supported on the right.

Reference:

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