SECTION 2
STABILITY, BALANCE, AND CAPACITY

Section 2 Objectives

At the end of this section, you will be able to:

1. Explain the Principle of Balance.
2. Define the terms "center of gravity" and "load center."
3. Describe the information on the capacity plate.
4. Explain the Principle of Stability.
5. Explain how a lift truck can tip over and what causes can lead to a tip-over.
6. Know how attachments affect the capacity and stability of a lift truck.

Importance Statement

It is important that you:

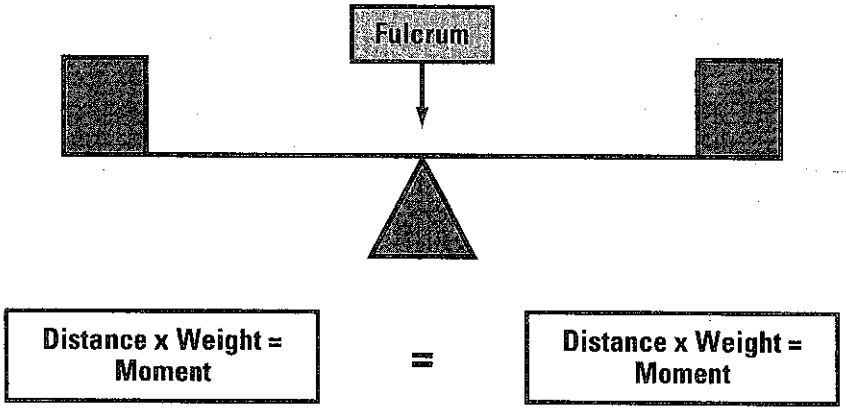
1. Reduce the risk of tipping a truck over and injuring yourself or other employees.
2. Understand the concepts of keeping a truck stable and in balance.

The Principle Of Balance

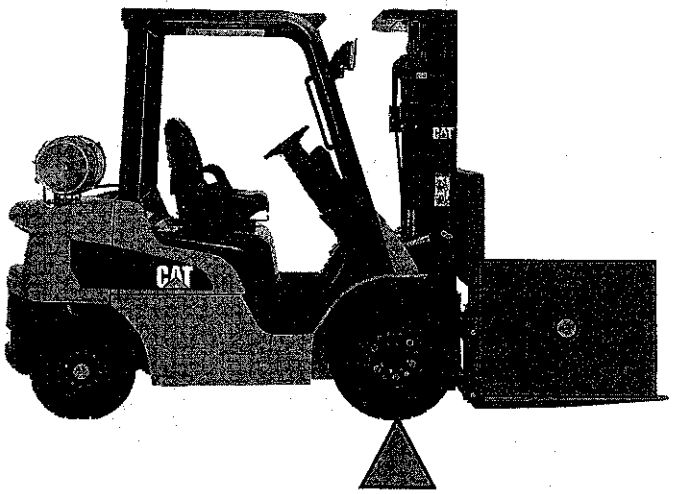
A lift truck acts much like a child's teeter-totter. The weight of the load must be balanced by the weight of the truck. This is known as the Principle of Balance.

In the example below, the distance from the balance point (fulcrum) times the weight of object **A** must equal the distance from the balance point (fulcrum) times the weight of object **B** to stay in balance.

Any change to the distance from the balance point or weight of object **A** must be offset by an equal change to the distance from the balance point or weight of object **B** to remain in balance.



The same holds true for a lift truck. The balance point is the drive axle. The load carried in front of the vehicle must be offset by the weight of the vehicle behind the drive axle.



Because the truck and its weight are fixed, when you increase the load distance from the balance point or increase the weight of the load, you will decrease the capacity rating of the truck. We will discuss more about capacity and stability a little later in this section.

Offsetting Weights

Internal Combustion Trucks

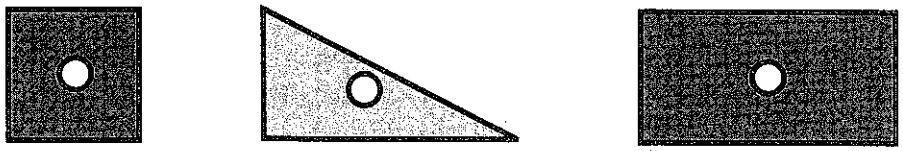
- Counterweight **(primary weight)**
- Engine
- Transmission
- Frame
- Steer axle.

Electric Lift Trucks

- Industrial battery **(primary weight)**
- Control panel
- Motors and pumps
- Frame
- Steer axle
- Counterweight.

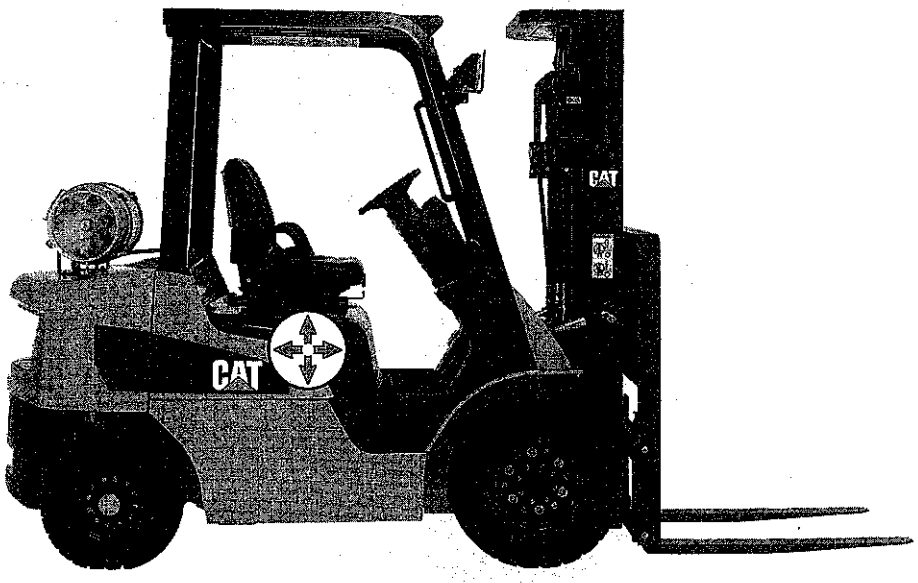
Center Of Gravity

The imaginary point in an object around which all weight is evenly distributed.



These three objects all weigh the same, but because they have different shapes, they have different centers of gravity.

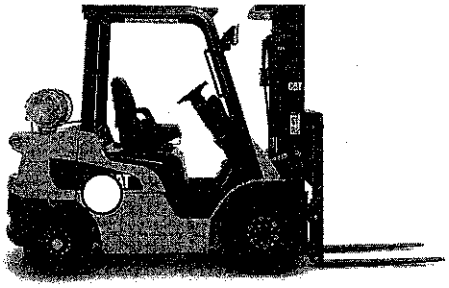
A lift truck also has a center of gravity.

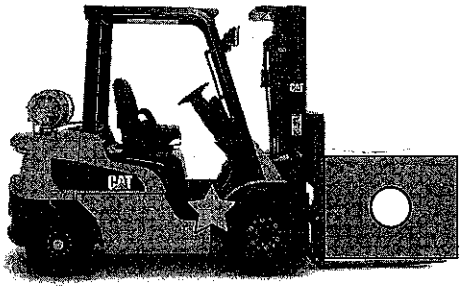


The lift truck's center of gravity does not remain static.

- The center of gravity moves up as the mast is raised and moves down as the mast is lowered.
- The center of gravity moves forward as the mast is tilted forward and moves back as the mast is tilted back.

When a lift truck picks up a load, the center of gravity of the truck and the center of gravity of the load produce a combined center of gravity. The combined center of gravity is indicated by the star.

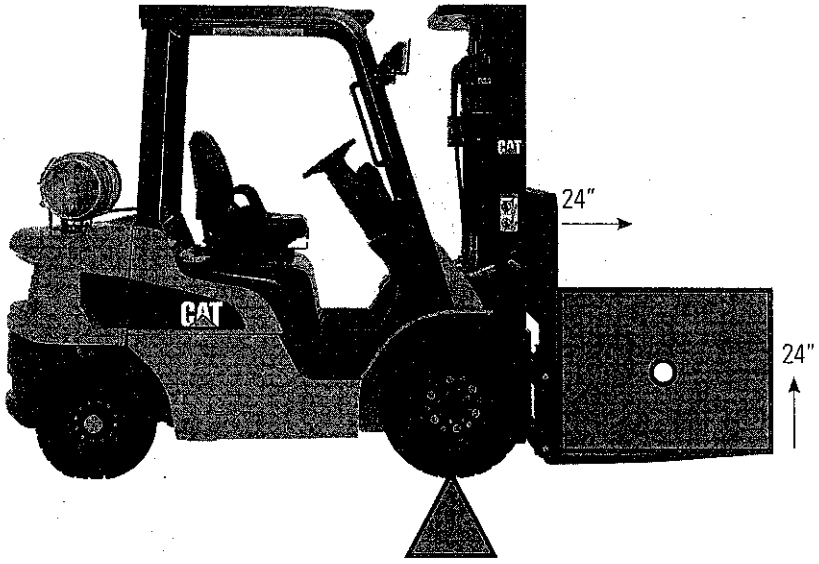




Load Center

Load center is defined as the distance from the face of the forks to the load's center of gravity.

Most lift trucks are rated using a 24-inch load center. That means the load's center of gravity must be 24 inches or less from the face of the forks. This is both a vertical and horizontal measurement.



Static Conditions And Dynamic Forces

Lift truck stability and balance are affected by both static conditions and dynamic forces.

Static Conditions

- Load size
- Load shape
- Load position on forks
- Tire pressure on air-filled tires

Dynamic Forces – Those Created By Motion

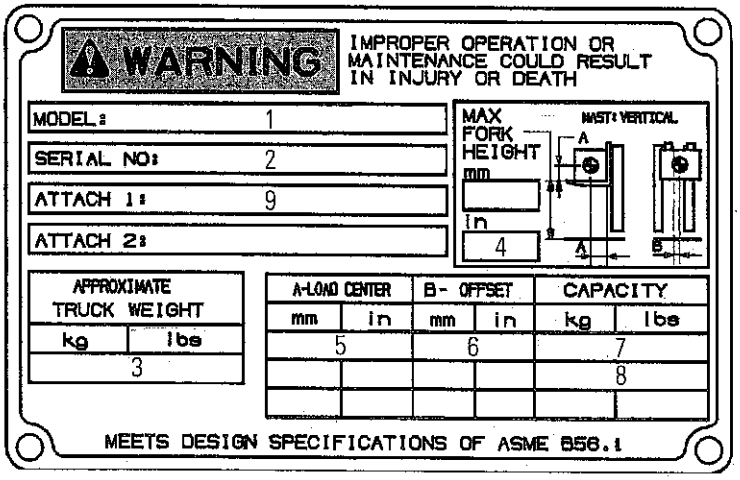
- Acceleration
- Speed
- Braking
- Ramps or other uneven surfaces
- Amount of tilt
- Lift Height

Capacity Plates

By law, every lift truck must have a legible capacity plate securely attached to the truck.

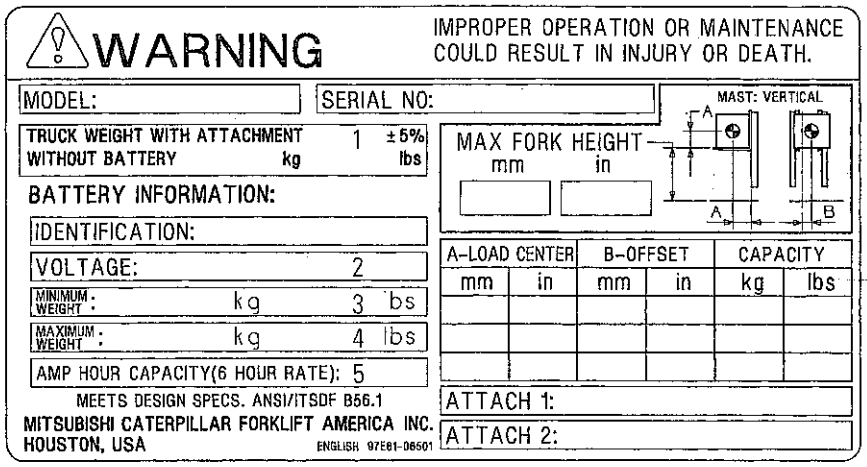
The plate includes:

1. Model number
2. Serial number
3. Truck weight in kilograms and pounds
4. Maximum fork (lift) height in inches and millimeters
5. Load center
6. Offset dimension
7. Maximum weight truck can lift with forks or permanently installed attachment (if equipped)
8. Maximum weight truck can lift with intermittent use attachment (if equipped)
9. Attachment model number (if equipped)



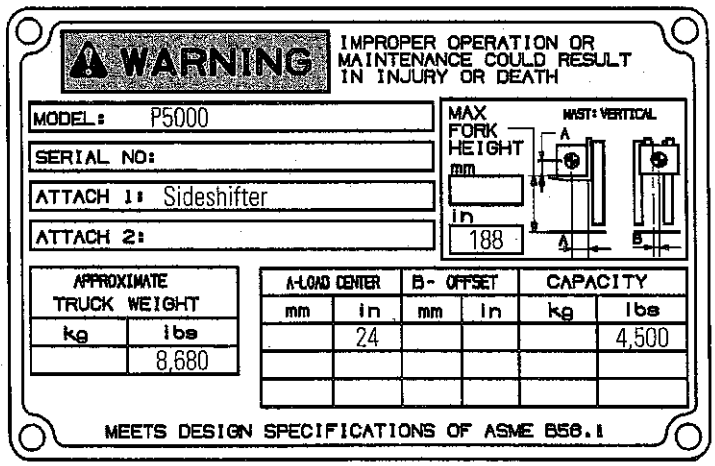
On electric trucks, additional information includes:

1. Truck weight without battery
2. Truck voltage
3. Minimum battery weight
4. Maximum battery weight
5. Amp hours



In order for the lift truck to lift the weight indicated on the capacity plate, the battery must weigh between the minimum and maximum battery weight.

Given the capacity plate shown below, what is the lift truck's weight, load center, lifting capacity, and lift height?



Truck weight _____

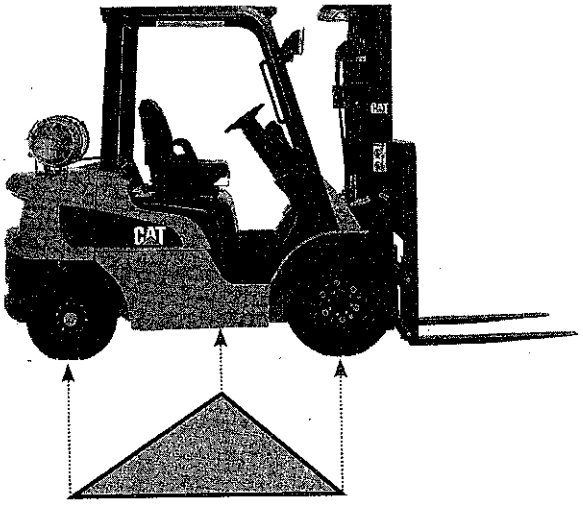
Load center _____

Lifting capacity _____

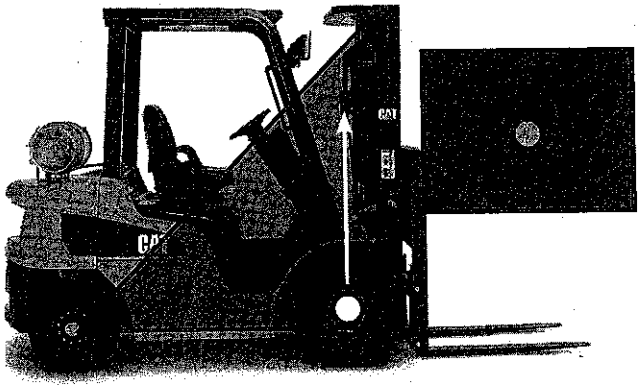
Lift height _____

The Principle Of Stability

Lift trucks have a three-point suspension – the two drive tires and the center of the steer axle. This forms the base of the Stability Triangle. This is known as the Principle of Stability.



With the added dimension of lift height, a Stability Pyramid results.

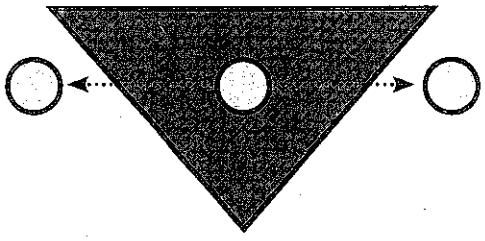


When you move the center of gravity outside this pyramid, you create imbalance resulting in:

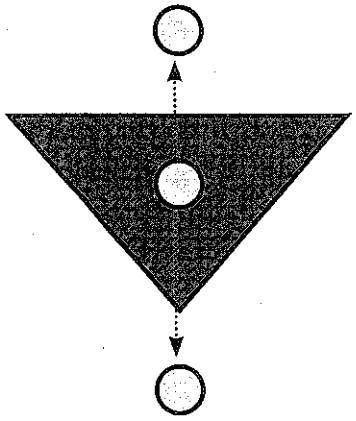
- Loss of steering
- Loss of traction
- Unstable loads
- Potential for a tip-over.

About 25 percent of all lift truck accidents occur when the truck tips over.

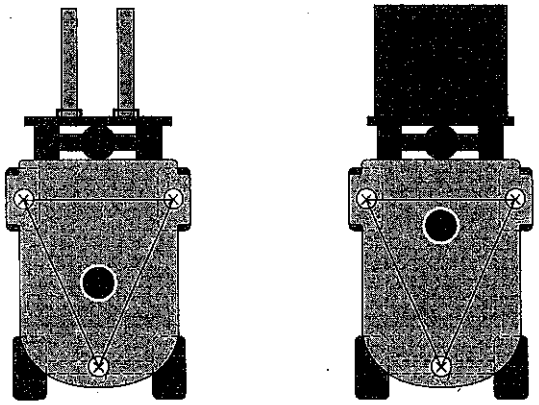
Lateral stability is lost when the center of gravity moves too far to either side and crosses over the Stability Pyramid, causing the truck to tip sideways.



Longitudinal stability is lost when the center of gravity moves too far forward or backward and crosses over the Stability Pyramid, causing the truck to tip forward or backward.



Which truck will resist tipping over laterally – the one with a load or the one without a load?



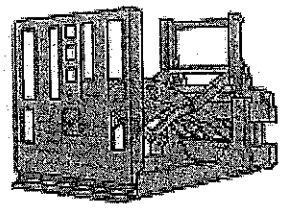
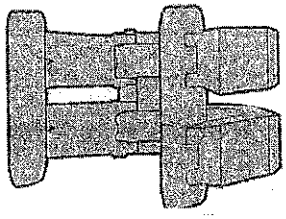
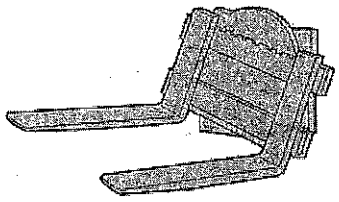
The one with the load. As you can see, the center of gravity of the truck with the load is closer to the base of the Stability Triangle. It has more room to travel side to side before it crosses over the edge of the Stability Triangle. The center of gravity of the truck without a load is closer to the edges of the Stability Triangle and does not need to travel far before it crosses over the edge of the Stability Triangle.

Causes Of Tip-Overs

- Overloading the truck
- Traveling with the load too high
- Traveling or stacking with the mast tilted forward beyond vertical
- Sharp turns
- Braking abruptly
- Excessive speed
- Potholes
- Overhead obstructions
- Wet or uneven surfaces
- Turning while driving on ramps
- Low tire pressure on pneumatic tire trucks

Remember – it is your responsibility to maintain the center of gravity inside the Stability Triangle and Pyramid.

Attachments And Effect On Capacity And Stability

Sometimes, lift trucks are equipped with attachments other than forks.

Lift truck capacity is affected in two ways when equipped with an attachment:

1. The weight of the attachment further reduces the lifting capacity of the truck. You should consider your truck partially loaded.
2. The attachment increases the load center, moving the load farther away from the balance point, or fulcrum.

If you add an attachment to your truck after the truck is received, Federal OSHA regulations state that:

- You must have prior written approval from the lift truck manufacturer.
- The lift truck manufacturer must issue a new capacity plate to be installed showing the correct capacity.

End of Section 2

Stability, Balance, And Capacity: Course Review

1. The balance point, or fulcrum, on a LIFT TRUCK is the:
   A. Steer tire
   B. Battery
   C. Drive tire
   D. Mast.

2. The imaginary point in a load around which all weight is evenly distributed is known as the:
   A. Center of gravity
   B. Stability Triangle
   C. Principle of Balance
   D. Load center.

3. The load center is:
   A. The distance from the end of the load to the face of the forks
   B. The distance from the face of the forks to the load's center of gravity
   C. The distance from the mast to the operator's compartment
   D. The distance from the load's center of gravity to the drive tire.

4. A lift truck is designed much like a child's teeter-totter. This design is based on the:
   A. Principle of Gravity
   B. Principle of Rear End Swing
   C. Principle of Balance
   D. Principle of Stability.

5. The center of gravity of a lift truck always stays in the same place.
   True_____ False_____

6. A lift truck WITH A LOAD is less likely to tip over sideways than a truck WITHOUT A LOAD if both trucks turn too quickly.
   True_____ False_____

7. Which is NOT one of the supporting points of the Stability Triangle on a lift truck?
   A. Center point of the steer axle
   B. Left drive tire
   C. Right drive tire
   D. Center point of the drive axle.

8. Which of the following can cause a lift truck to tip over?
   A. Turning too sharply at excessive speeds
   B. Traveling with load too high
   C. Overloading the truck
   D. All of the above.

9. If you add an attachment to your truck after it ships from the factory, you must have PRIOR WRITTEN APPROVAL from the lift truck manufacturer.

   True_____ False_____

10. Fill in the blanks:
    A. Vehicle weight _____
    B. Load center _____
    C. Lifting capacity _____
    D. Maximum fork (lift) height _____

