RAIL WHEEL INTERACTION

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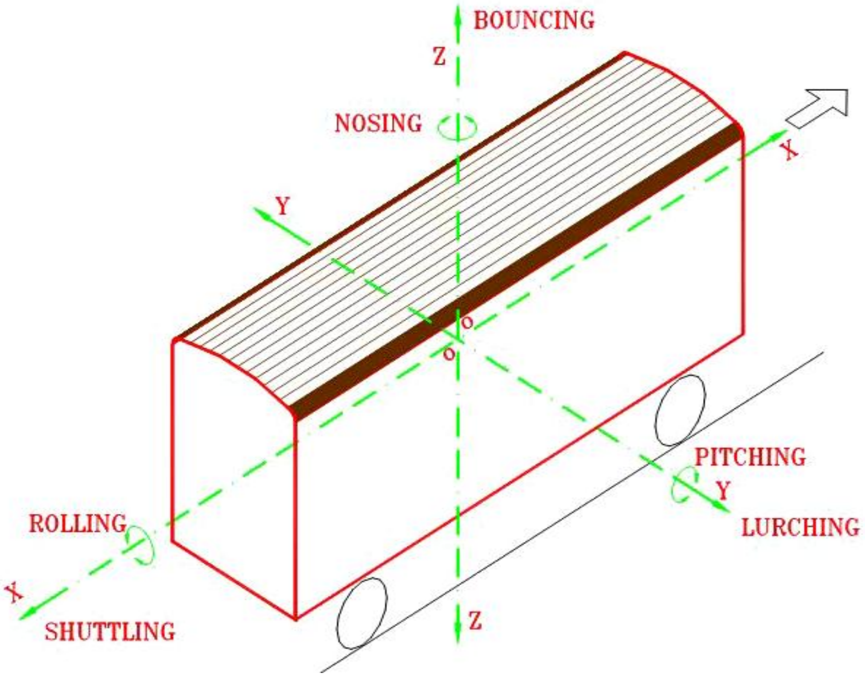
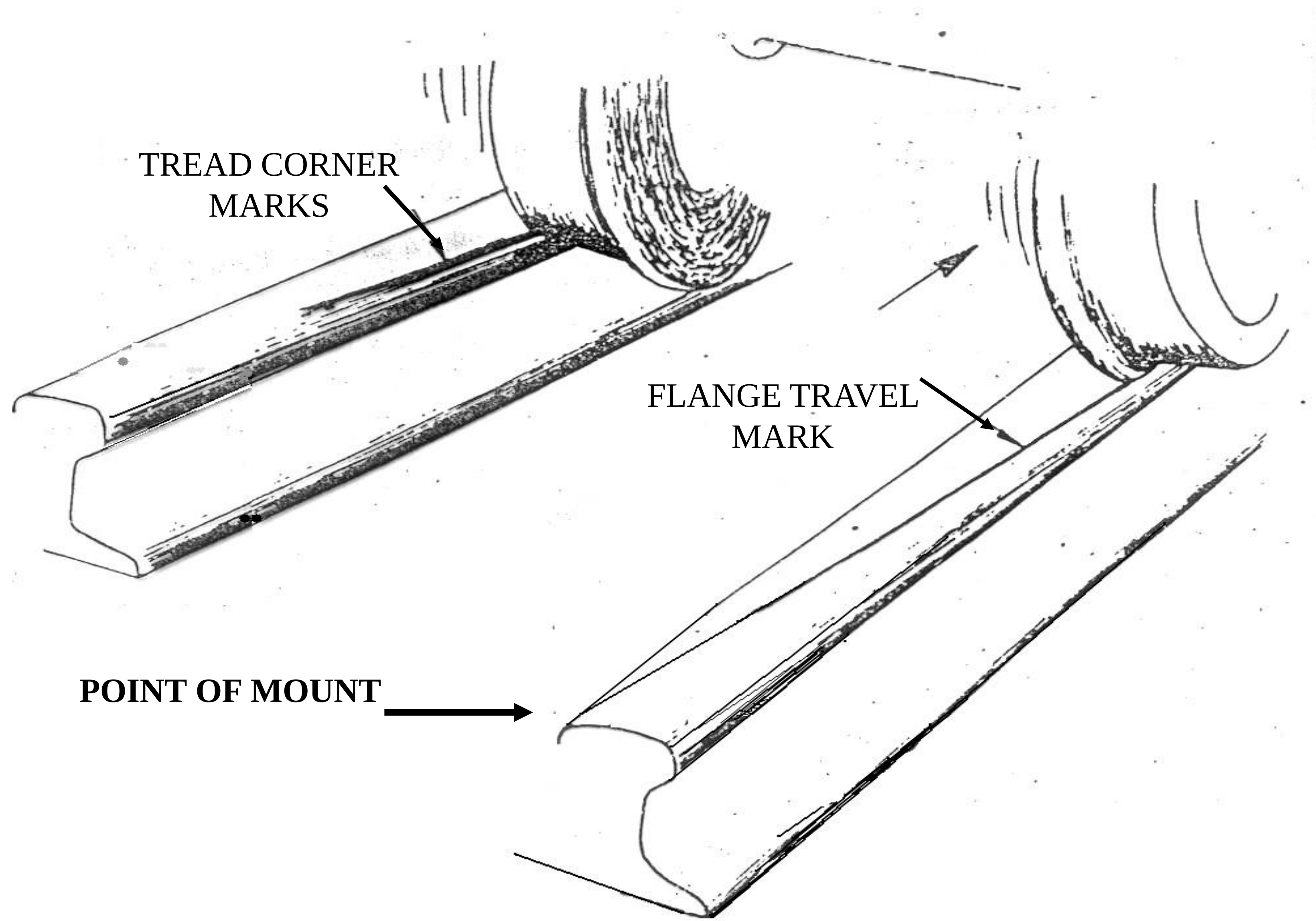
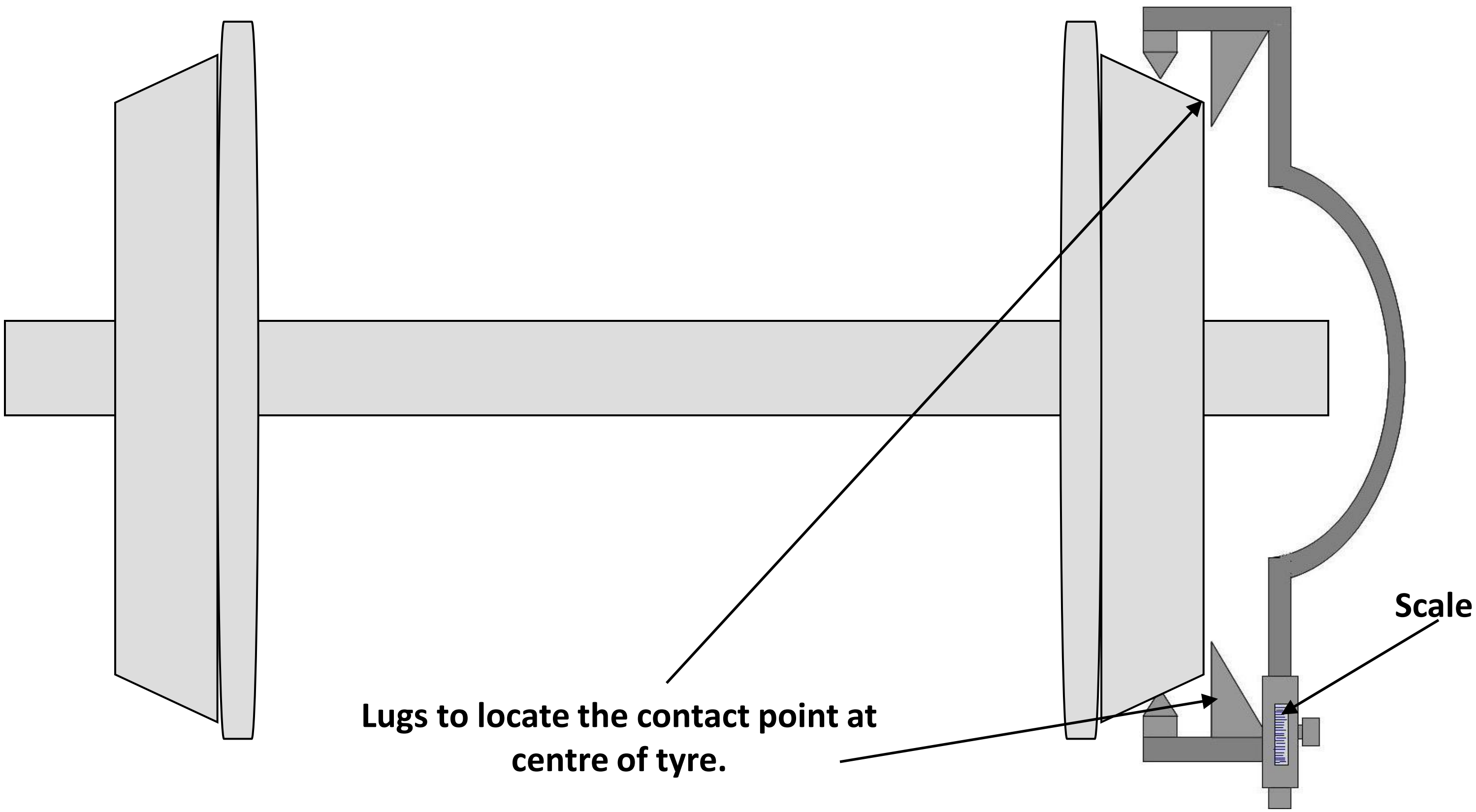


RAIL-WHEEL INTERACTION

- **Normally a vehicle follows the track geometry both in the vertical and lateral directions.**
- **Vertical guidance is obtained by the weight of the vehicle (and the load inside the vehicle) transferred to the wheel through suspension.**
- **Lateral guidance is ensured by the wheel flange.**

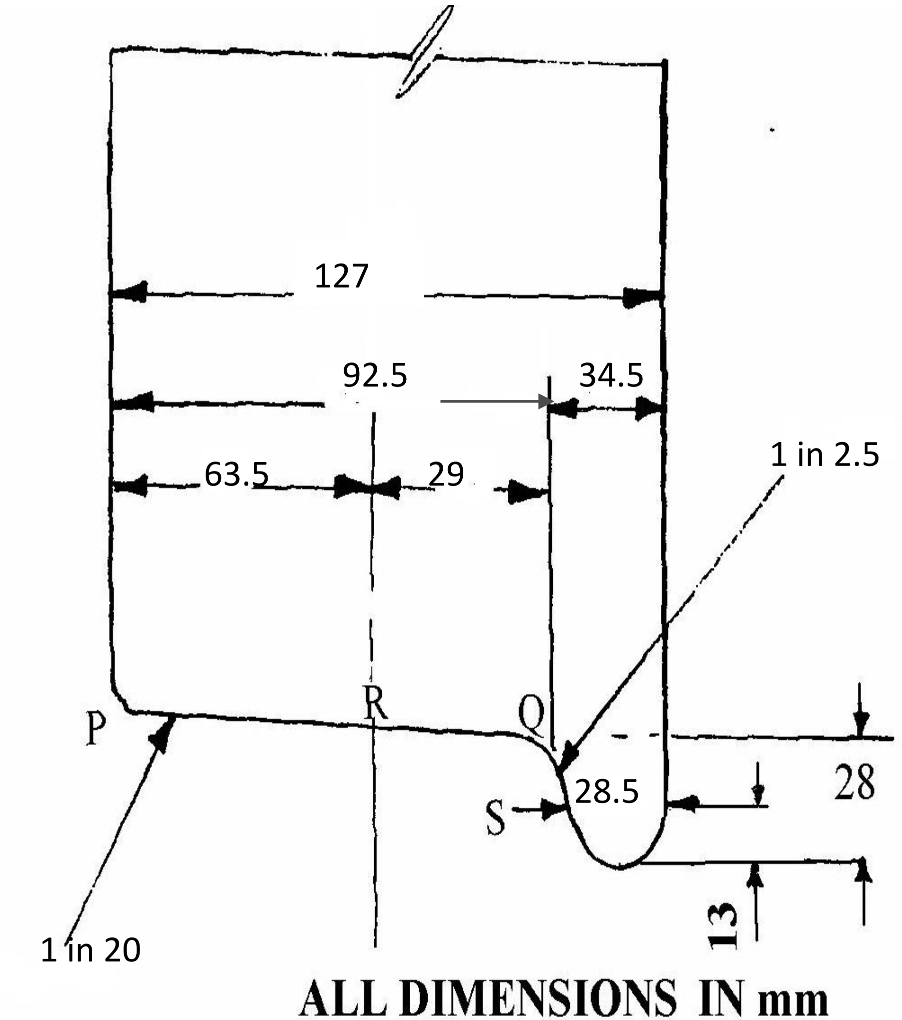

TREAD CORNER MARKS
FLANGE TRAVEL MARK
POINT OF MOUNT

Wheel diameter measured with wheel calipers



When the lugs contact the outer rim of the wheel, the tips of the gauge contact the centre of the tyre.

CONICITY OF WHEEL TREAD



Dia at R……. D 'say'

Dia at P……. D – (65÷20)x 2 or D – 6.5

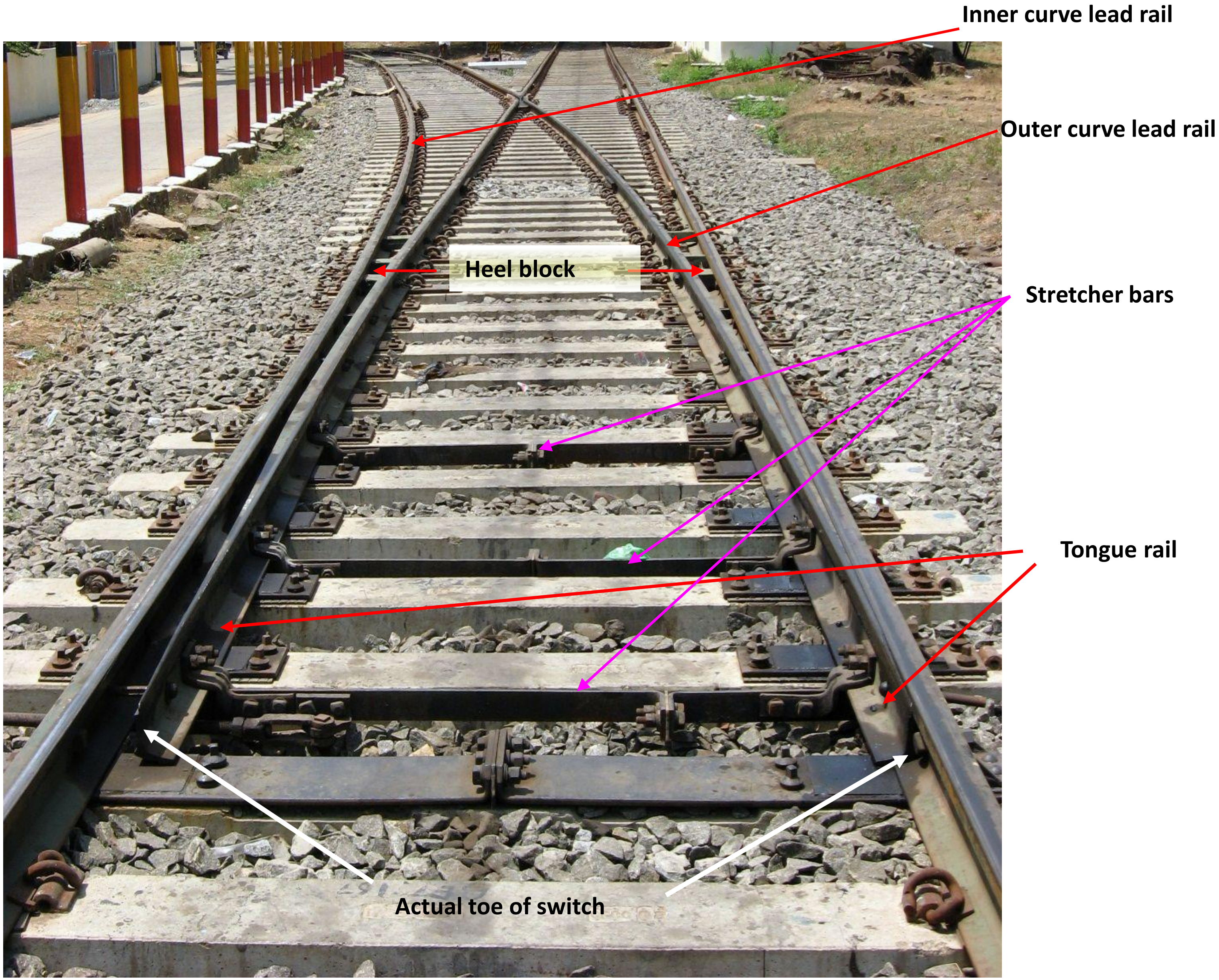
Dia at Q…… D + (31÷20)x 2 or D + 3.1

For a new wheel, thickness of flange at S = 28.5

Thickness of flange at Q…

28.5 +[(28-13) ÷2.5]

= 34.5


Inner curve lead rail
Outer curve lead rail
Heel block
Stretcher bars
Tongue rail
Actual toe of switch

Derailment

- **Definition** – Derailment of rolling stock is defined as a wheel or set of wheels leaving their due place from the rail top surface.

Theoretical Aspects

1. **Derailment mechanism**
2. **Wheel off loading**
3. **Vehicle oscillation**
4. **Lateral stability of track**

Reasons for Derailment

- P. way defect
- C&W defect
- Signal defect
- Loco defect
- Operational defect
- etc.
- etc.

Derailment Mechanism

- μ Frictional force
- Q Stabilising load
- Y Lateral force

- Y/Q has a major contribution in determining derailing tendency of the rolling stock.

Type of derailments:

(a) **Sudden derailments** –

Instant dismounting of wheel from track.

(b) **Gradual derailments** –

Gradual climbing of flange on the rail.

Sudden derailments

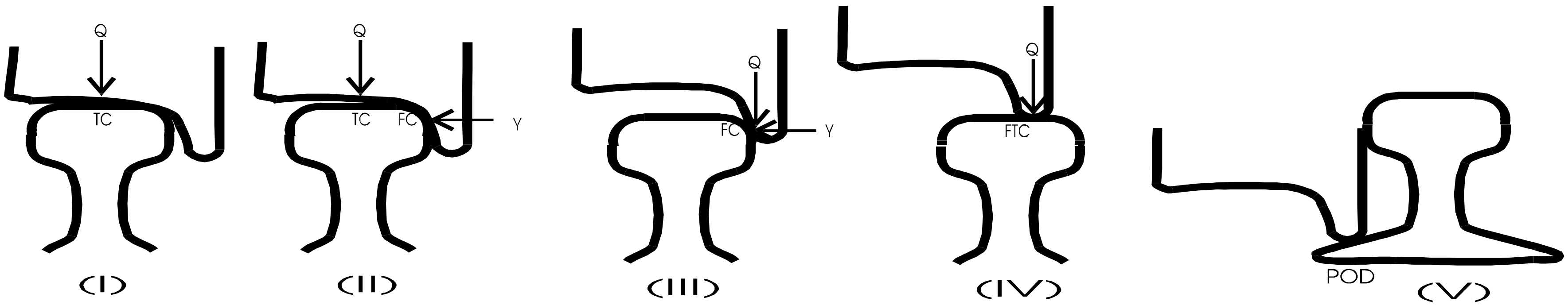
Causes –

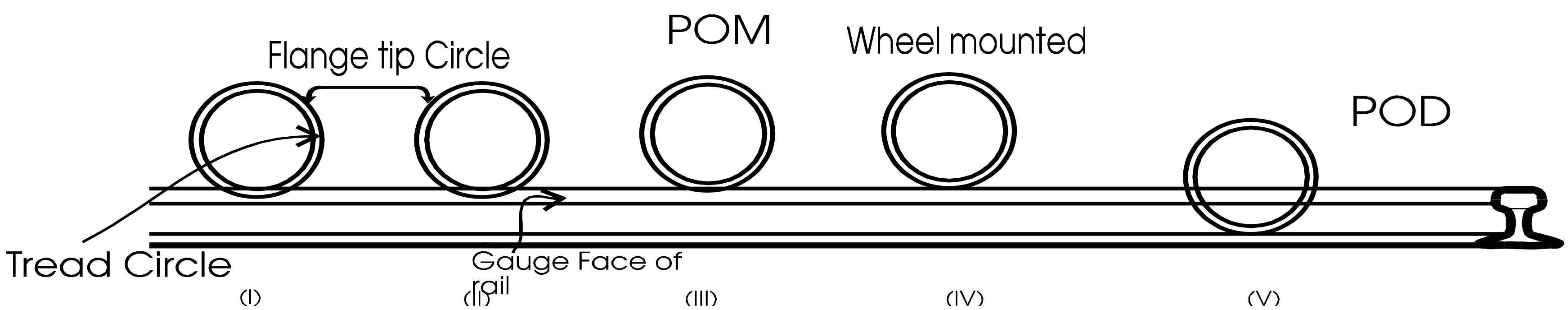
- Sudden shifting of load
- Improper loaded vehicle
- Excessive speed on curve or turn out
- Sudden variation in draw bar forces induced due to improper train operations(sudden braking or acceleration)
- Broken wheels/springs or suspension gear components.
- Failure of track or vehicle component
- Obstruction on track.

Gradual derailment

- The cause of accident may be singly or normally jointly any of the following:
    (i) Track defects
    (ii) Vehicle defects
    (iii) Unfavorable operating features

Stages of Flange Climbing in gradual derailment





Gradual Derailment

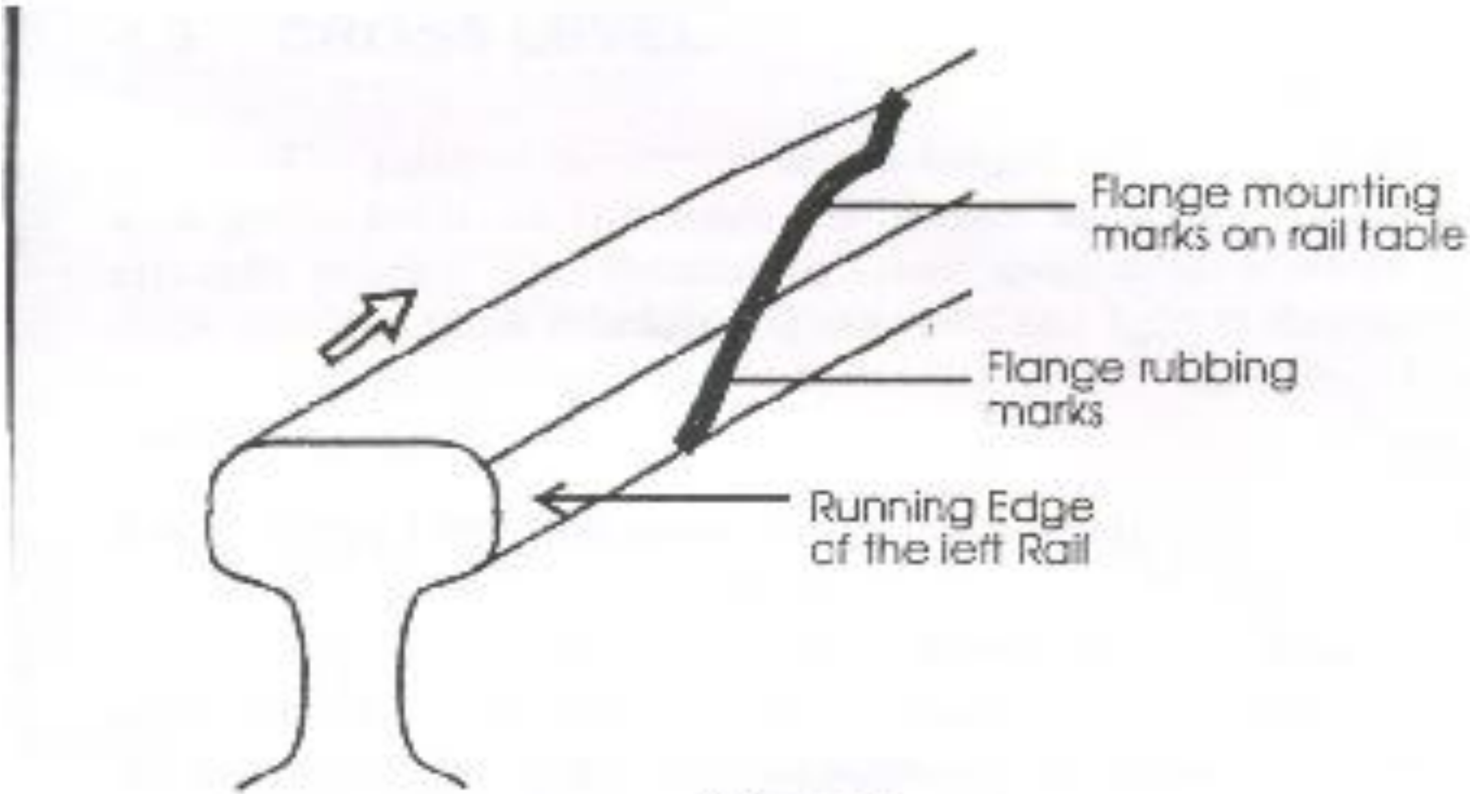


Fig. 4.7

4.5.5 . How To Measure Gauge

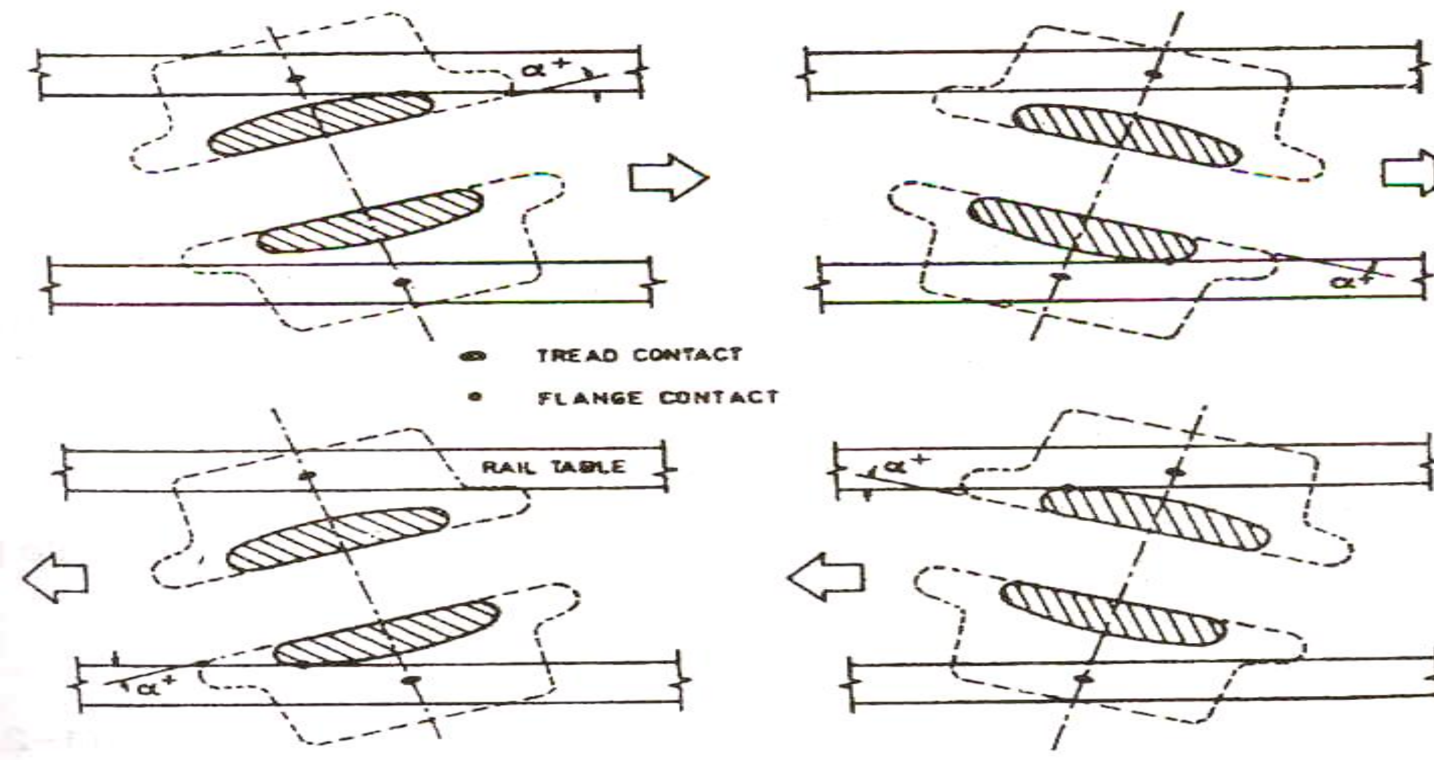
Wheel off loading

- **Nominal wheel load** – It is half the axle load as obtained when defect free vehicle with non eccentric loading on level track with perfect geometry.
- **Instantaneous wheel load**– It is the wheel load at any given instant of time during the motion of a wheel set. It constantly varies time.
- **On loading of wheel**
- **Off loading of wheel**

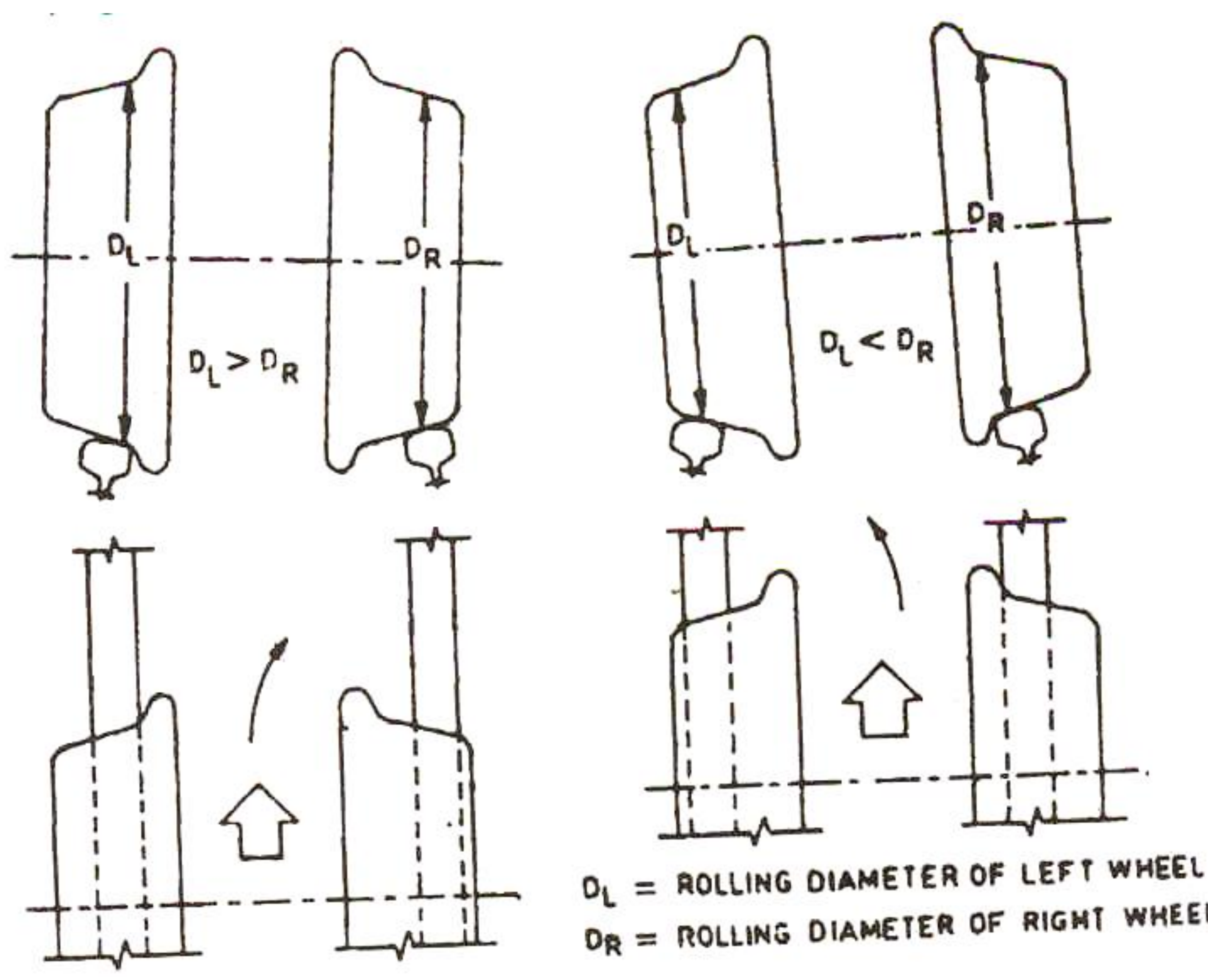
Angle Of Attack

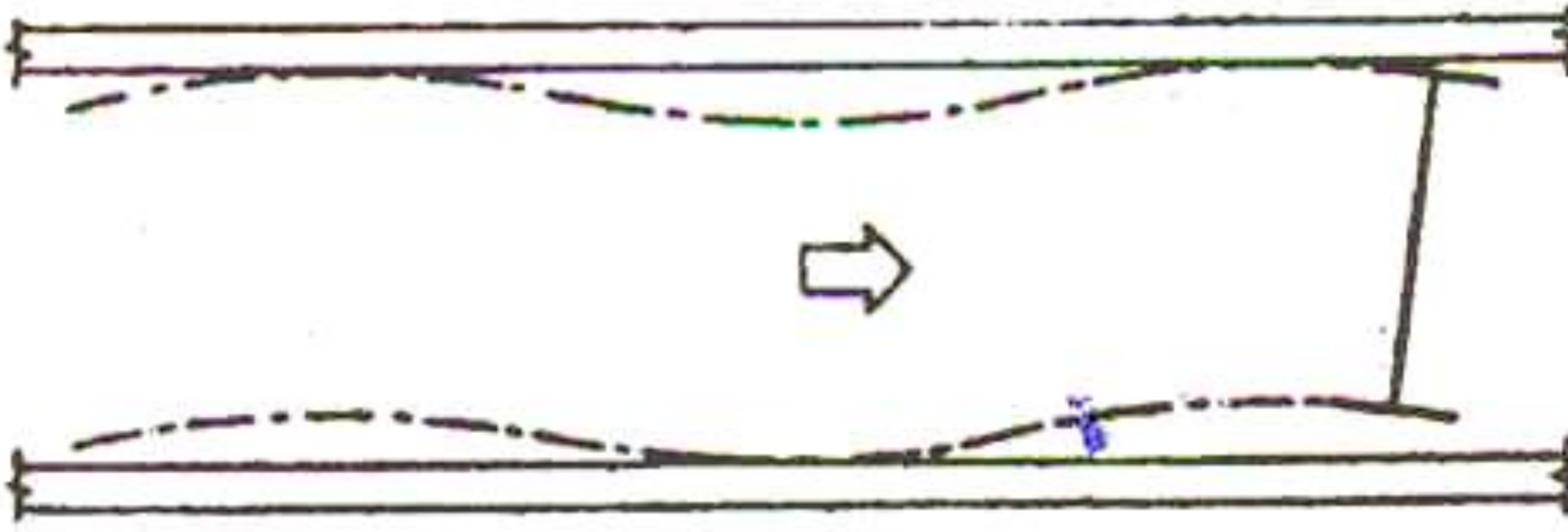
ANGULARITY OF AXLES

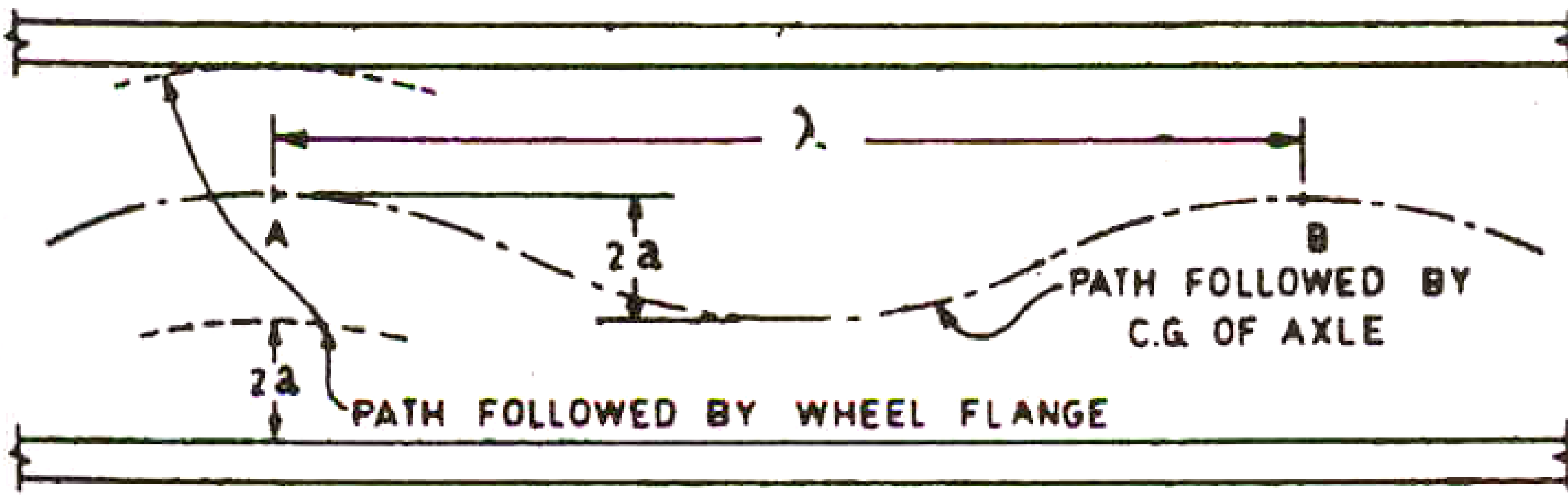
ANGULARITY due to Sinusoidal Motion caused by lateral clearance provided.



SINUSOIDAL MOTION OF FREE ROLLING WHEEL SET






λ
A
B
2a
2a
PATH FOLLOWED BY C.G OF AXLE
PATH FOLLOWED BY WHEEL FLANGE

Positive angularity

The flange contact leads the tread contact. It is called a case of leading contact. The longitudinal distance between the tread and flange contacts being called **positive eccentricity.**

Positive angularity

tive angle of attack (see fig. 1.7).

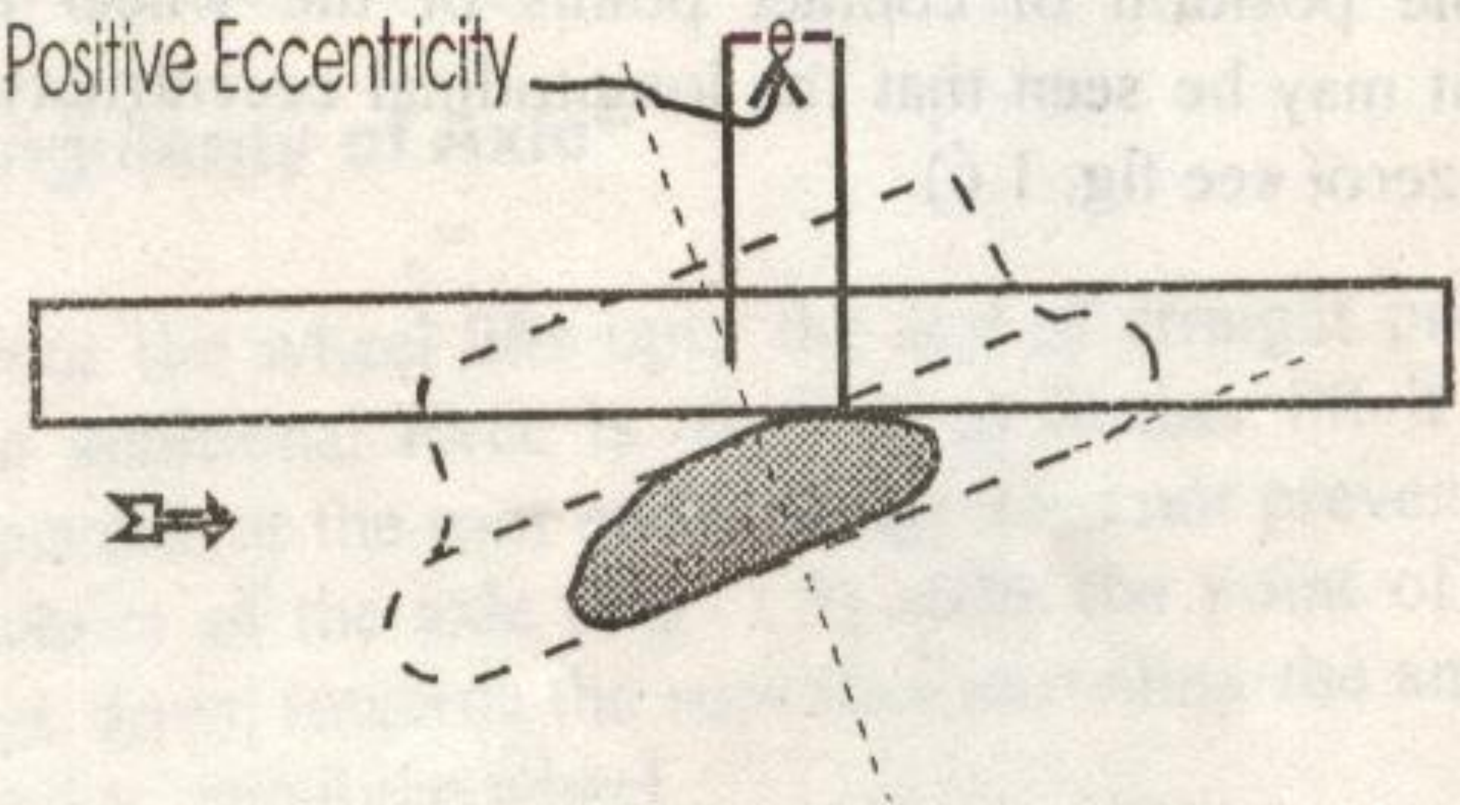


Fig. 1.7 Positive Angularity

Negative angularity

- In this case the wheel set makes flange contact near its trailing edge. The flange contact trails the tread contact. It is a case of trailing contact, the longitudinal distance between the two contacts is called – ve eccentricity.

Negative angularity

1.8).

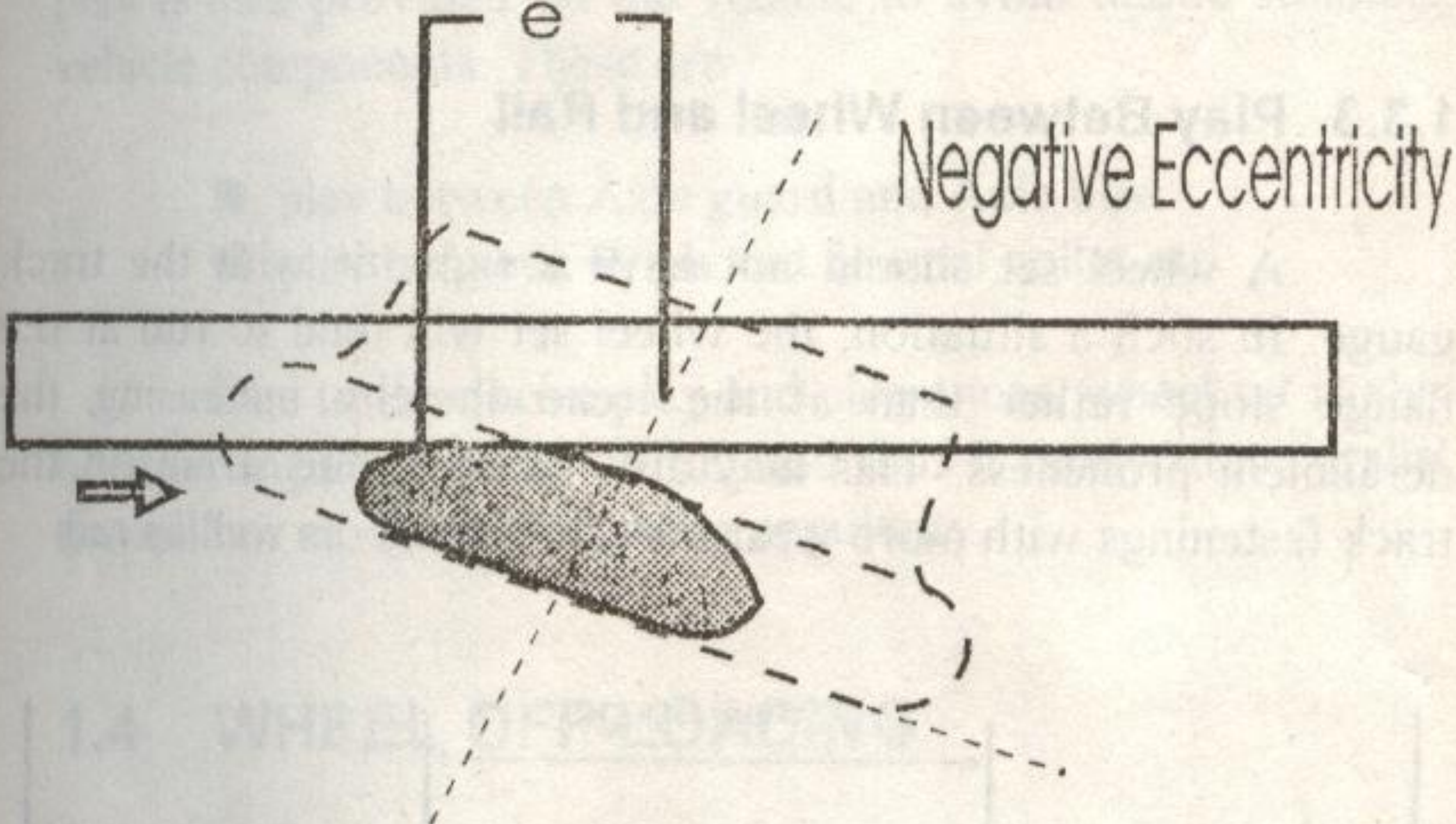


Fig. 1.8 Negative Angularity

Zero angularity

- In this case the frictional force acts horizontally as shown in sketch.

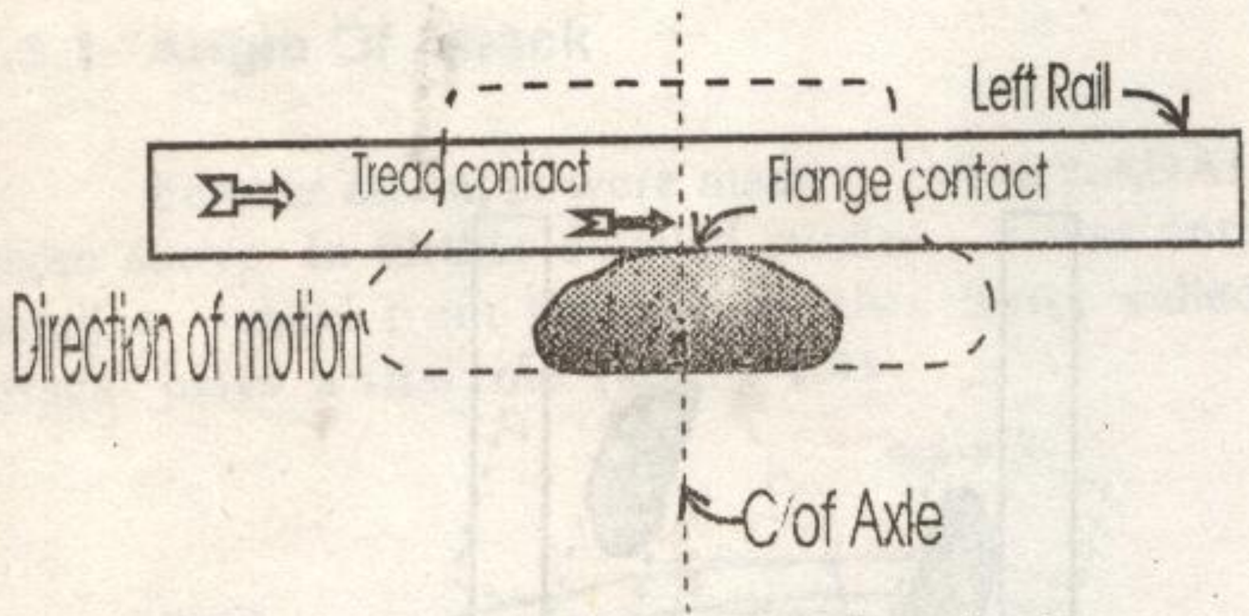
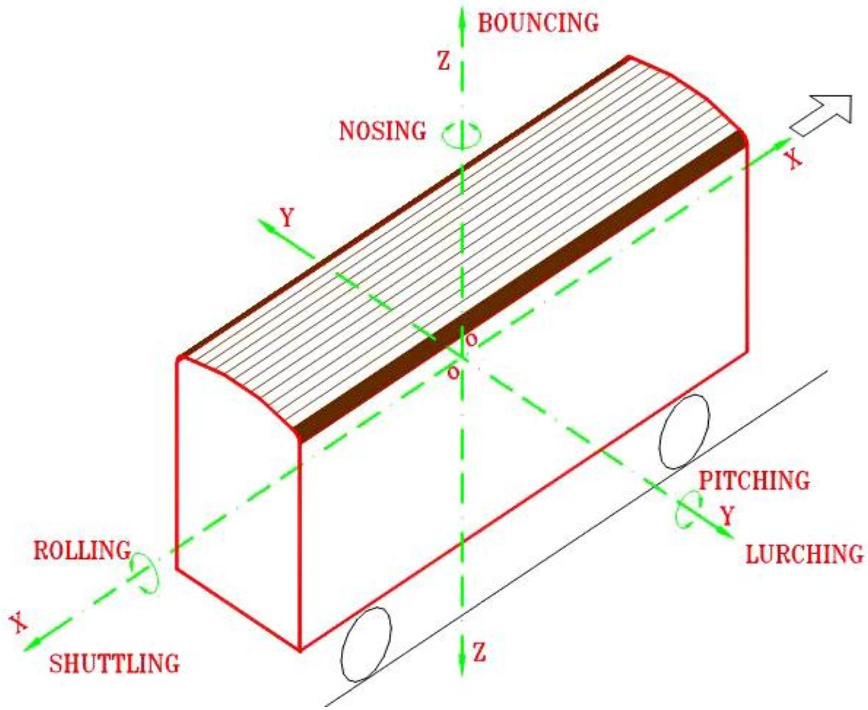


Fig. 1.6 Zero Angularity

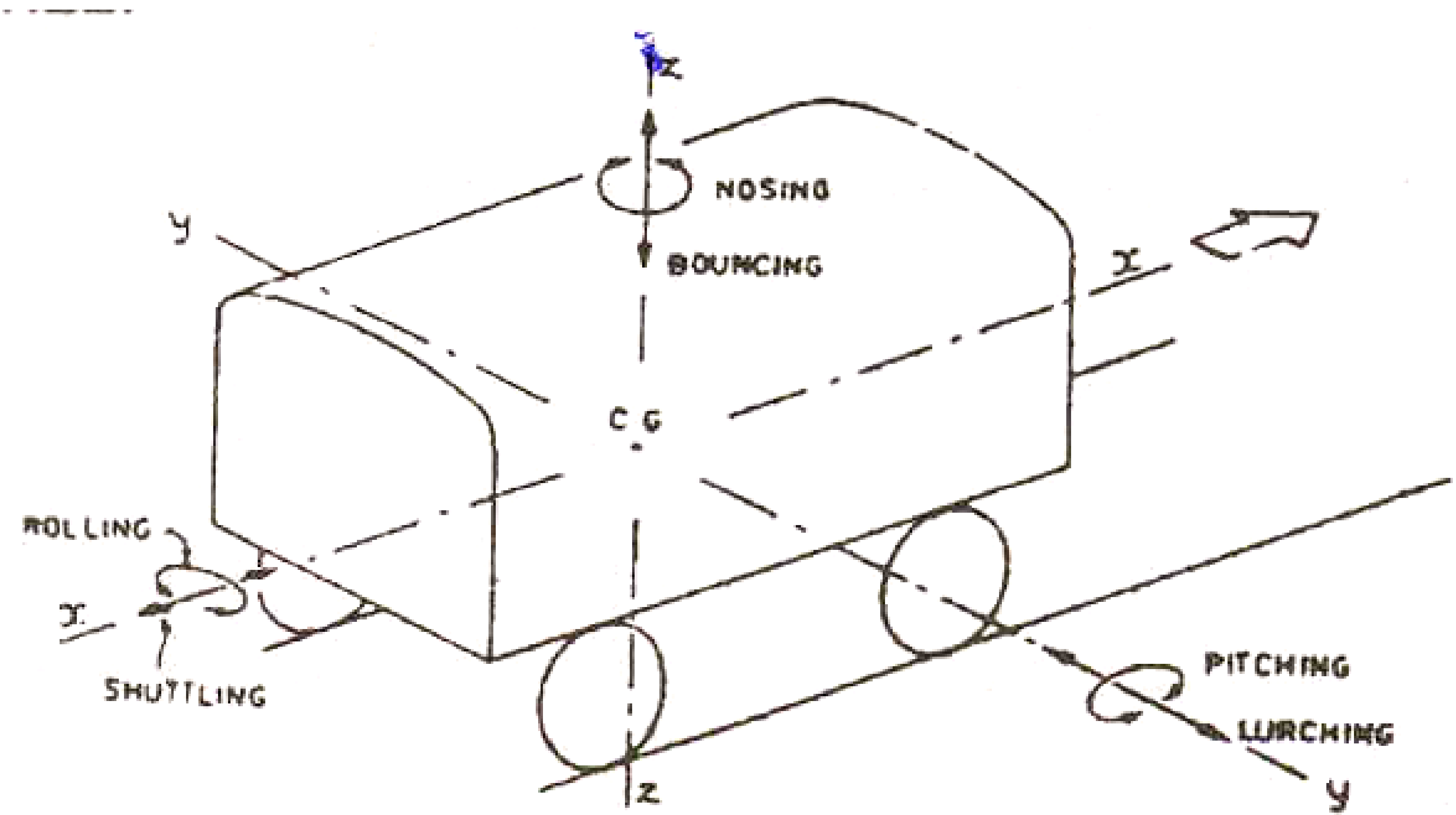
Positive Angularity is Most Critical

- In the case of positive angularity, the wheel flange rubs against the rail in a down ward arcing motion resulting in frictional forces acting upwards.
- In the case of negative angularity, the frictional forces will be directed downwards.
- In the case of zero angularity, the frictional force acts horizontally.

VEHICLE OSCILLATIONS



VEHICLE OSCILLATIONS

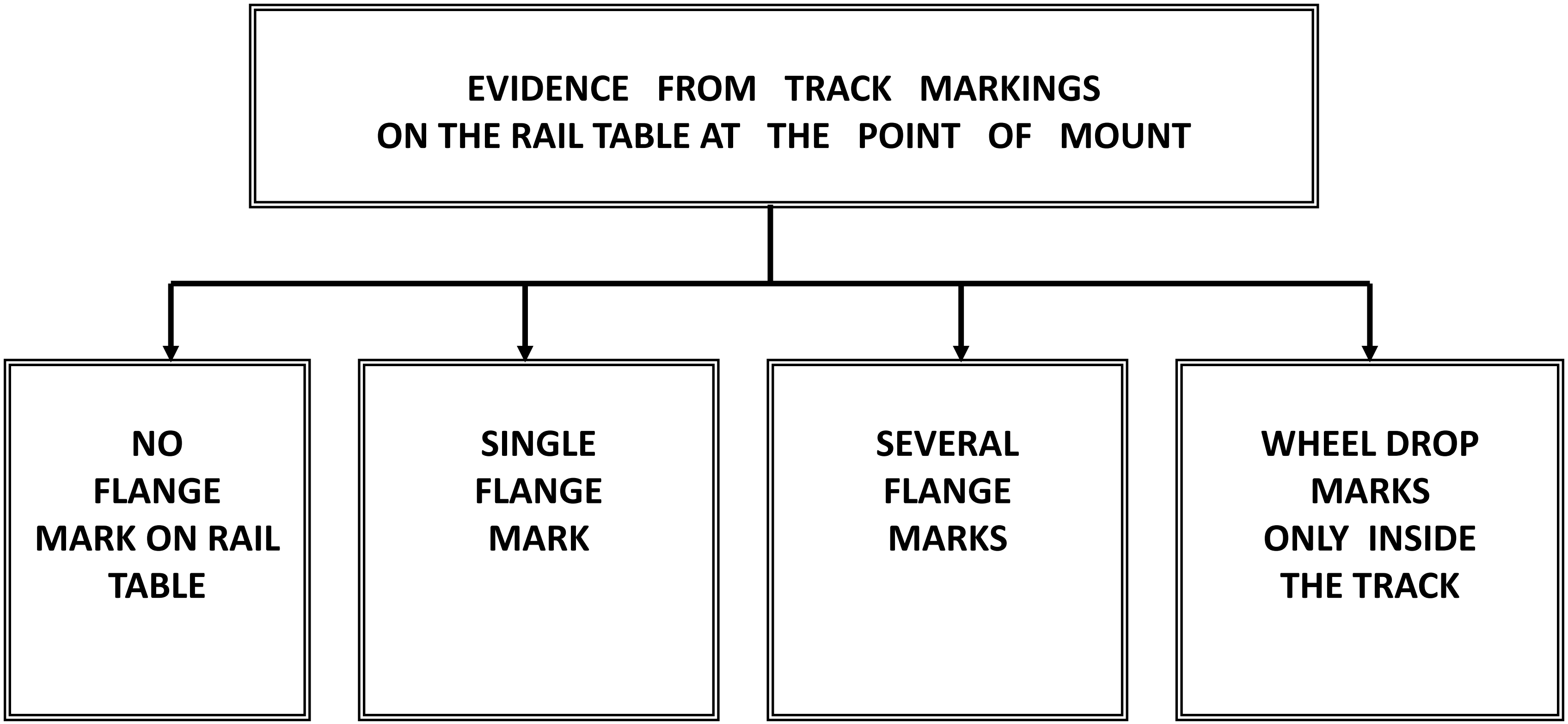


MODES OF OSCILLATION

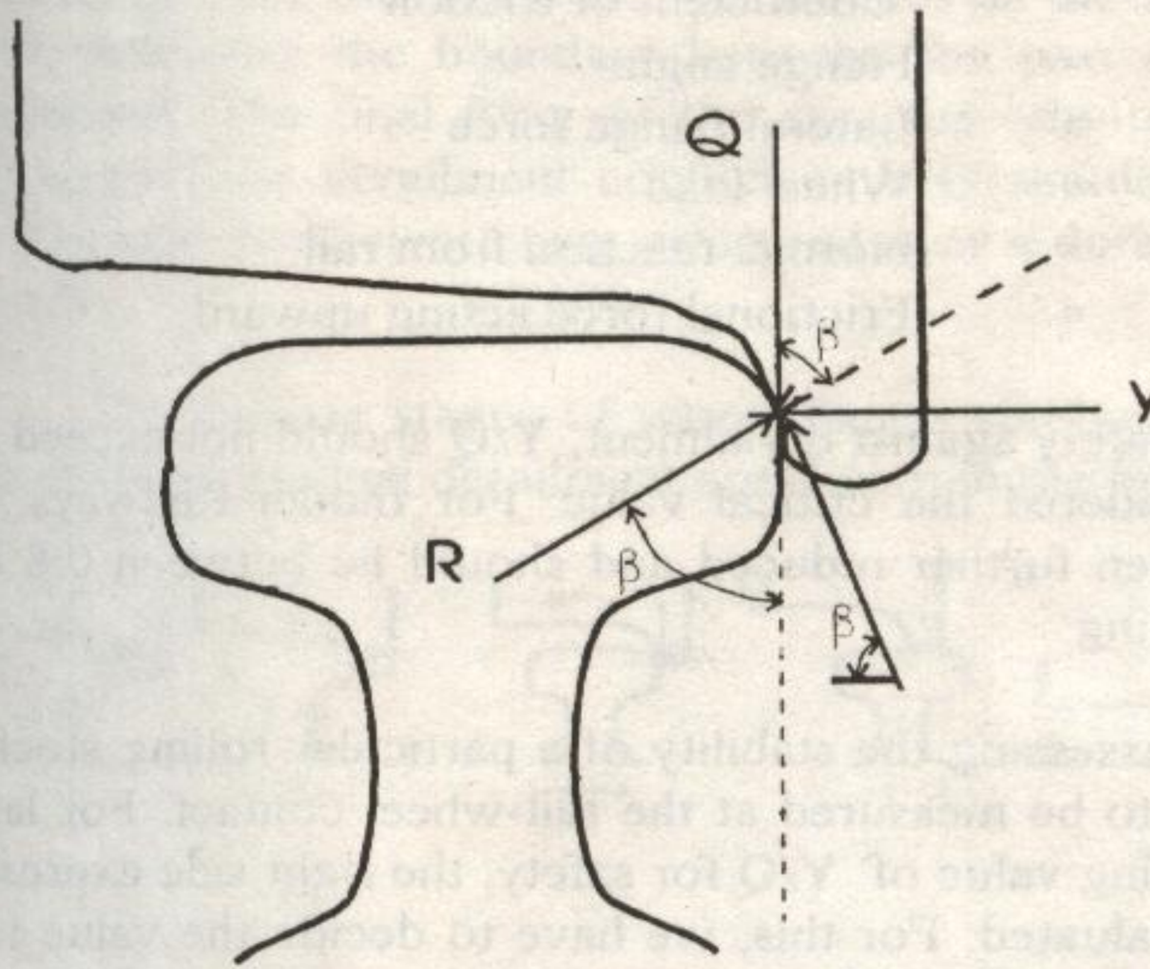
AXIS	MODES OF OSCILATION	
	LINEAR	ROTATIONAL
X	Shuttling	Rolling Q
Y	Lurching Y	Pitching Q
Z	Bouncing Q	Nosing or Yaw Q,Y,

Derailment Reasons

- Unless cause is obvious e.g. Axle Breakage, Cattle run over etc , thorough investigation is necessary which find role of track and vehicle to cause:-
  - Flange force Y to increase
  - Wheel load Q to decrease
  - Angle of attack to increase
- List of defects help in analyzing and determining the most probable cause of derailment.


EVIDENCE FROM TRACK MARKINGS
ON THE RAIL TABLE AT THE POINT OF MOUNT
NO FLANGE MARK ON RAIL TABLE
SINGLE FLANGE MARK
SEVERAL FLANGE MARKS
WHEEL DROP MARKS ONLY INSIDE THE TRACK

Derailment Mechanism



FORCES AT RAIL-WHEEL CONTACT

- $Y/Q = (\tan\beta - \mu) / 1 + \mu \tan\beta$

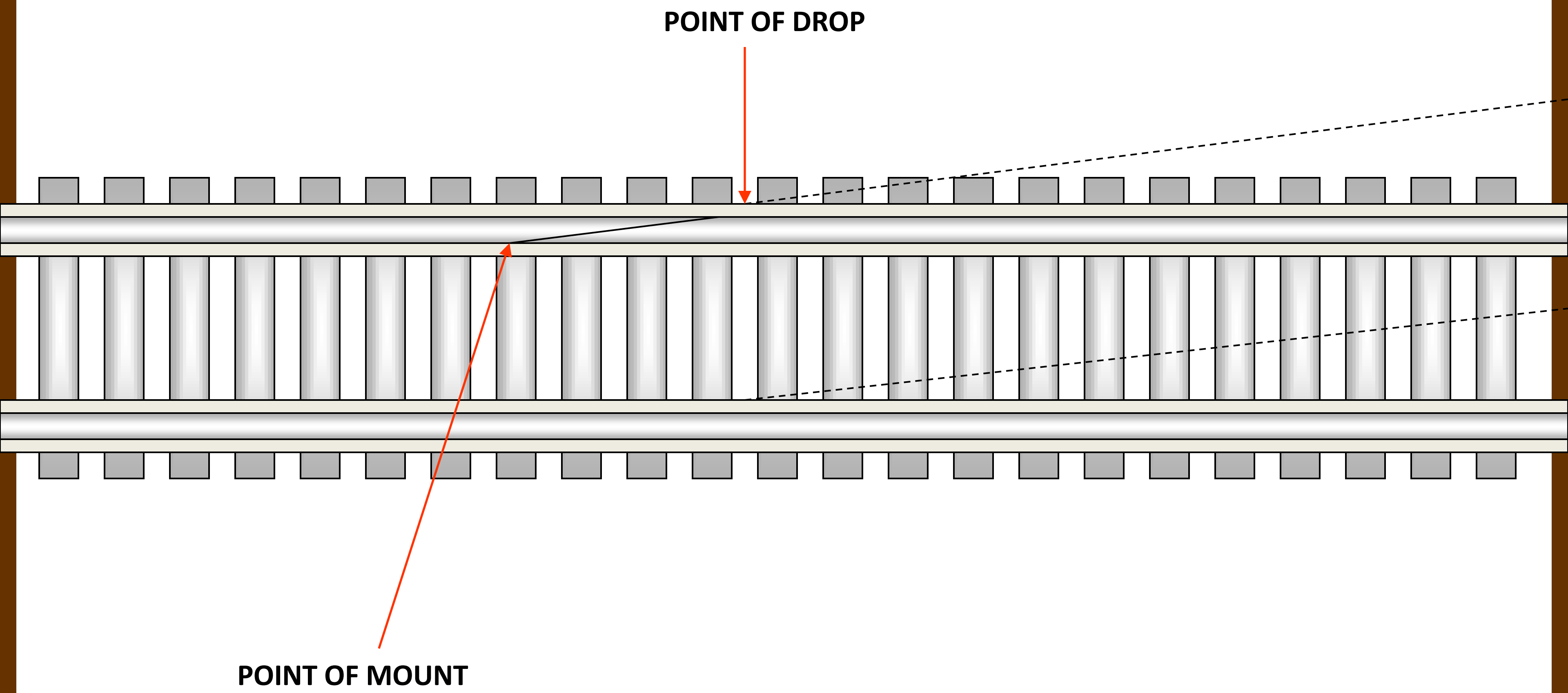
Where, μ = coefficient of friction
β = Flange angle
Y = Lateral flange force
Q = Wheel load
R = Normal reaction from rail

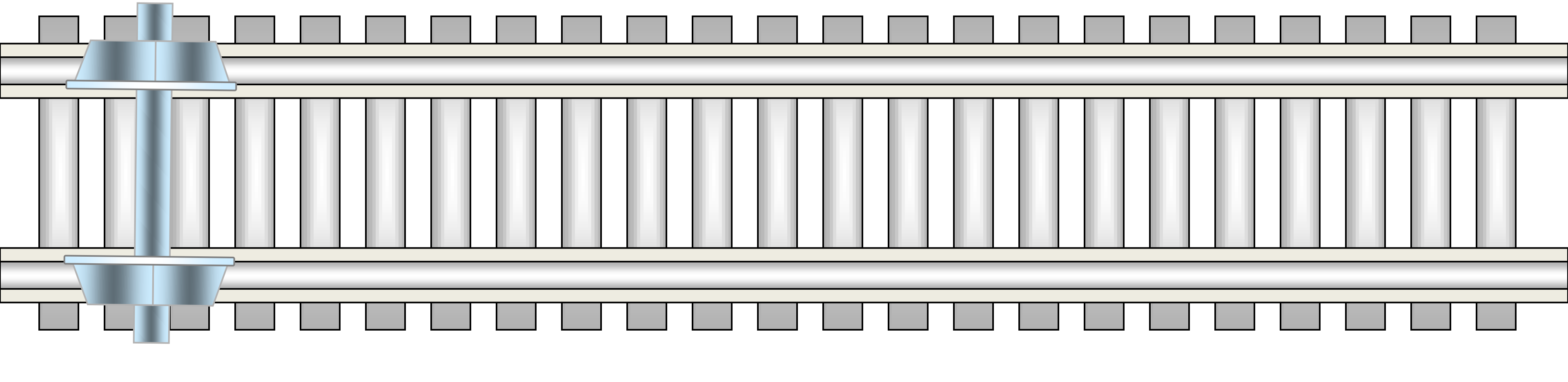
For safety Y/Q should not exceed 1.4 (considered as the critical value).

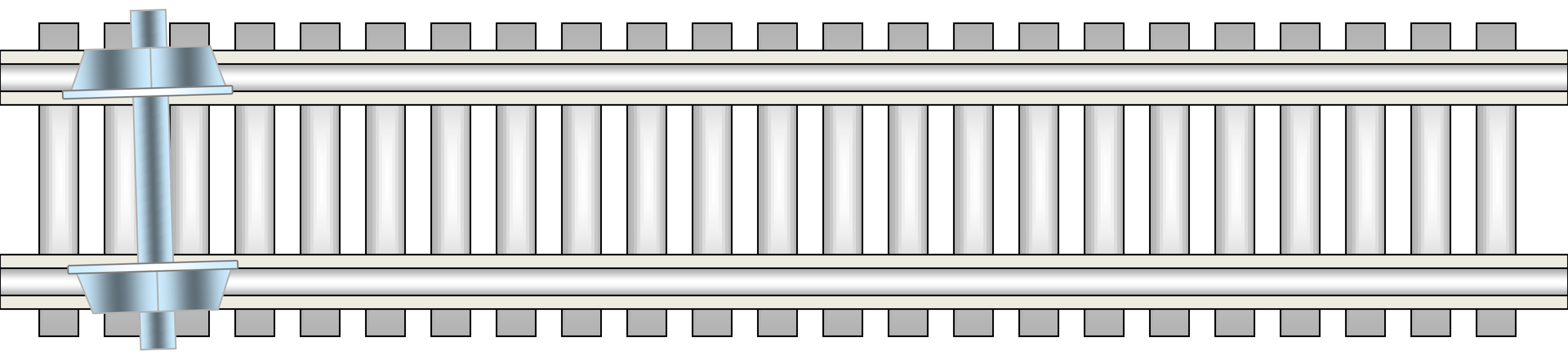
It should lie between 0.8 & 1 for safe running.

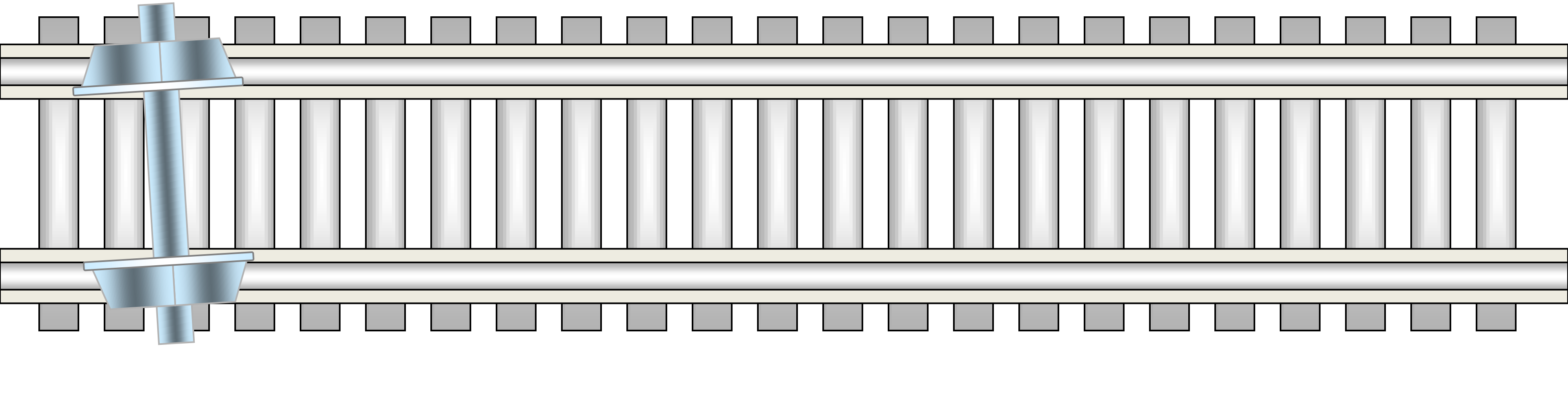
SUDDEN MOUNT AND DROP OF WHEEL

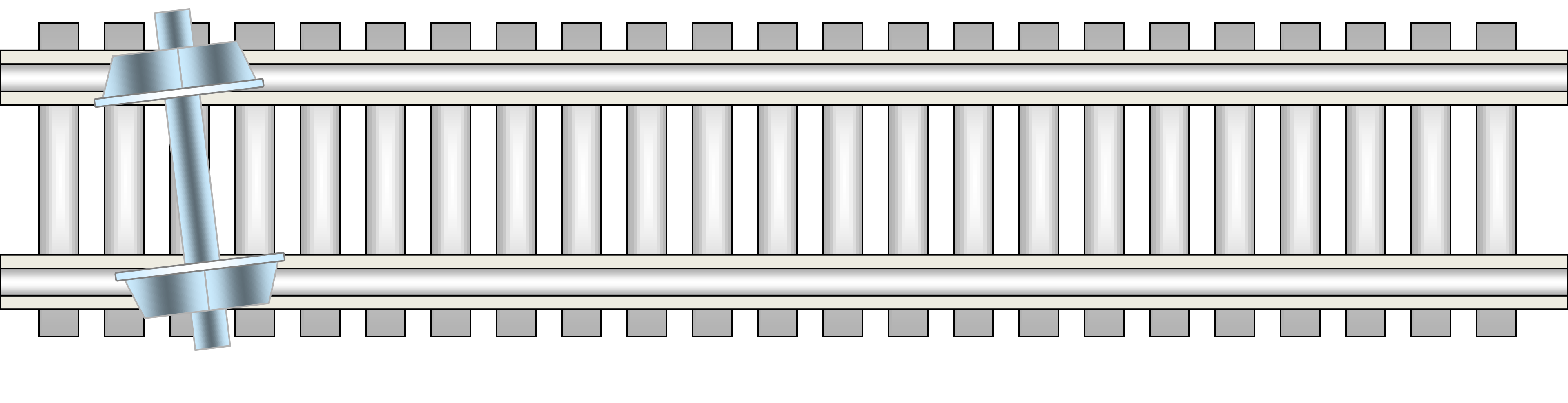
Short and sharp flange travel mark on rail table

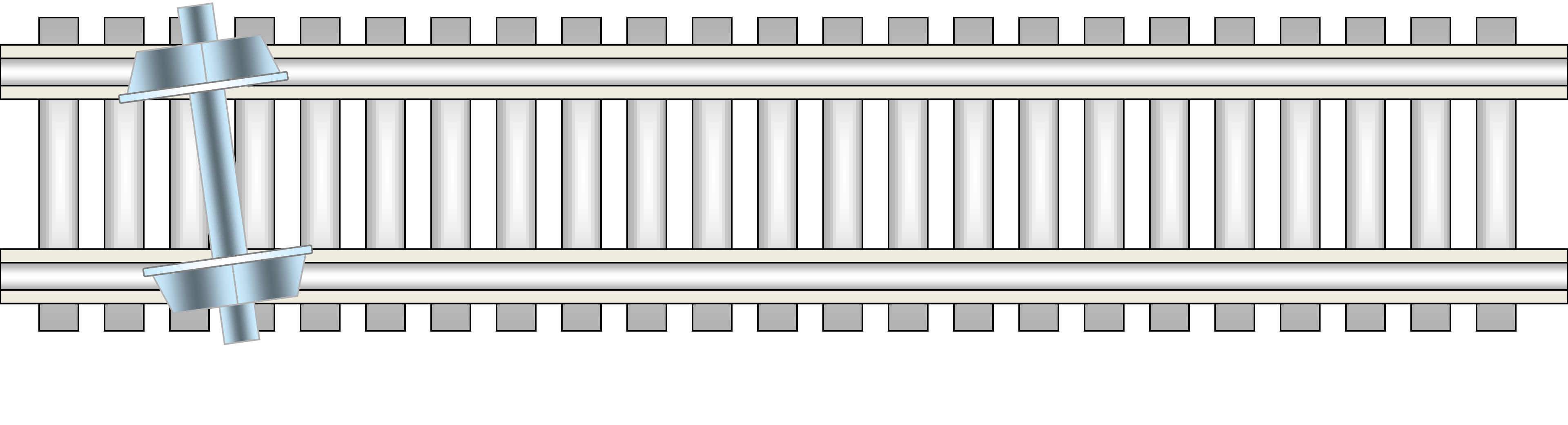


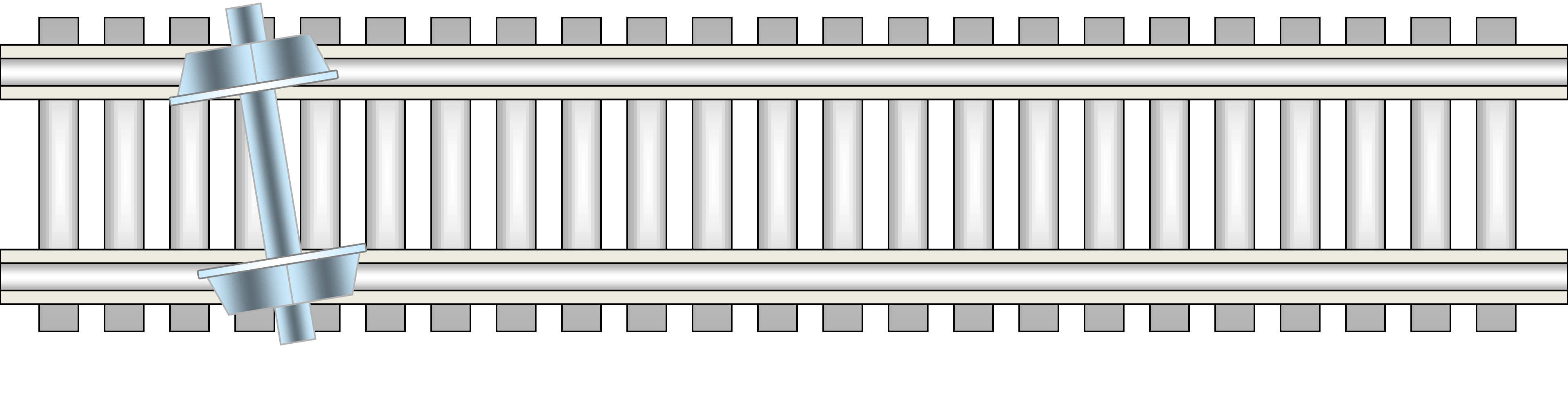


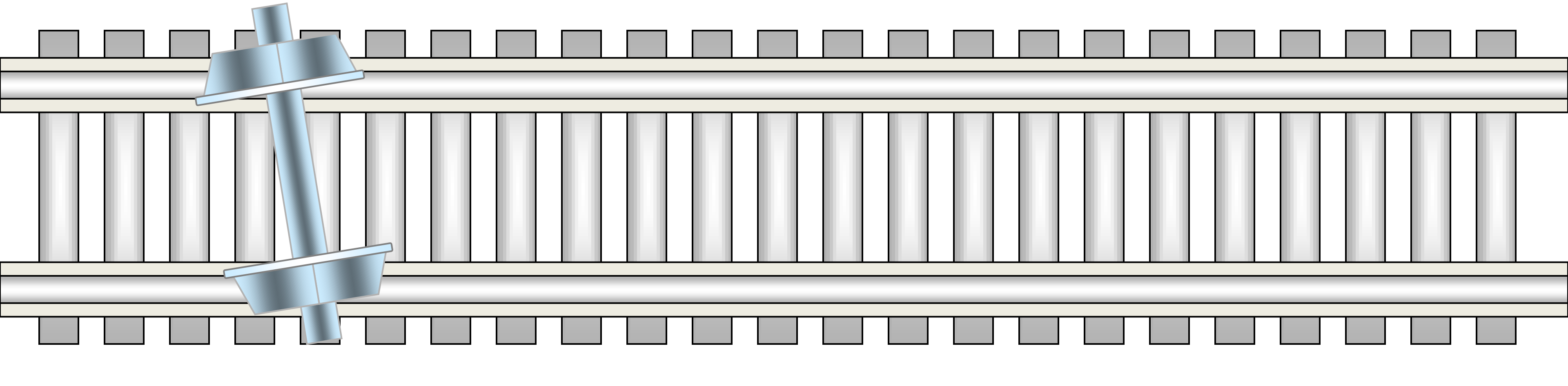


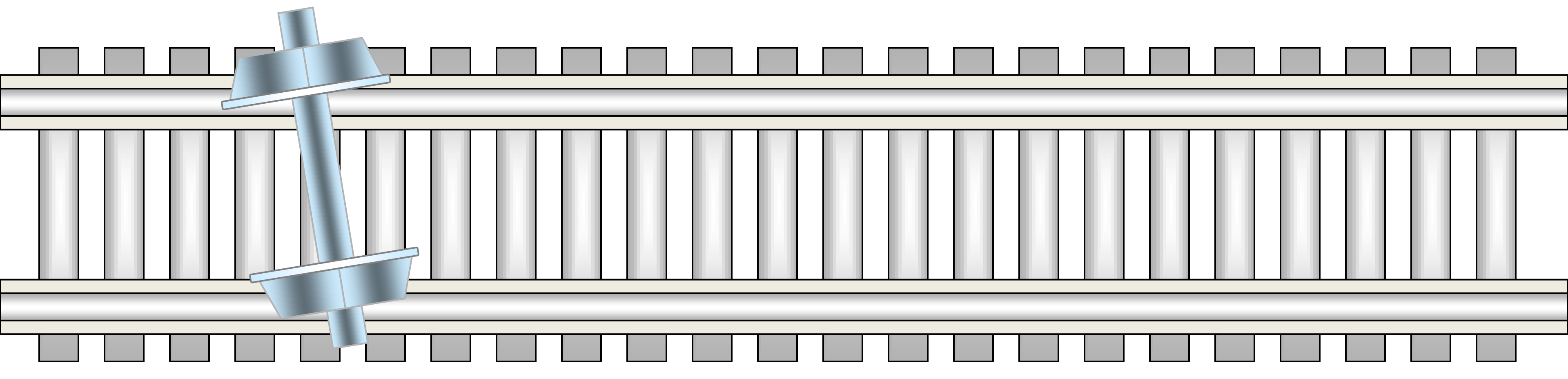


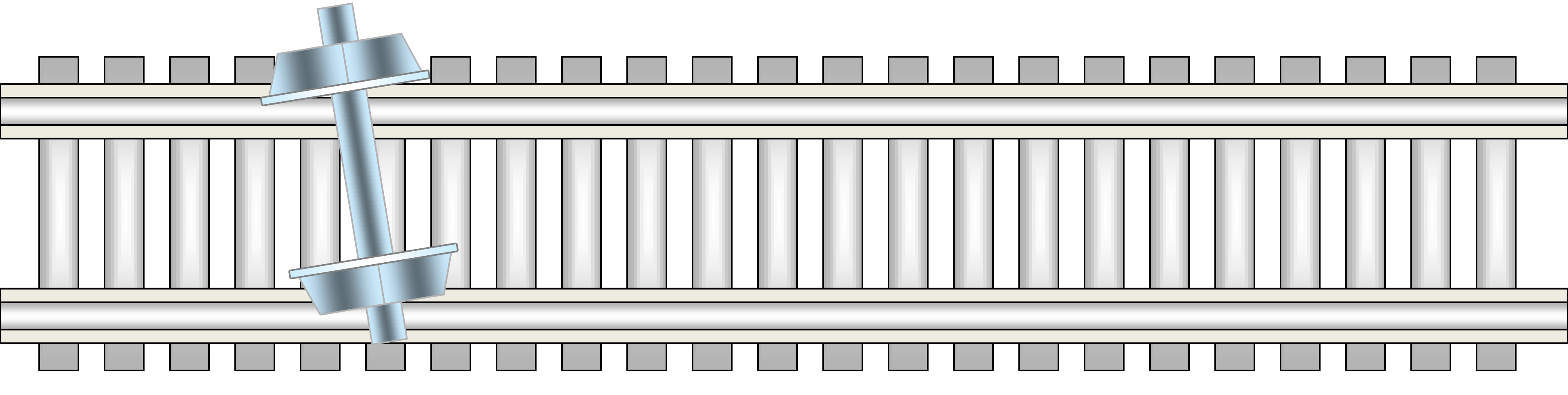


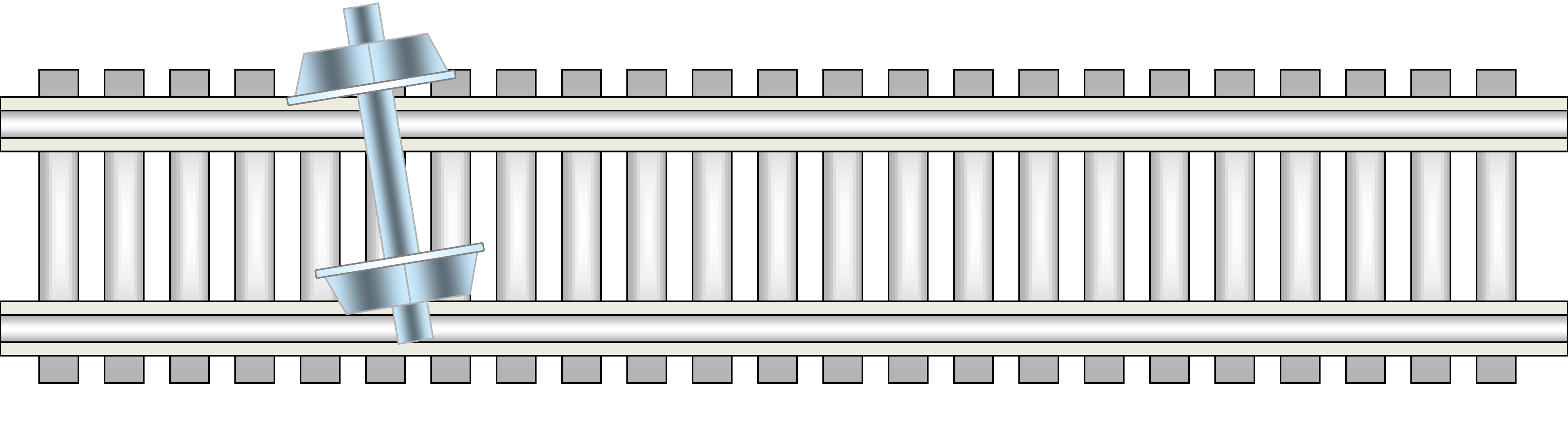


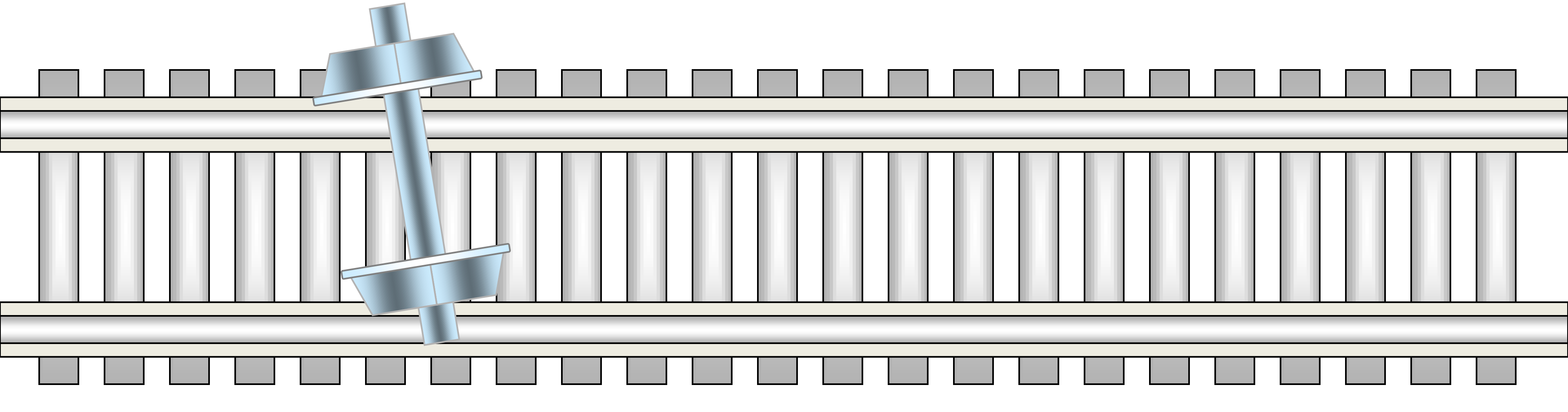


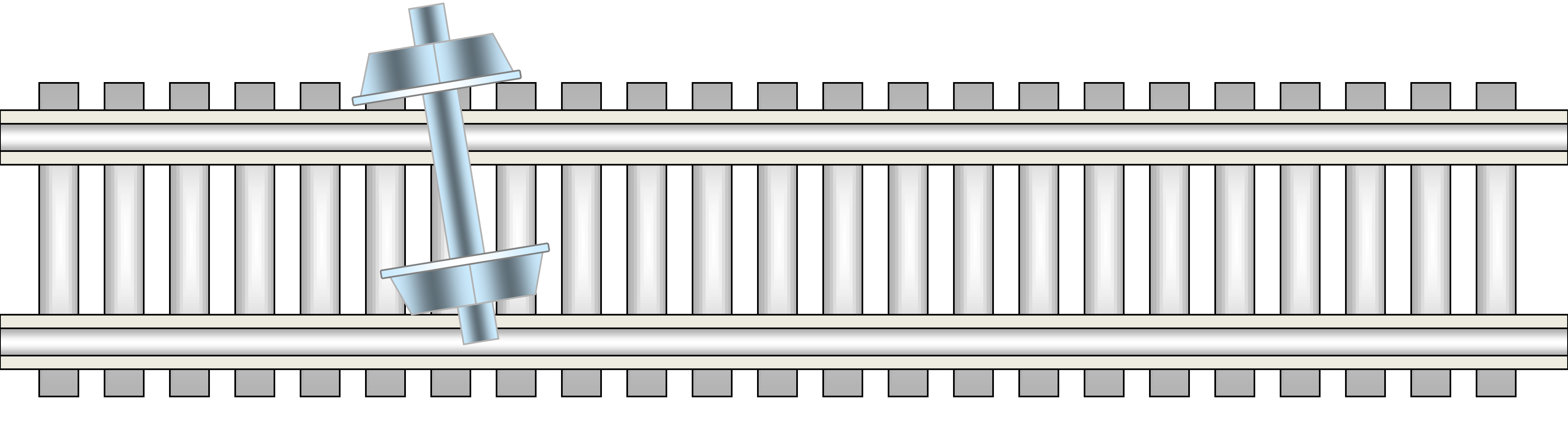


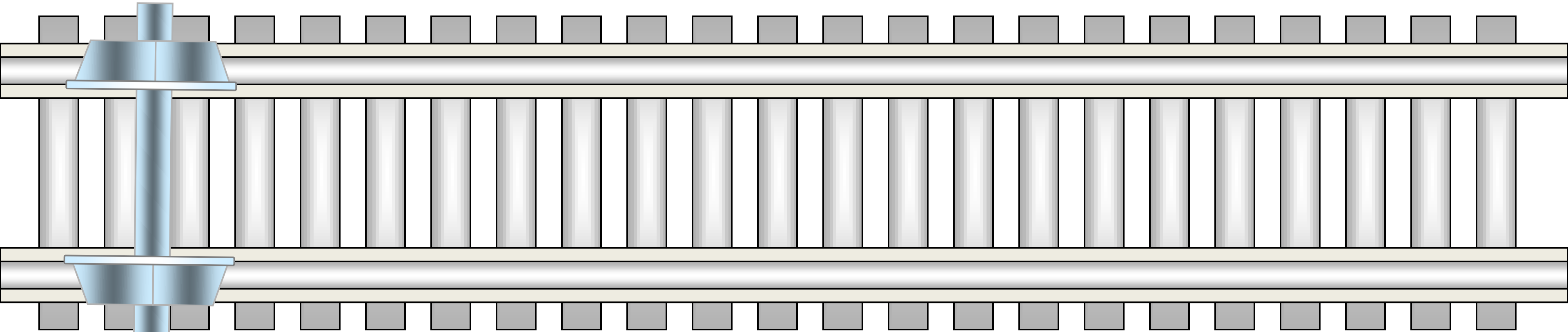


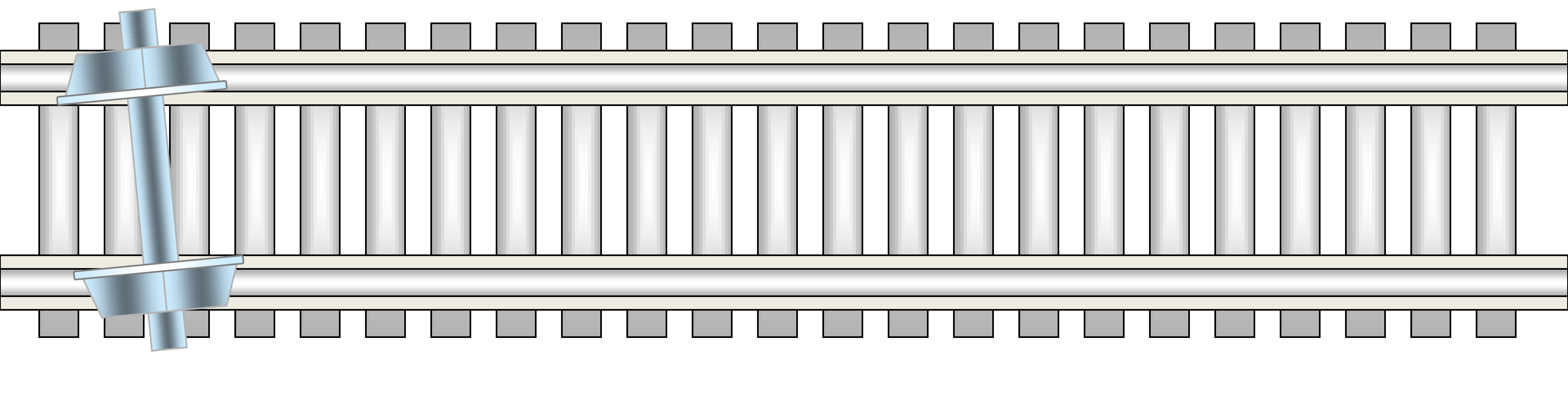


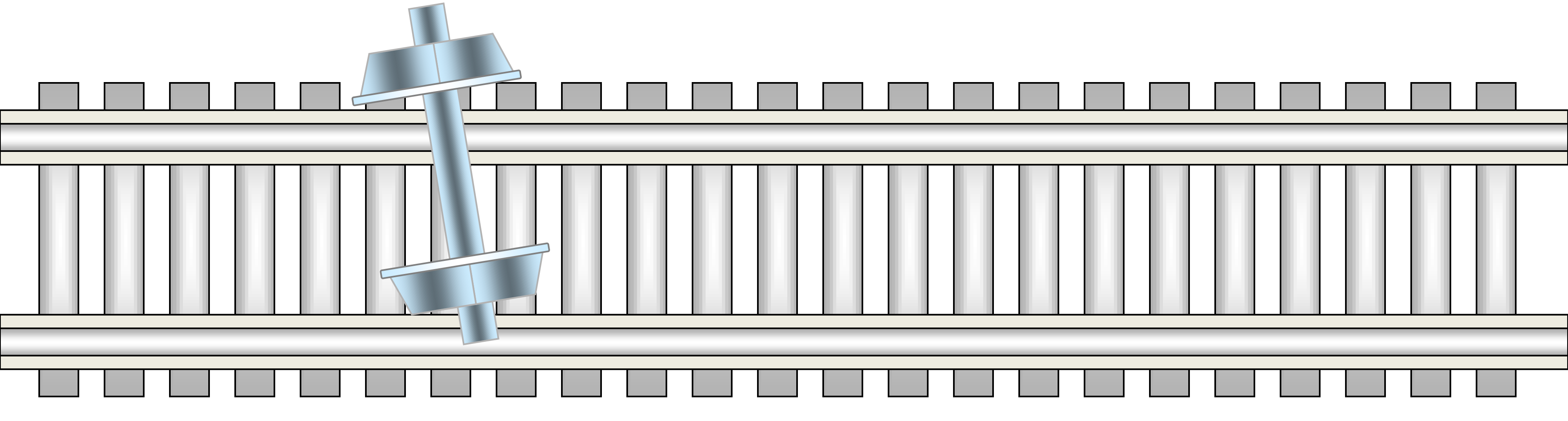


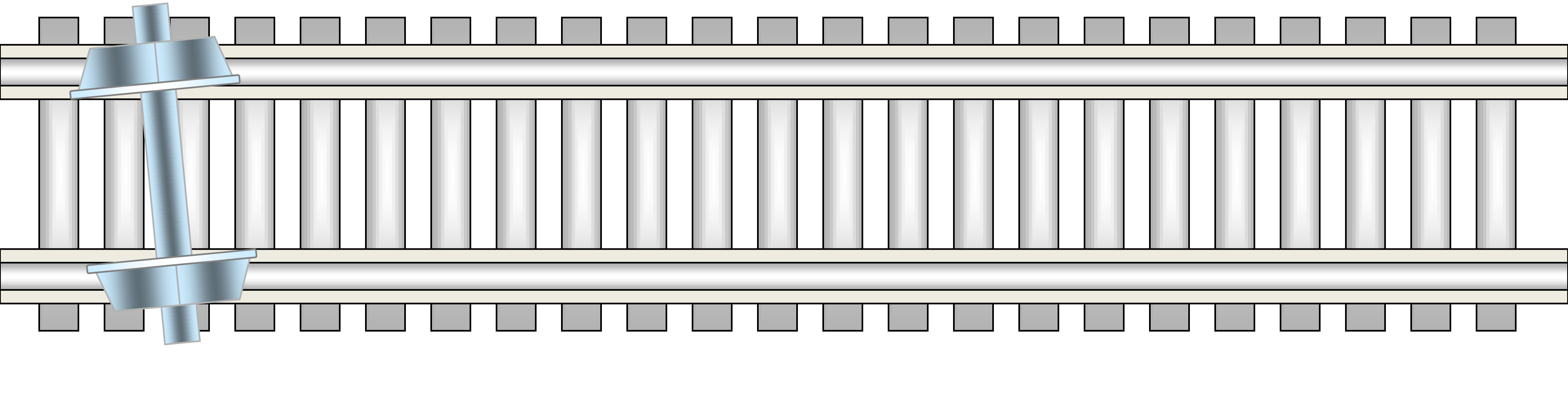


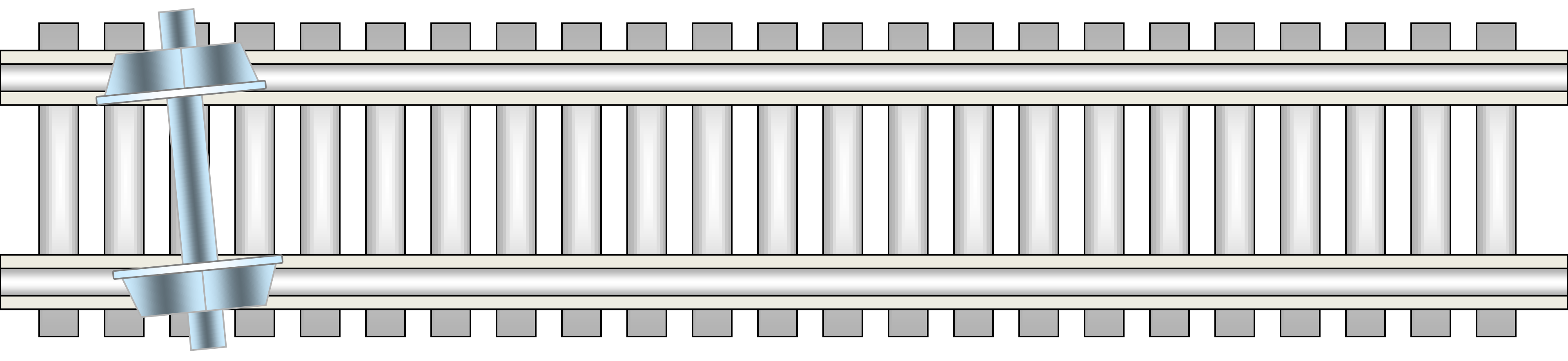


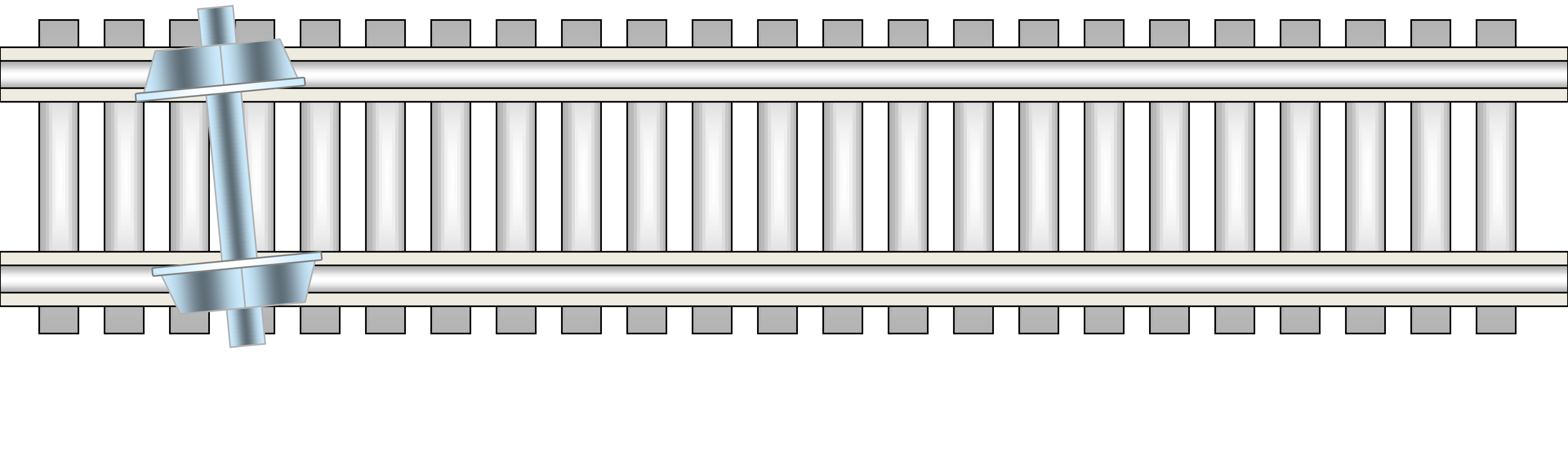


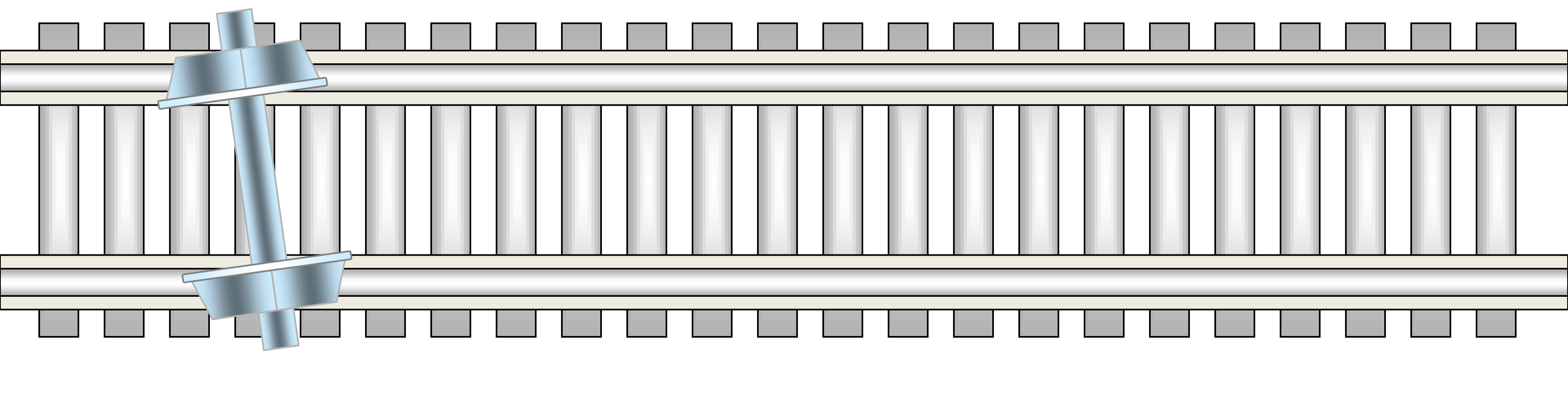


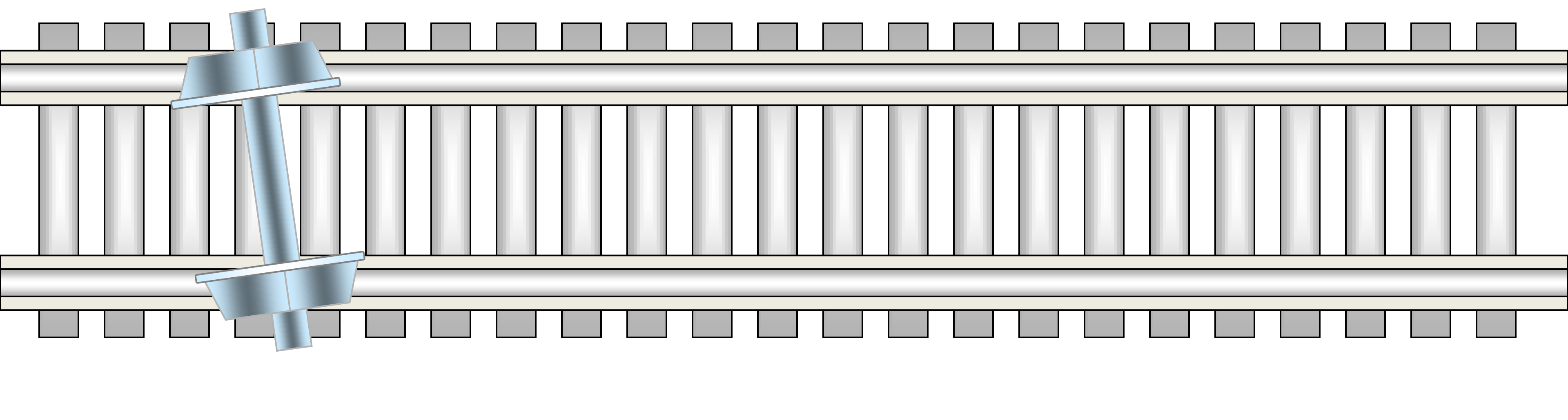


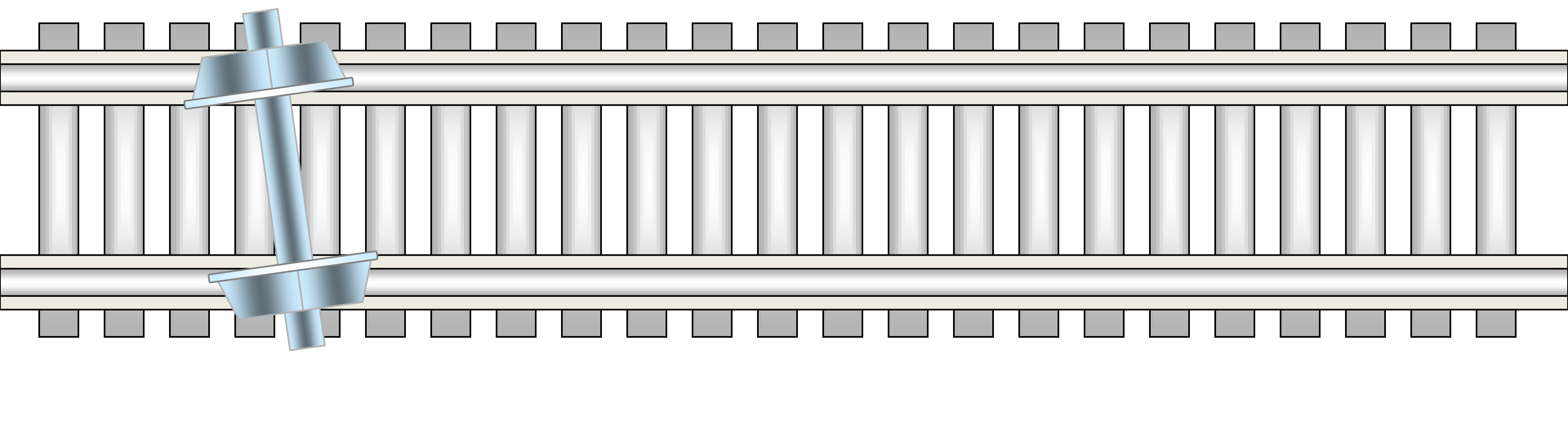


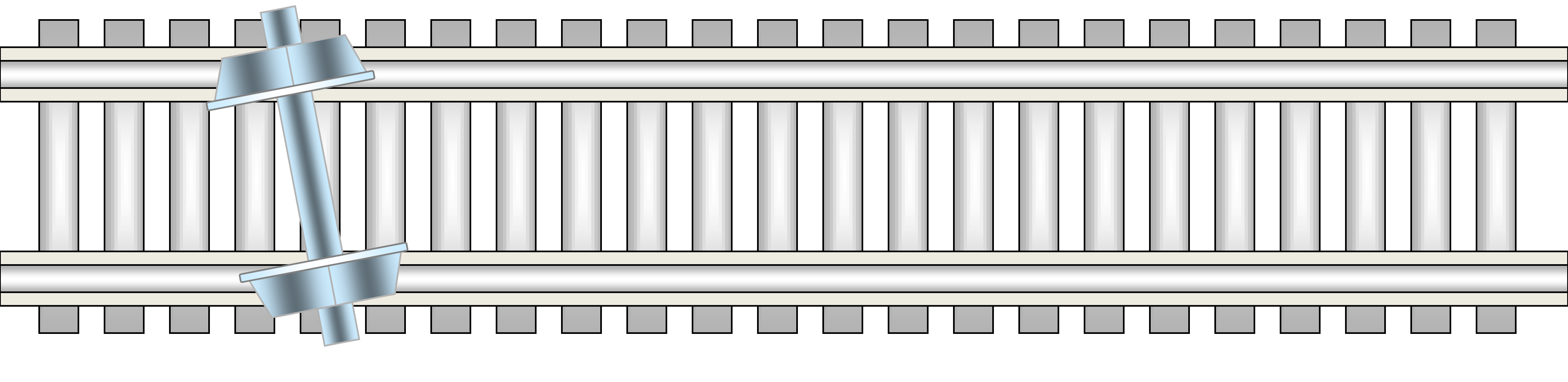


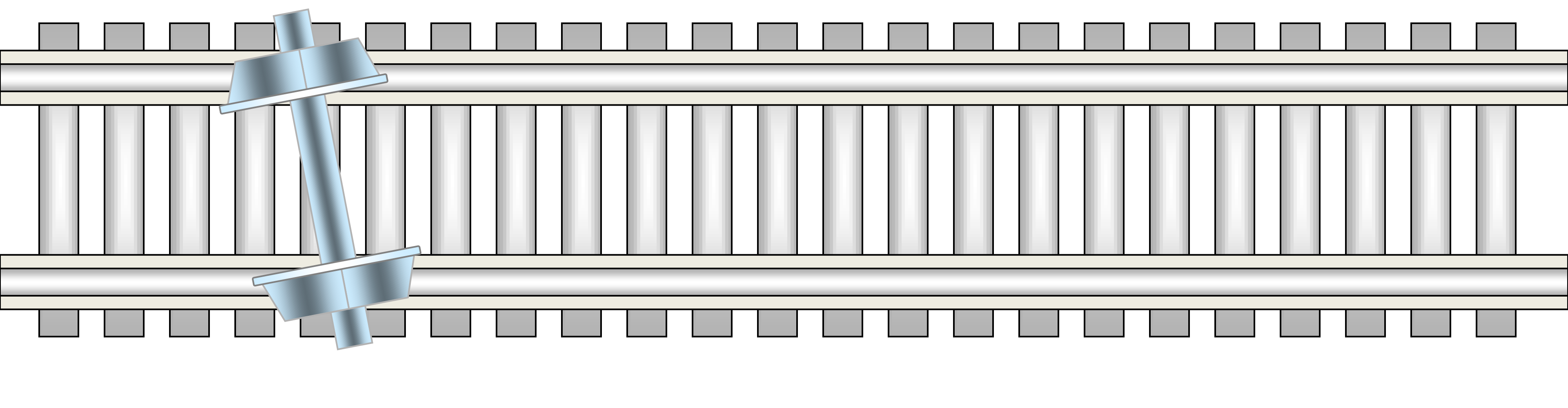


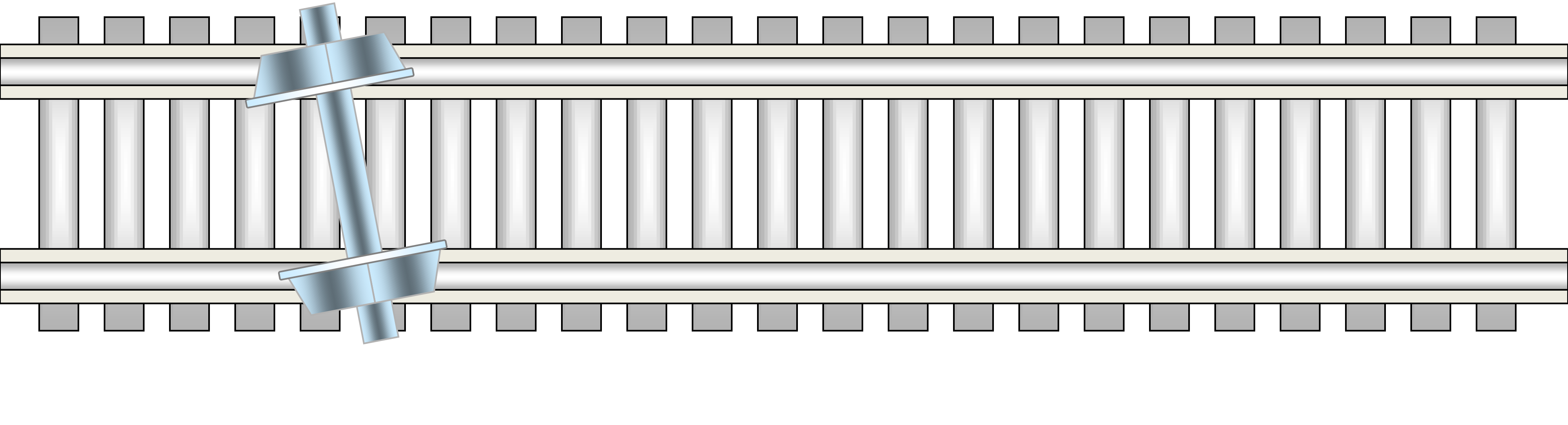


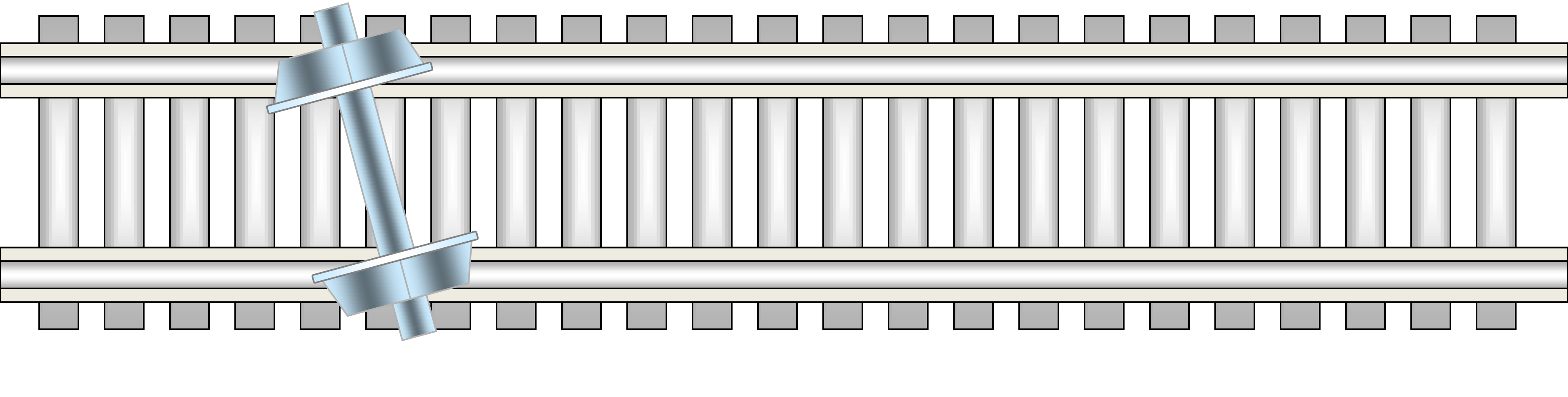


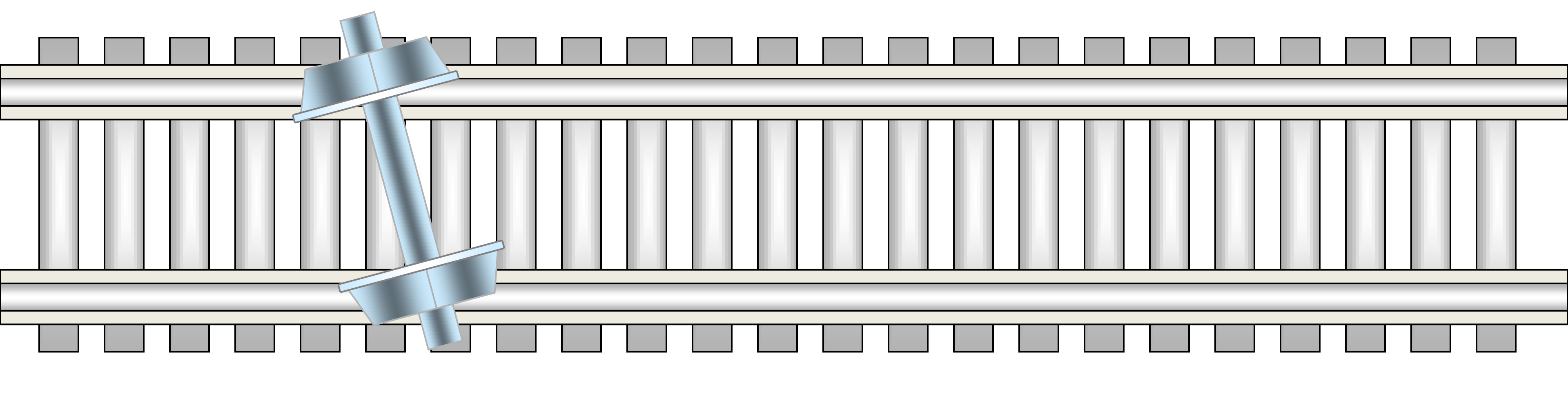


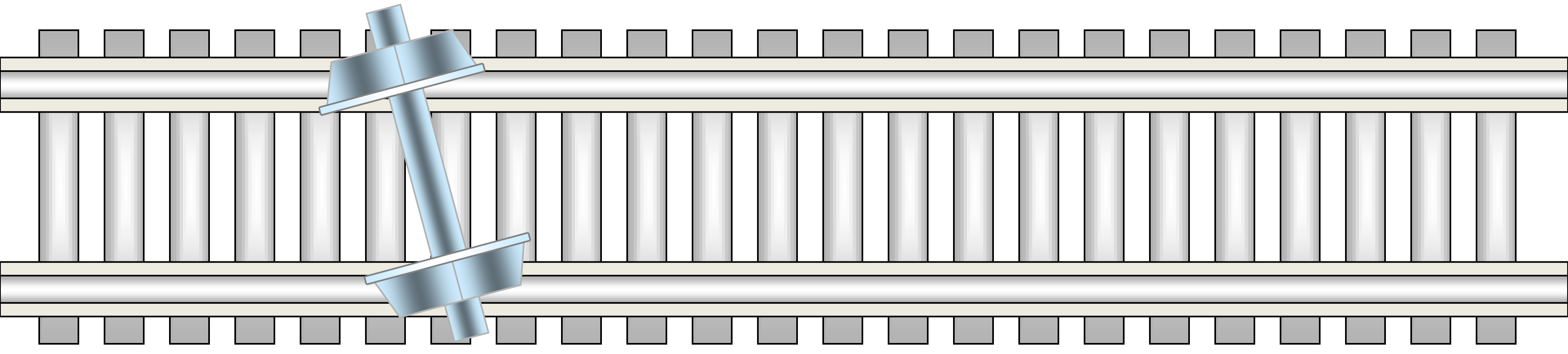


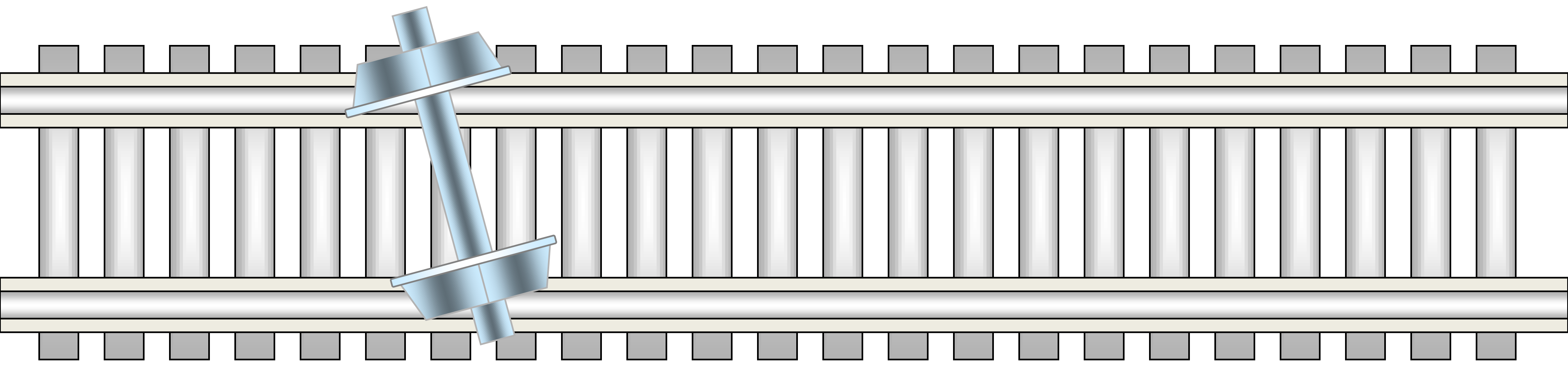


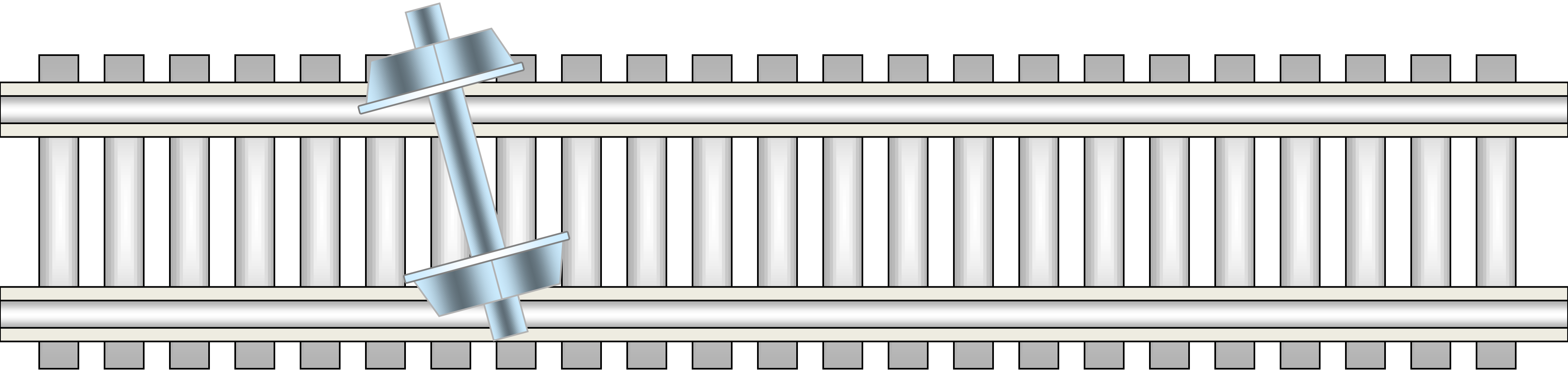


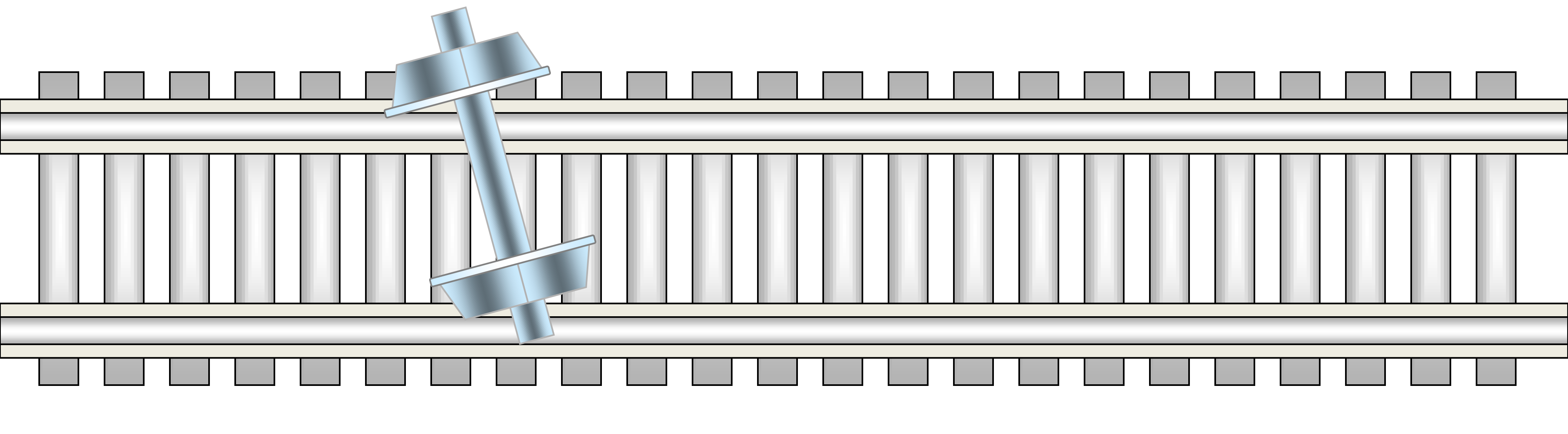


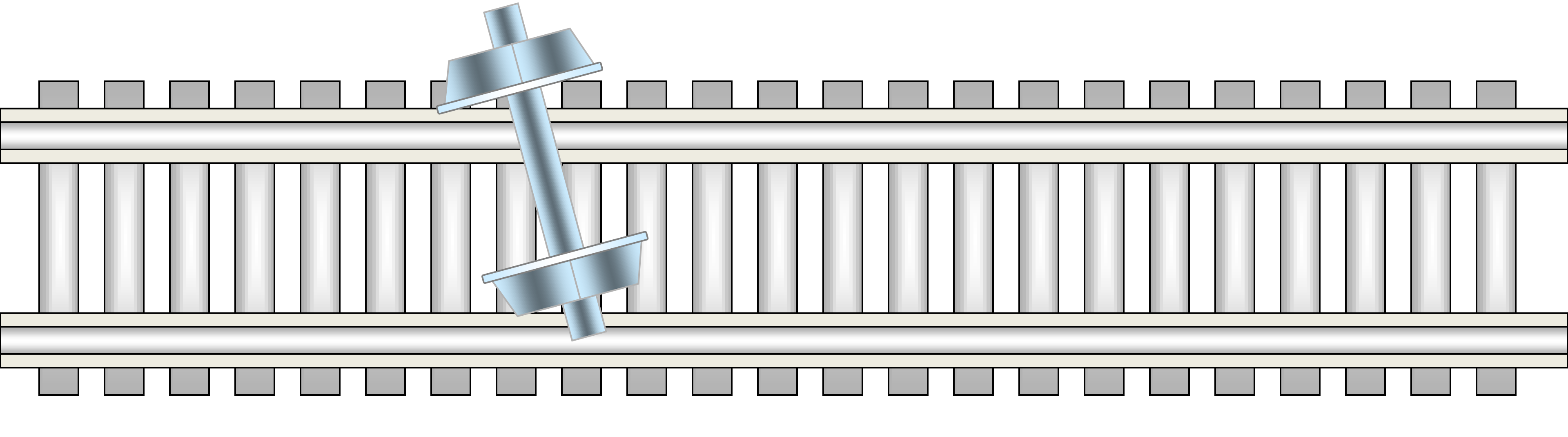






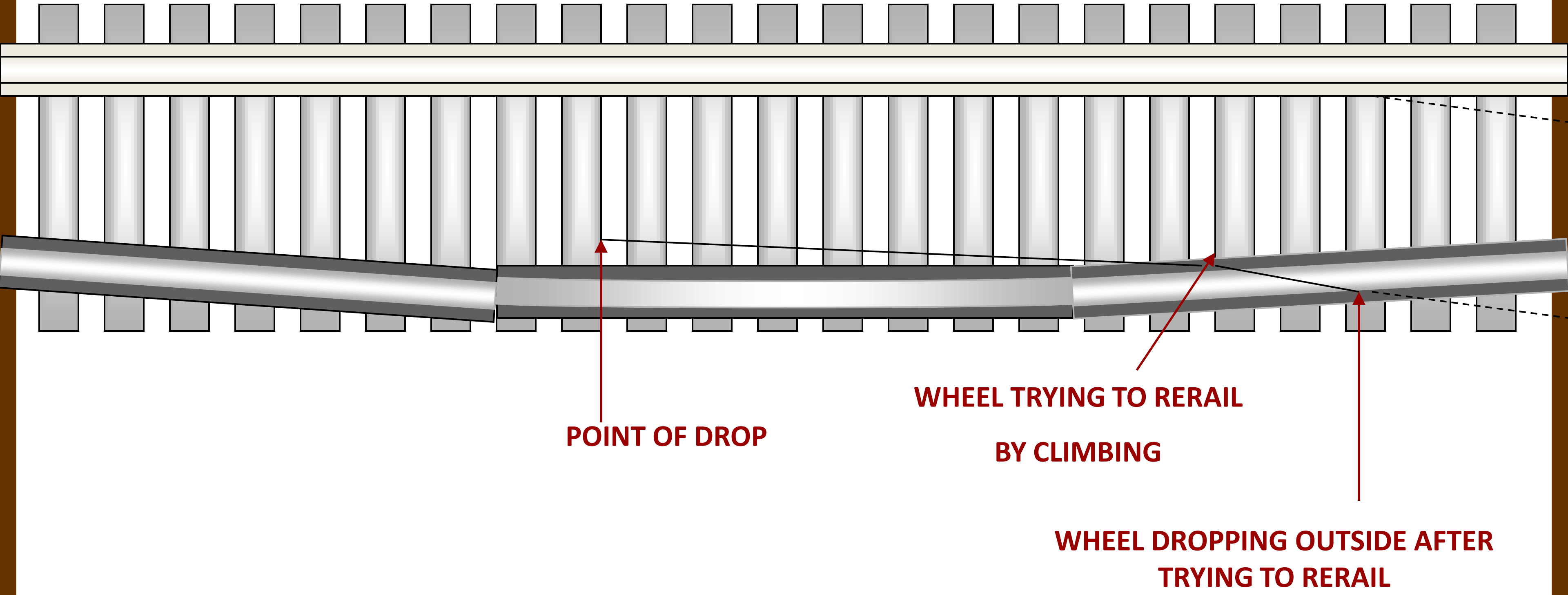


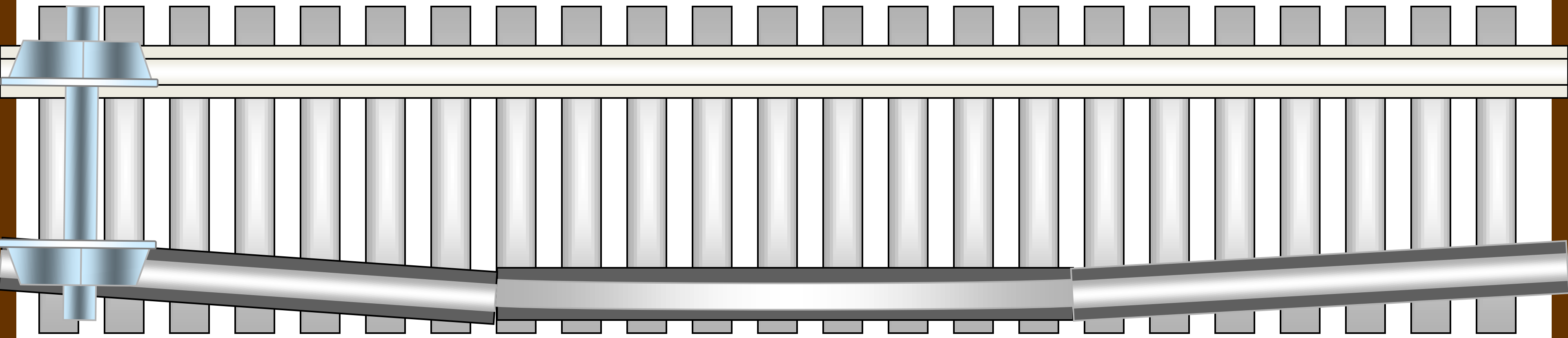


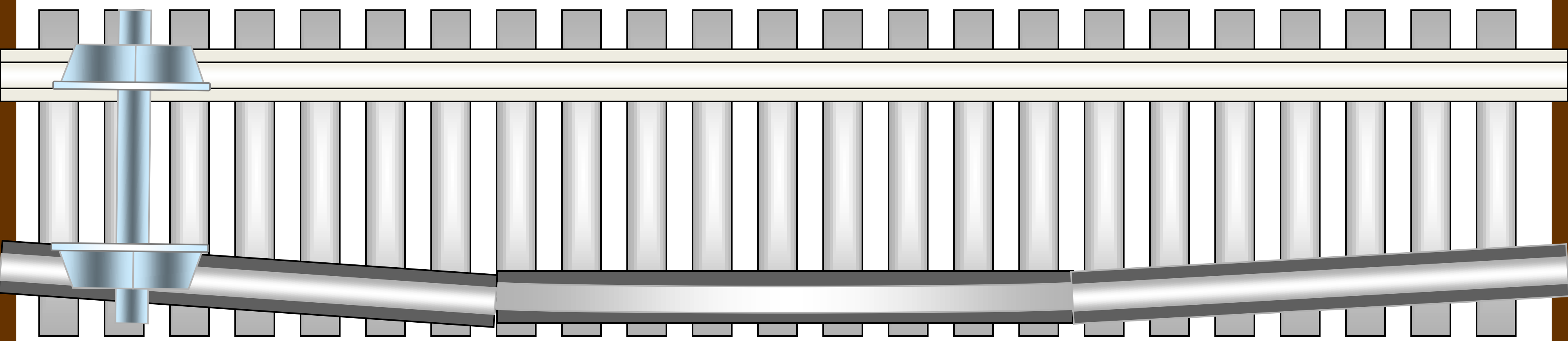


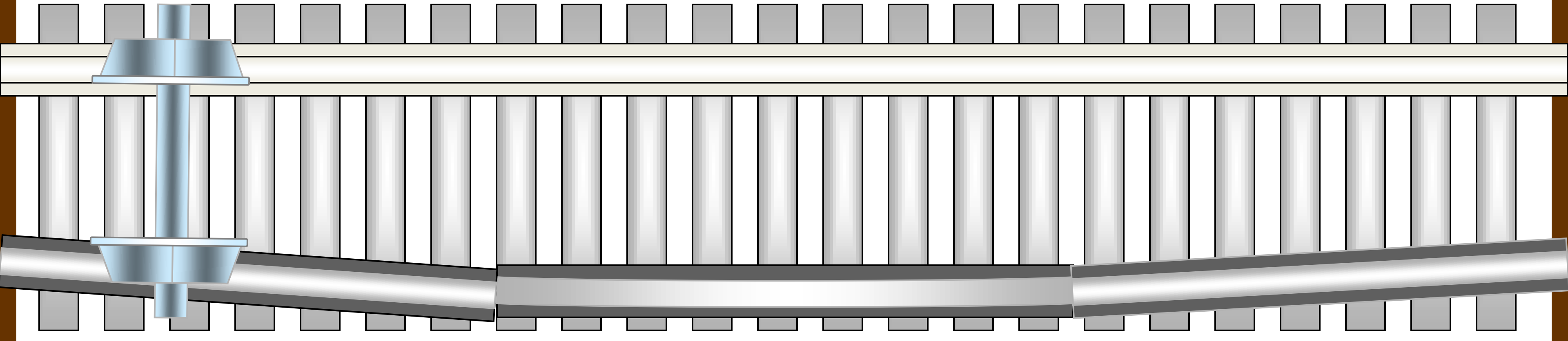
DROP OF WHEEL INSIDE THE TRACK

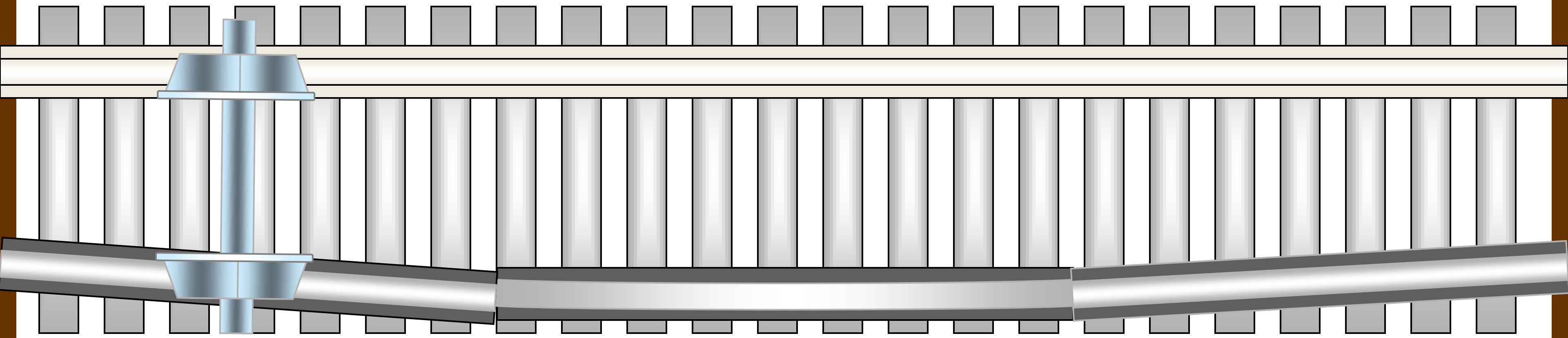
Wheel travel mark inside the two rails, some times followed by another mount, short travel and drop

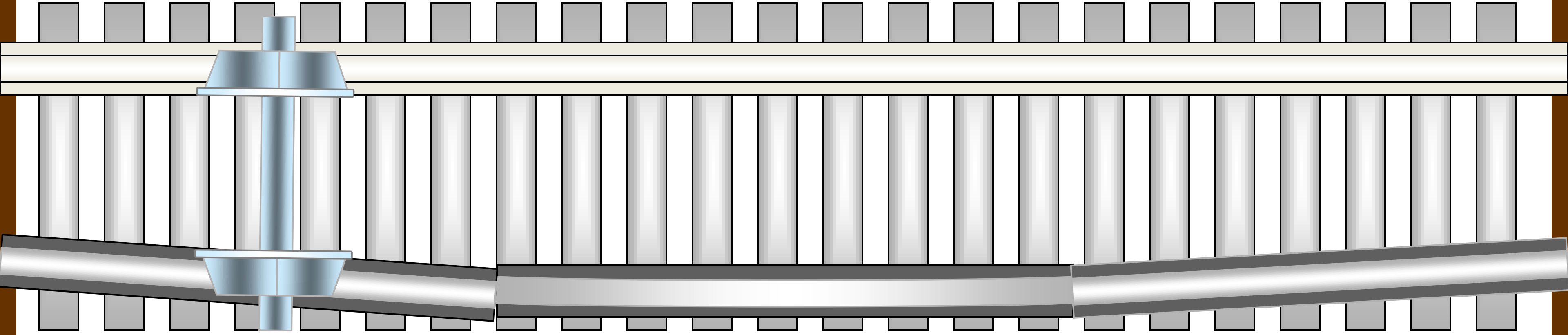


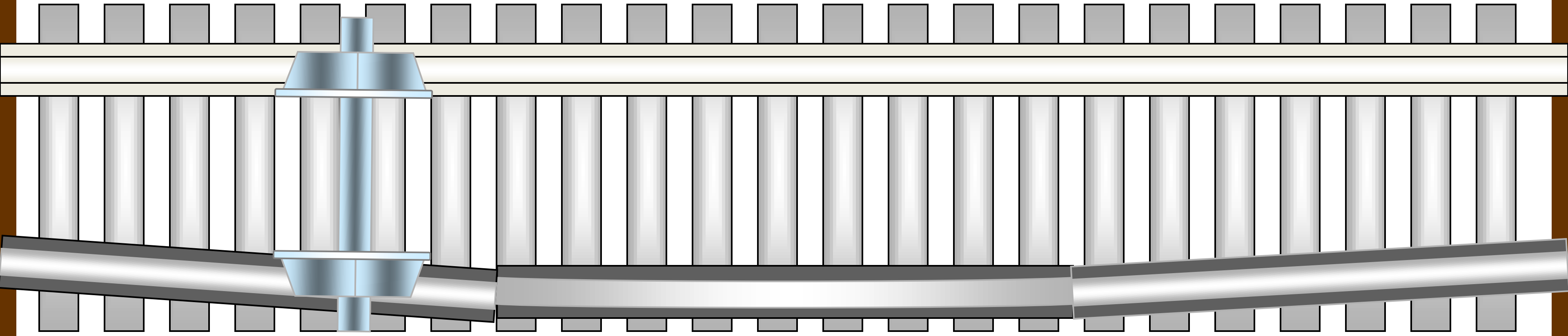


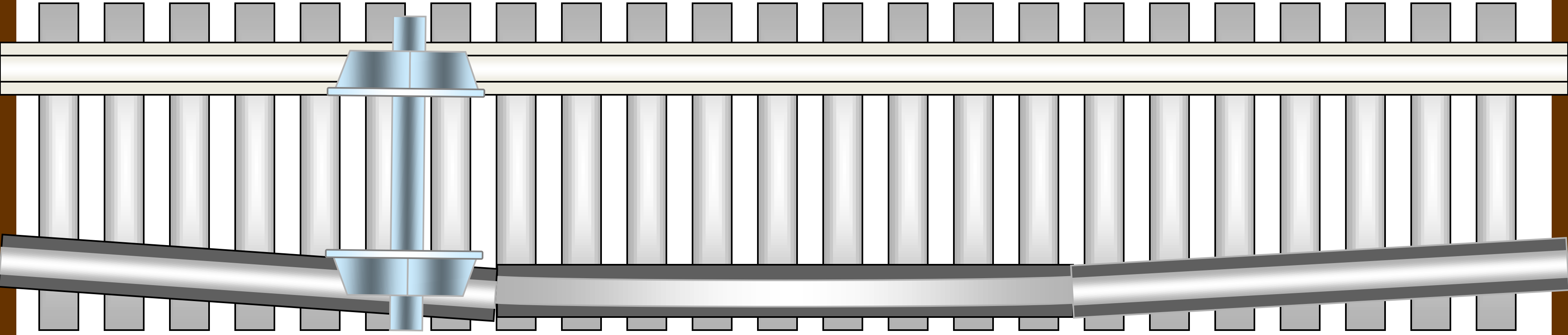


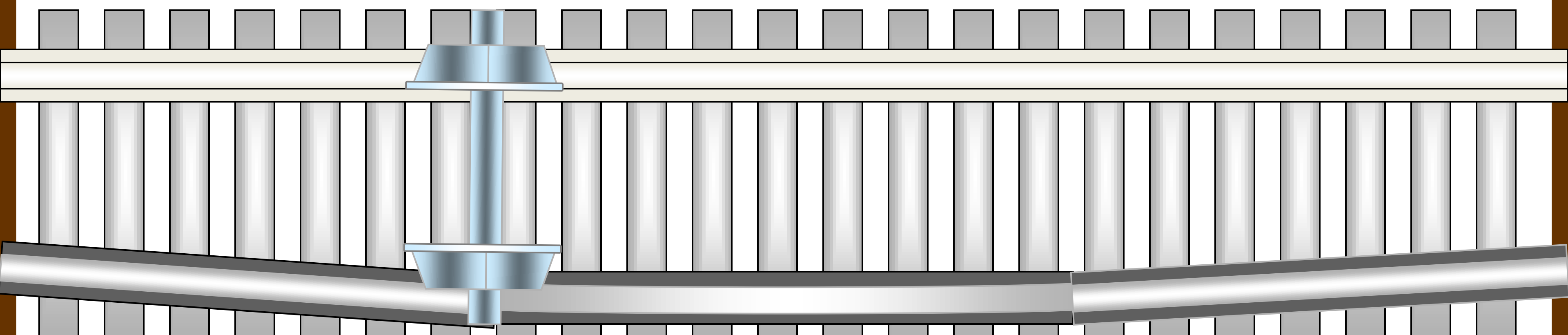


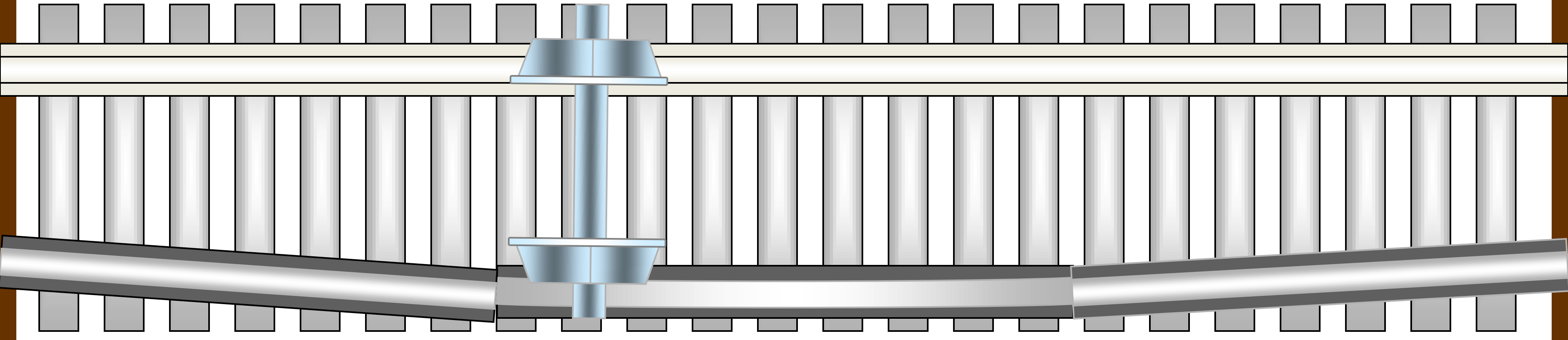


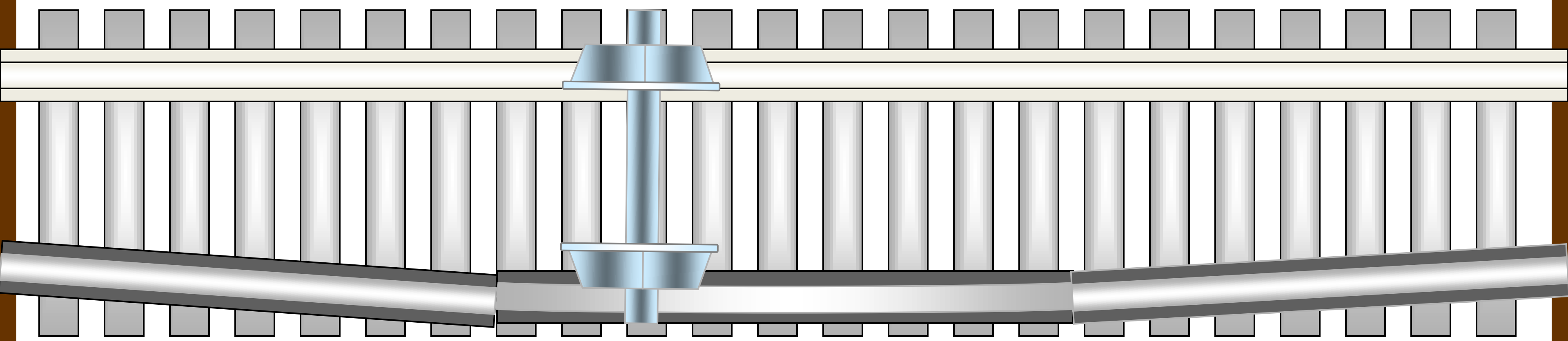


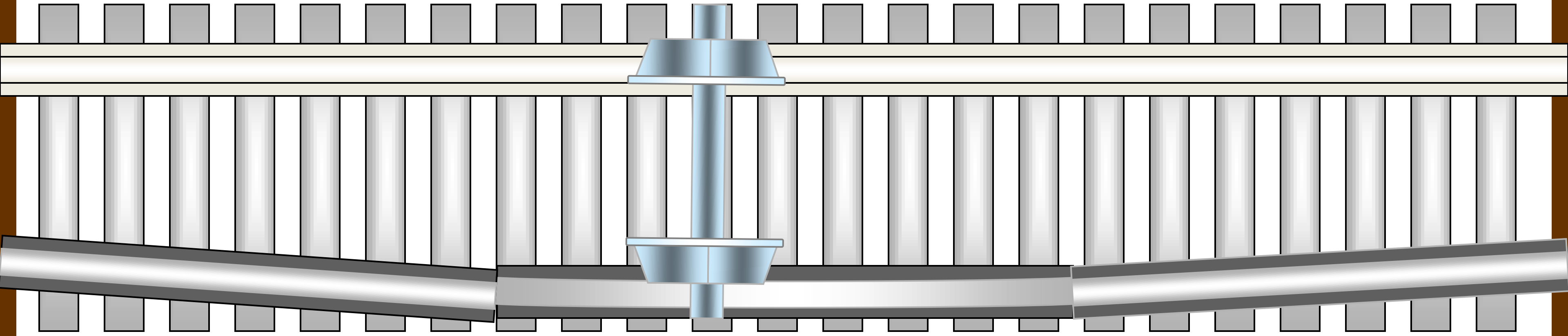


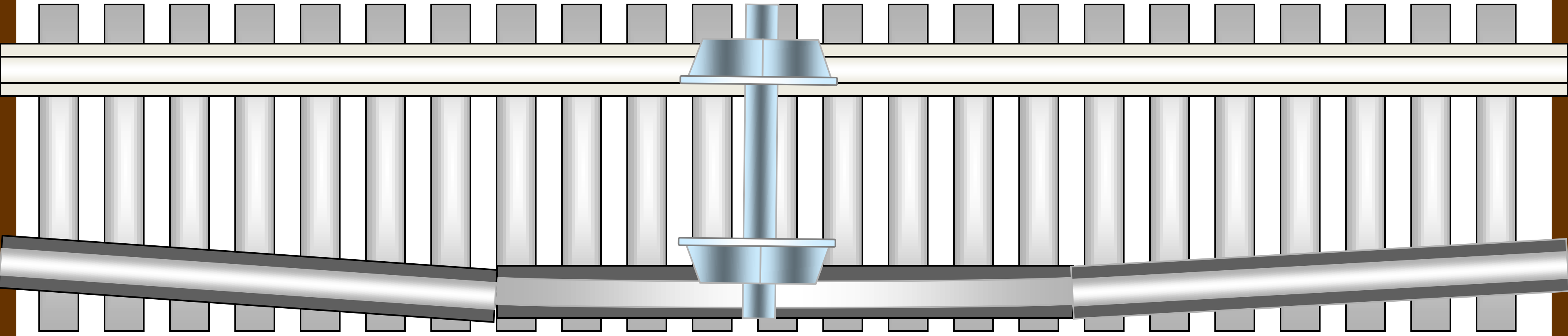


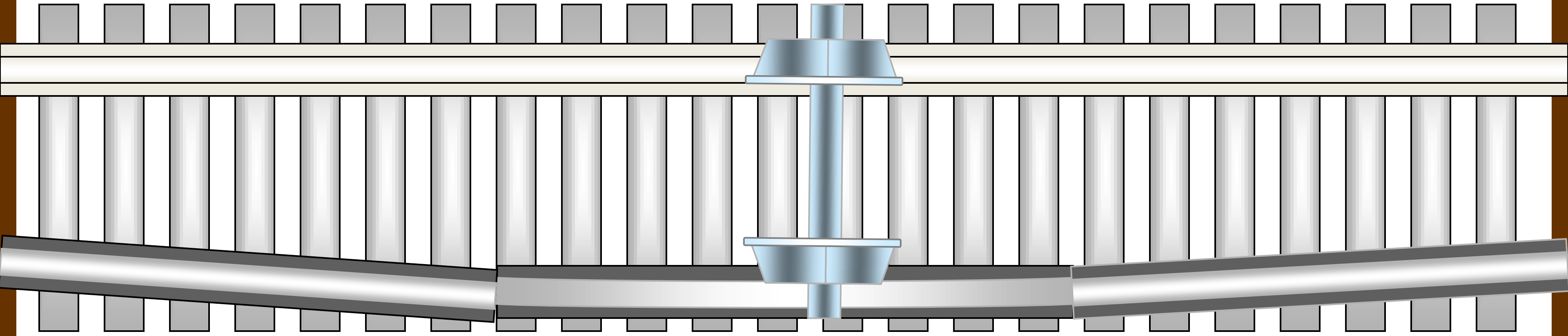


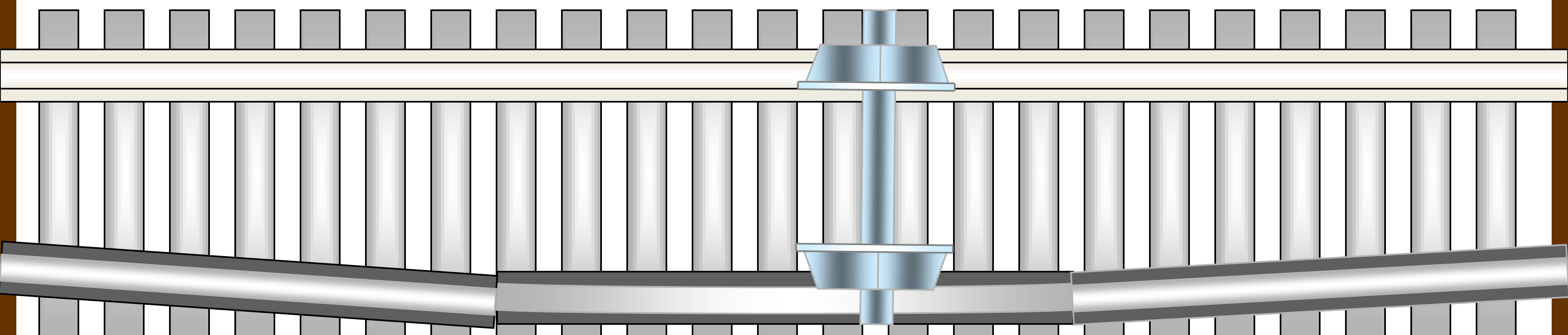


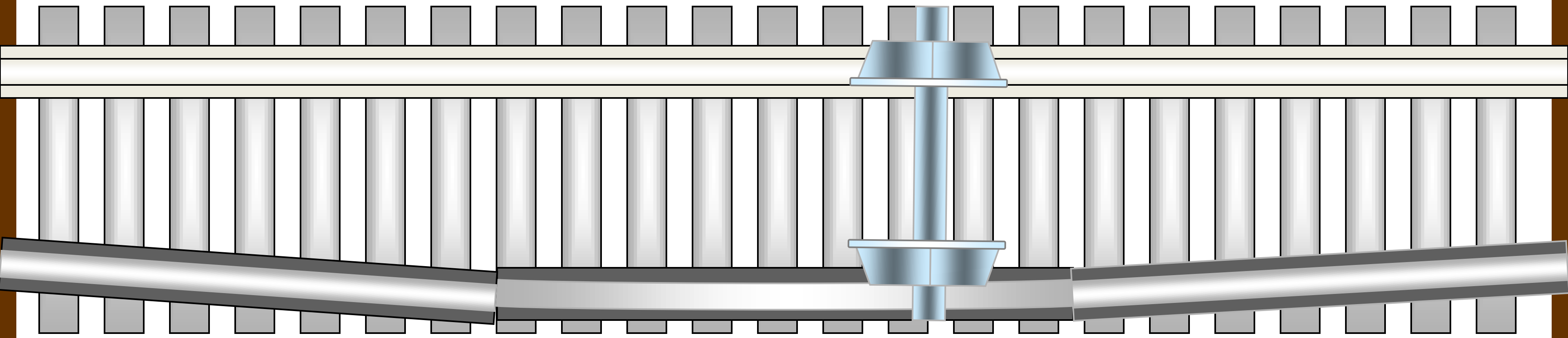


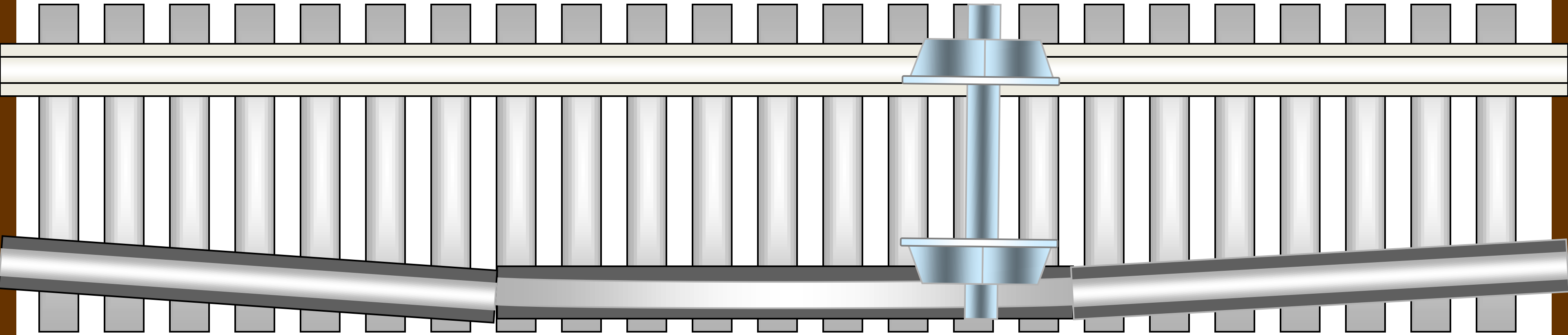


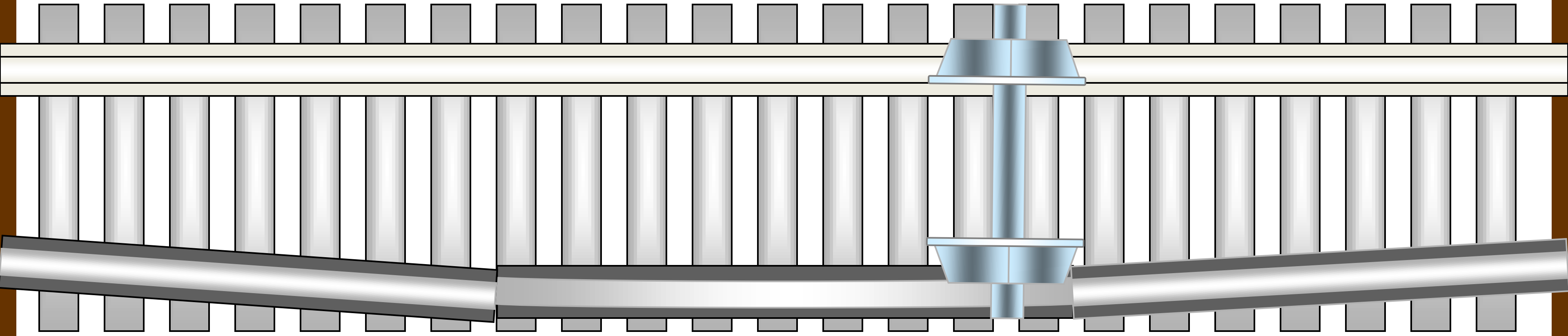


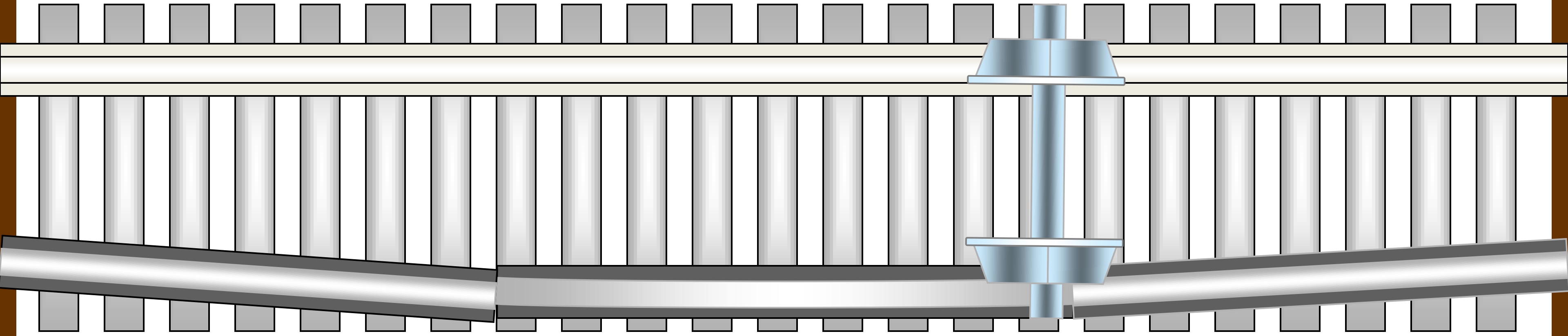


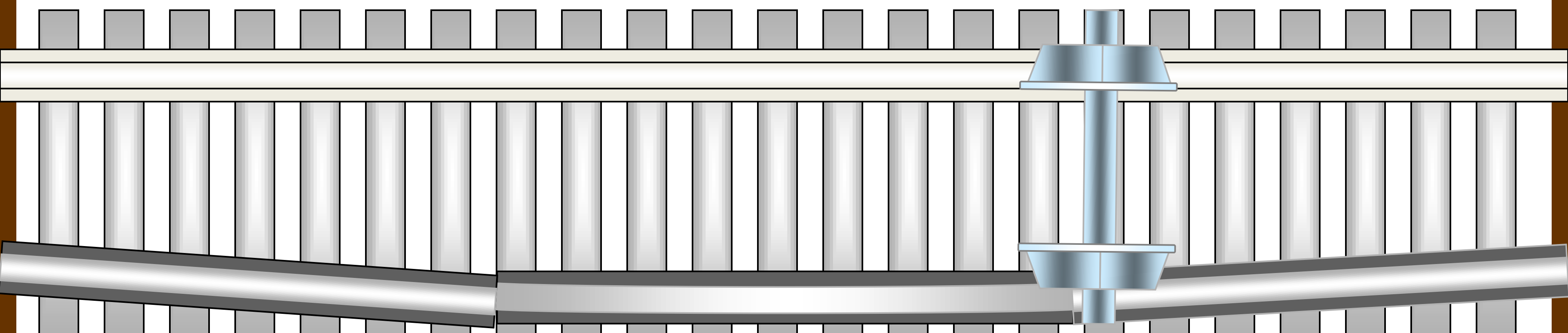


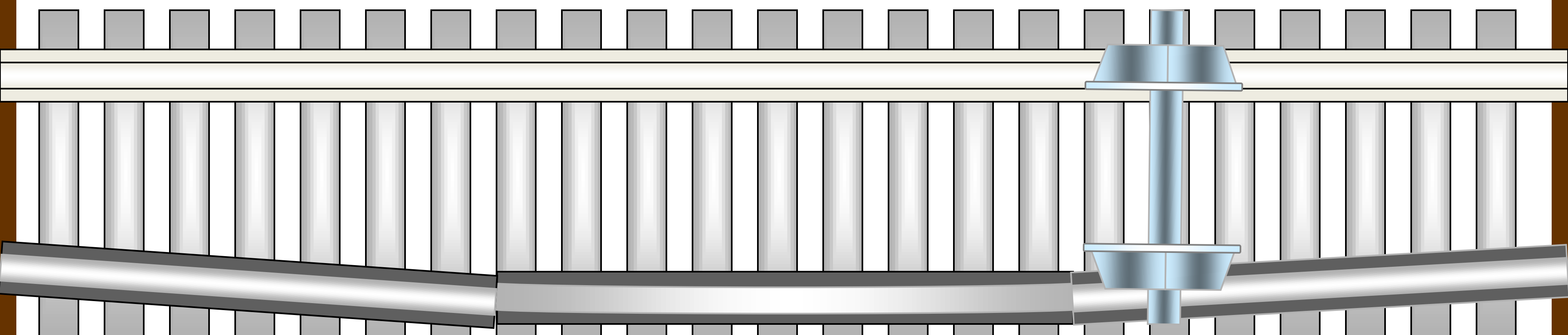


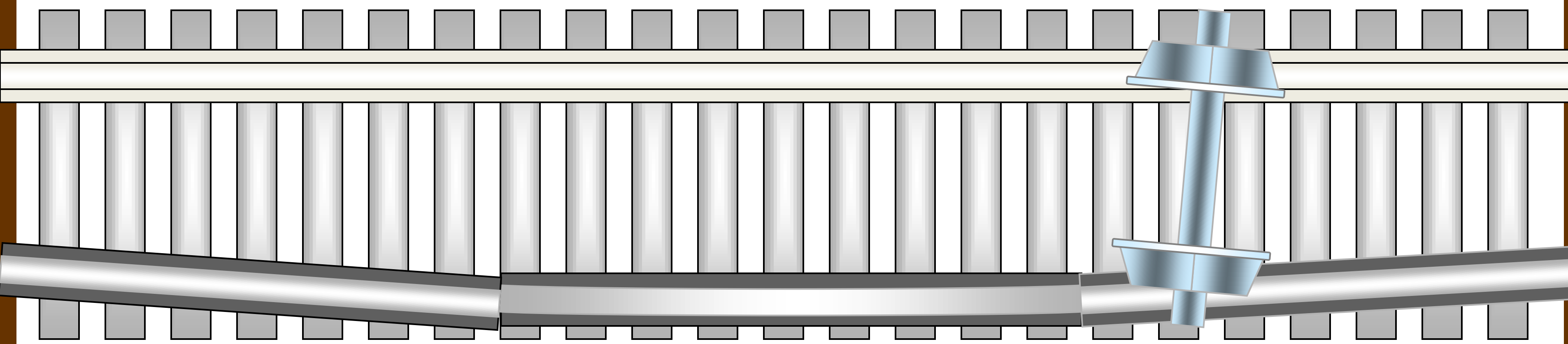


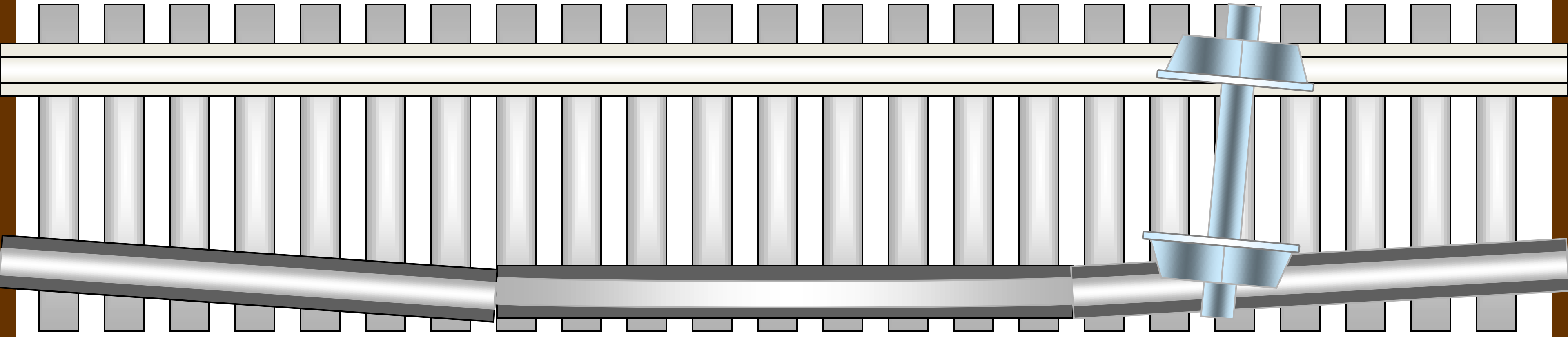


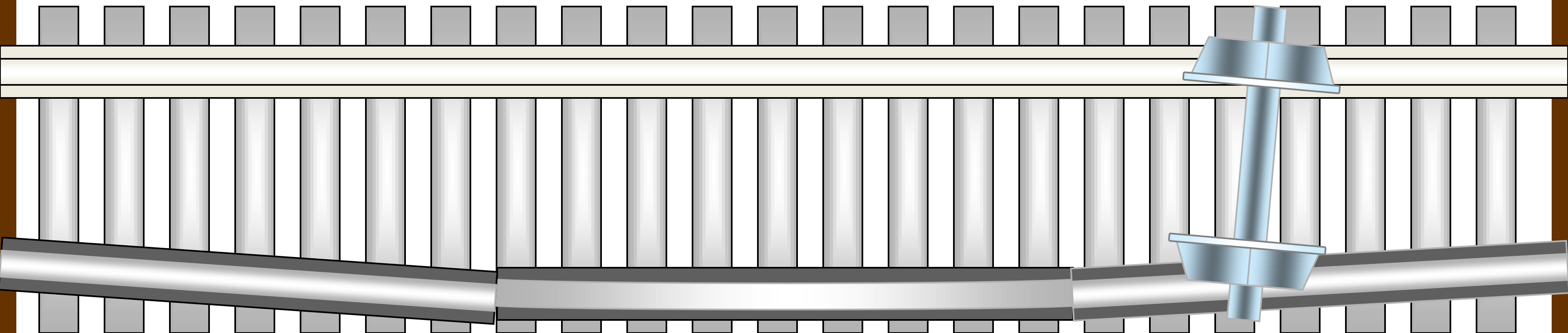


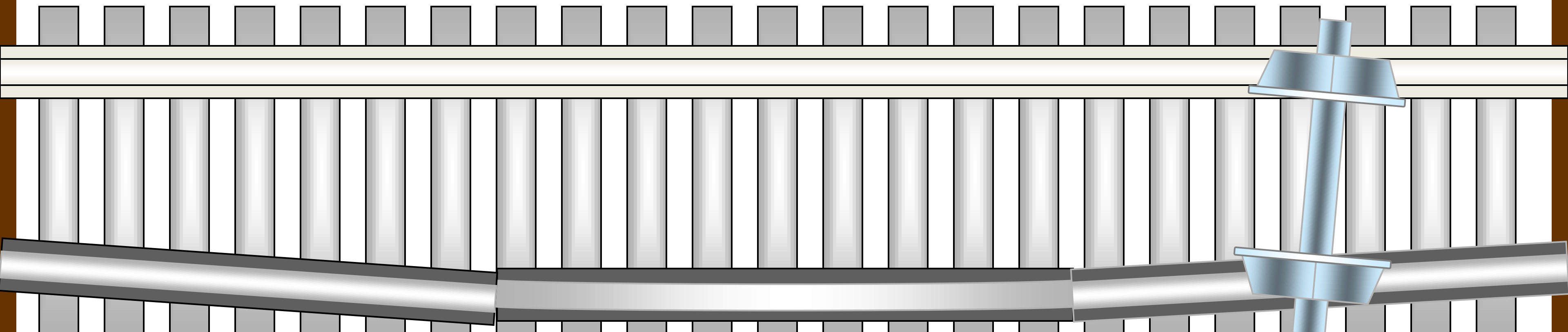


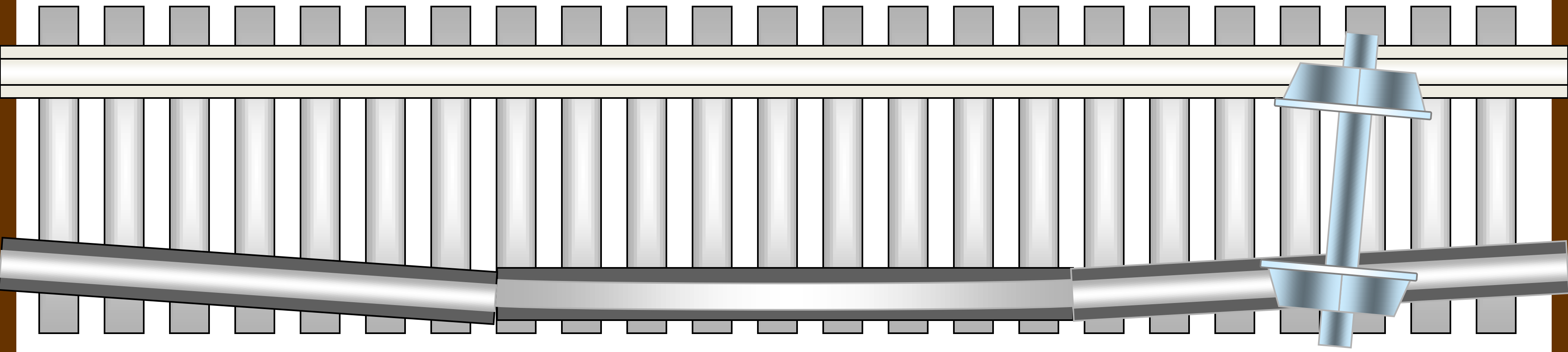


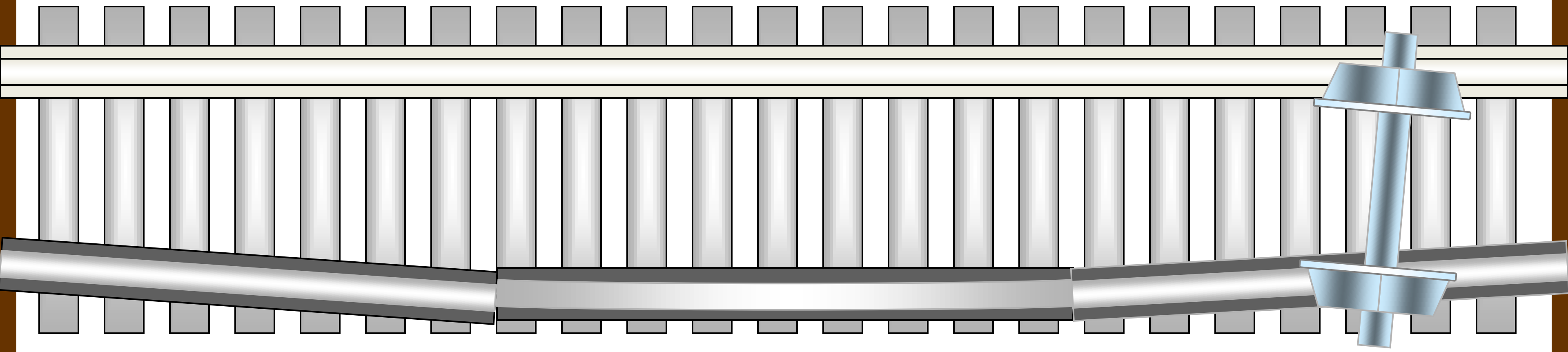


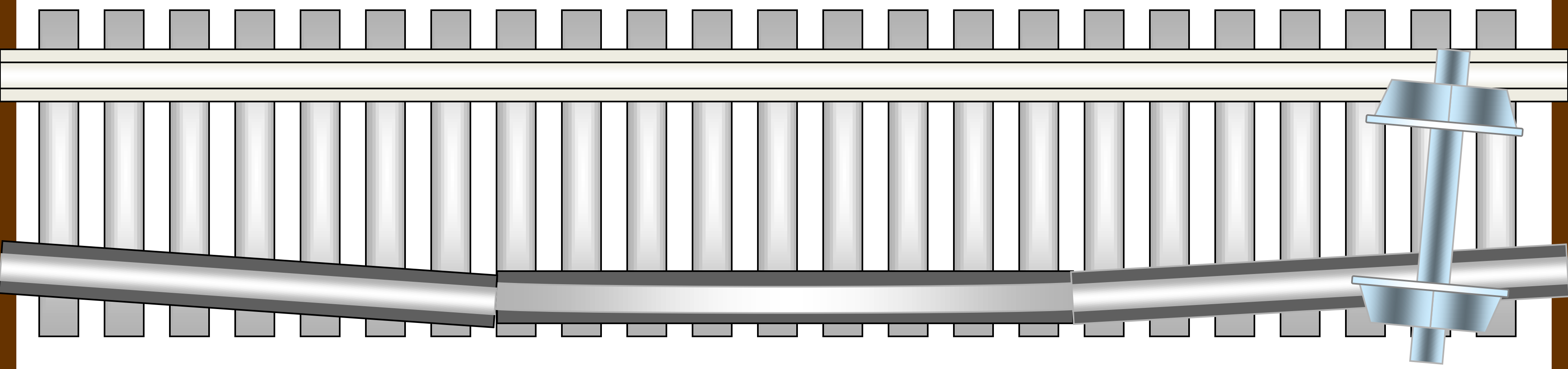


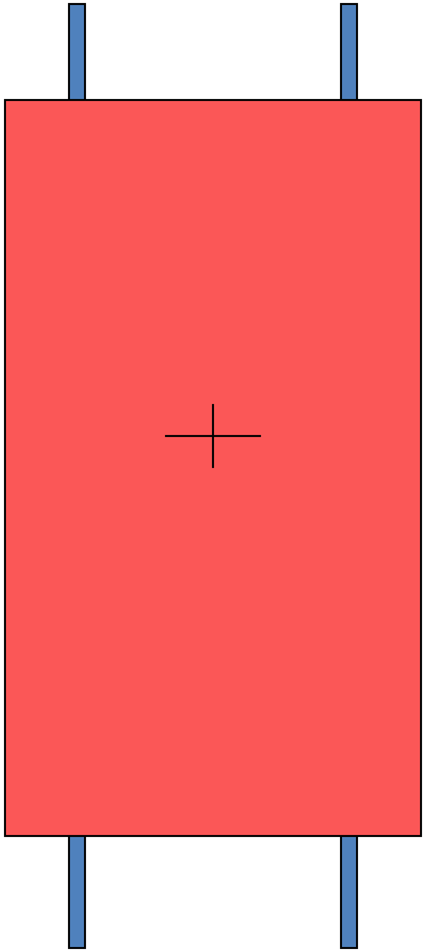






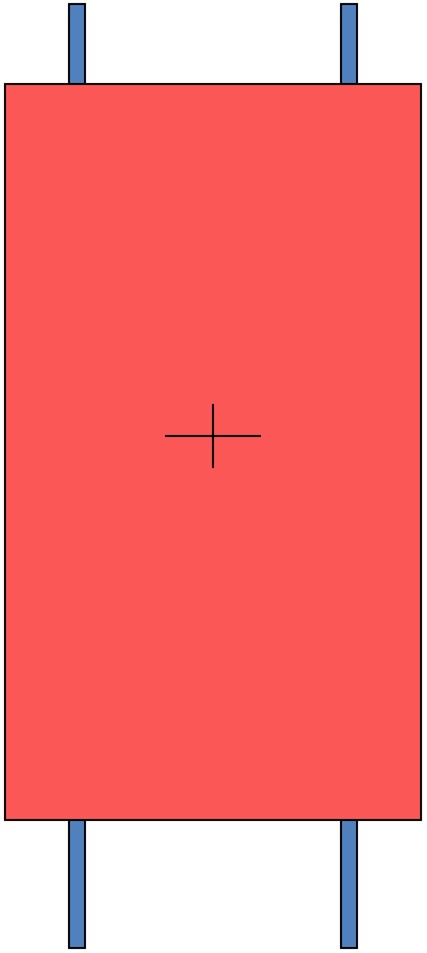






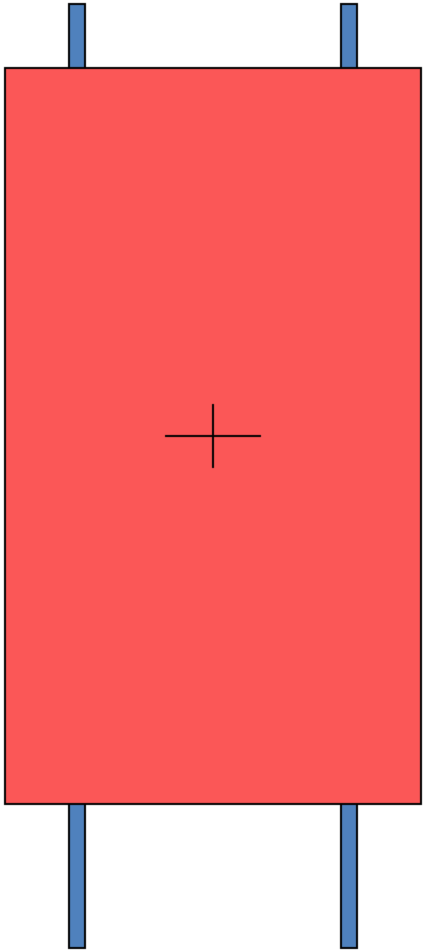
SHUTTLING ABOUT THE LONGITUDINAL AXIS

Compressive forces along the length of the train



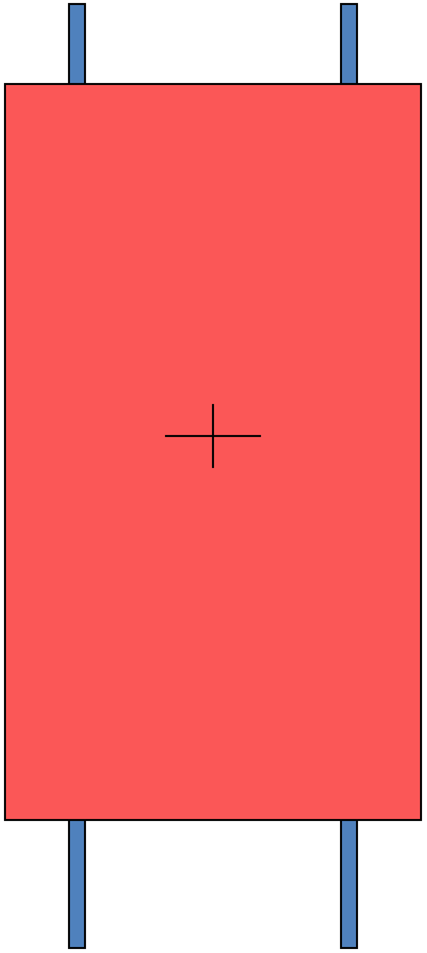
SHUTTLING ABOUT THE LONGITUDINAL AXIS

Compressive forces along the length of the train



SHUTTLING ABOUT THE LONGITUDINAL AXIS

Compressive forces along the length of the train



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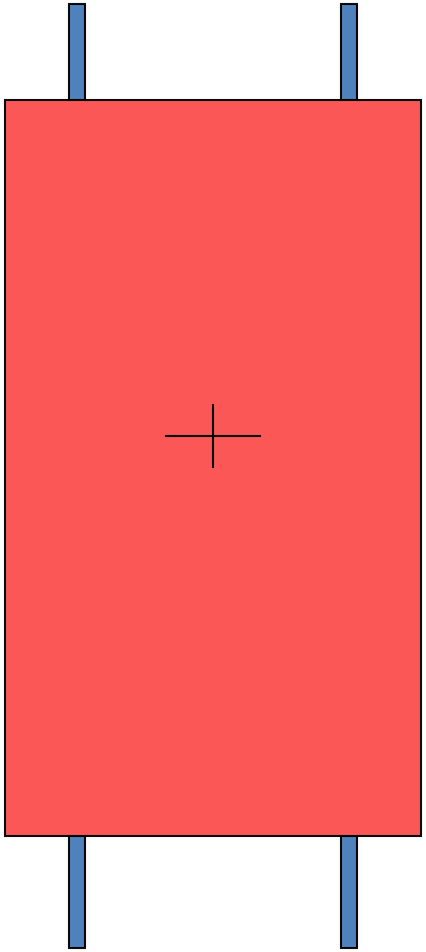

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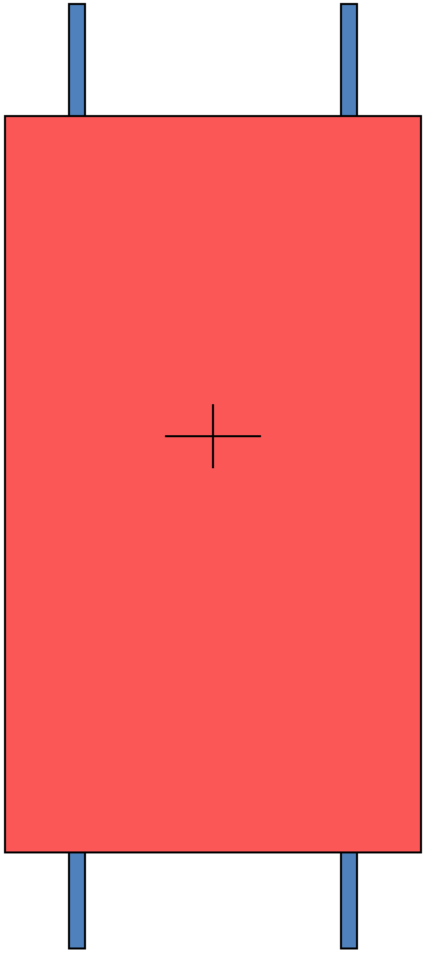
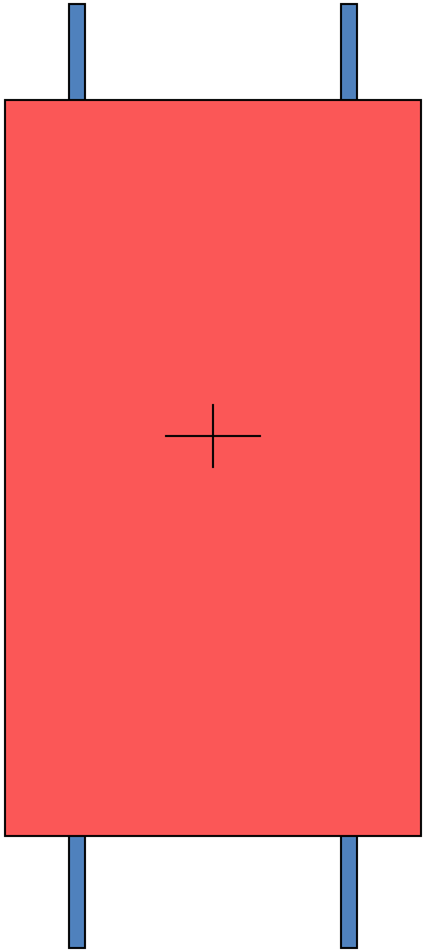
Compressive forces along the length of the train



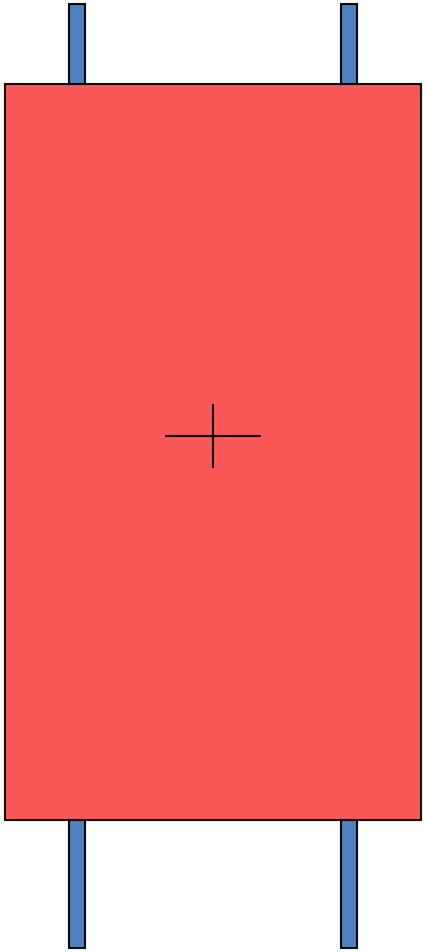
SHUTTLING ABOUT THE LONGITUDINAL AXIS

Compressive forces along the length of the train



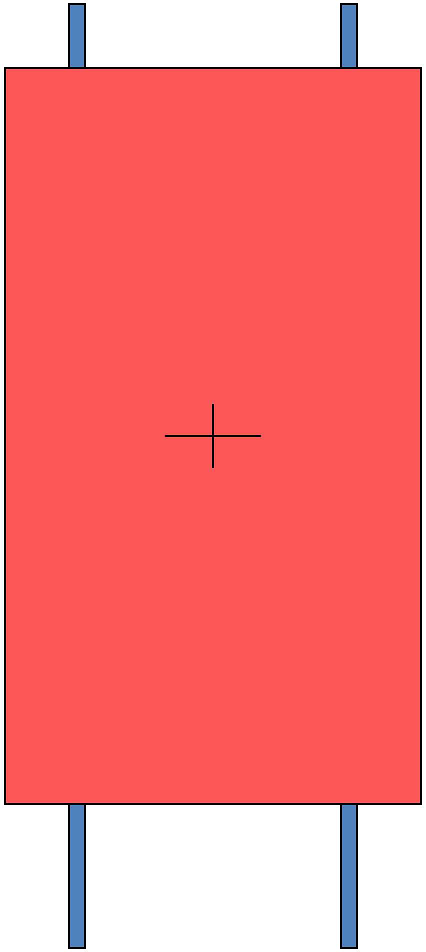
SHUTTLING ABOUT THE LONGITUDINAL AXIS

Compressive forces along the length of the train



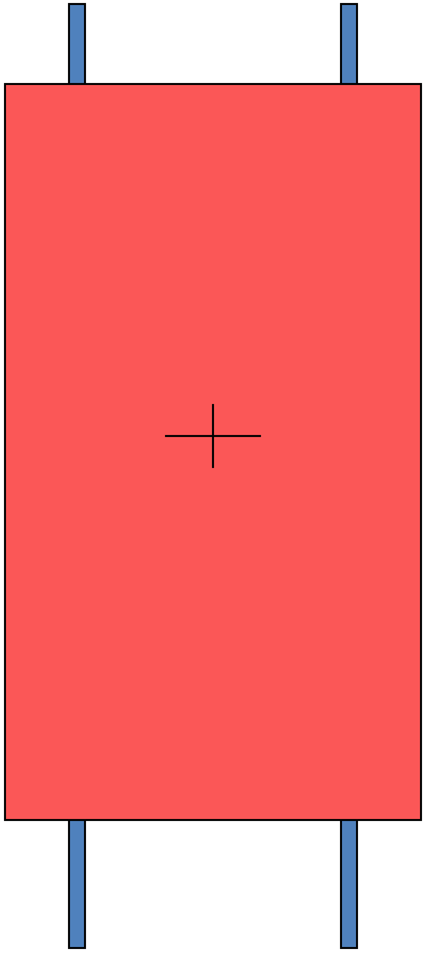
SHUTTLING ABOUT THE LONGITUDINAL AXIS

Compressive forces along the length of the train



SHUTTLING ABOUT THE LONGITUDINAL AXIS

Compressive forces along the length of the train



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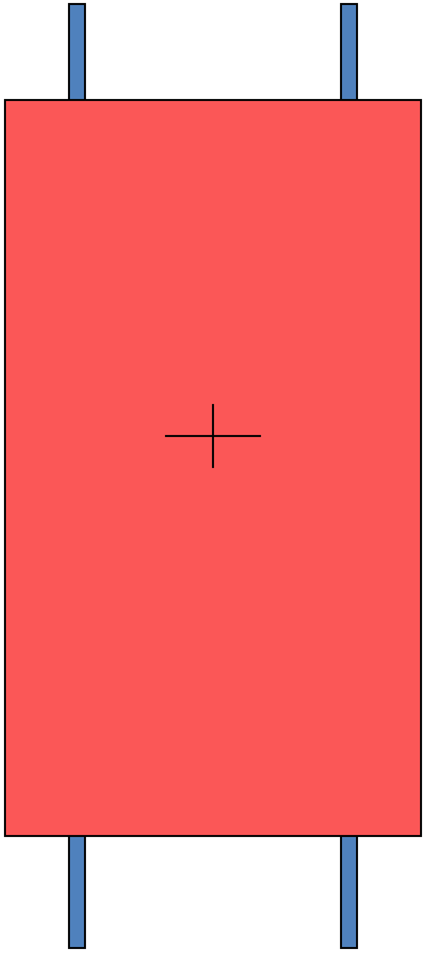
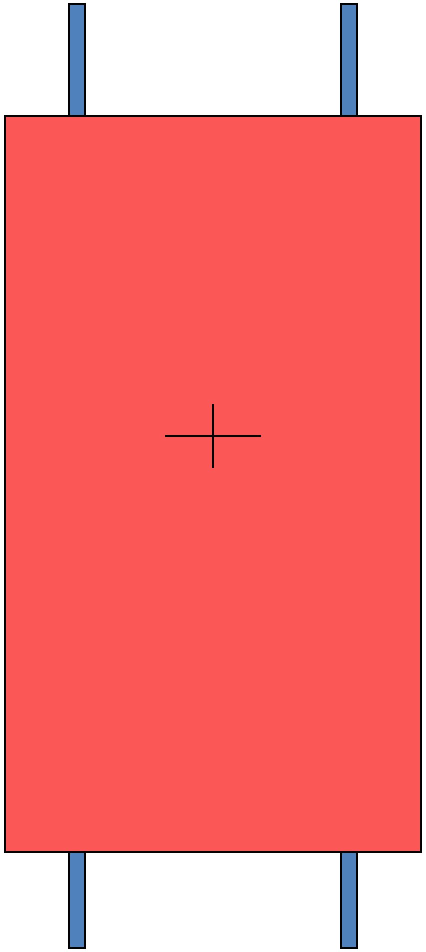
Compressive forces along the length of the train



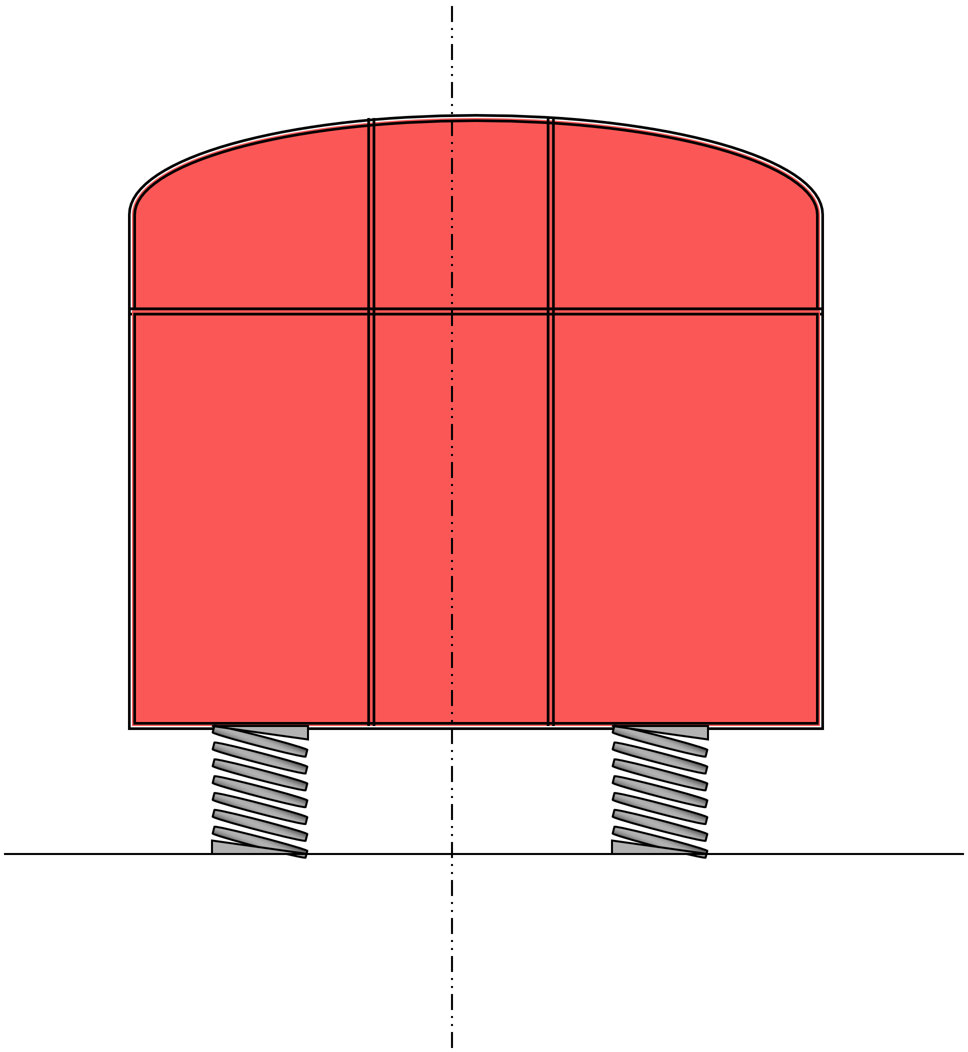
SHUTTLING ABOUT THE LONGITUDINAL AXIS

Compressive forces along the length of the train



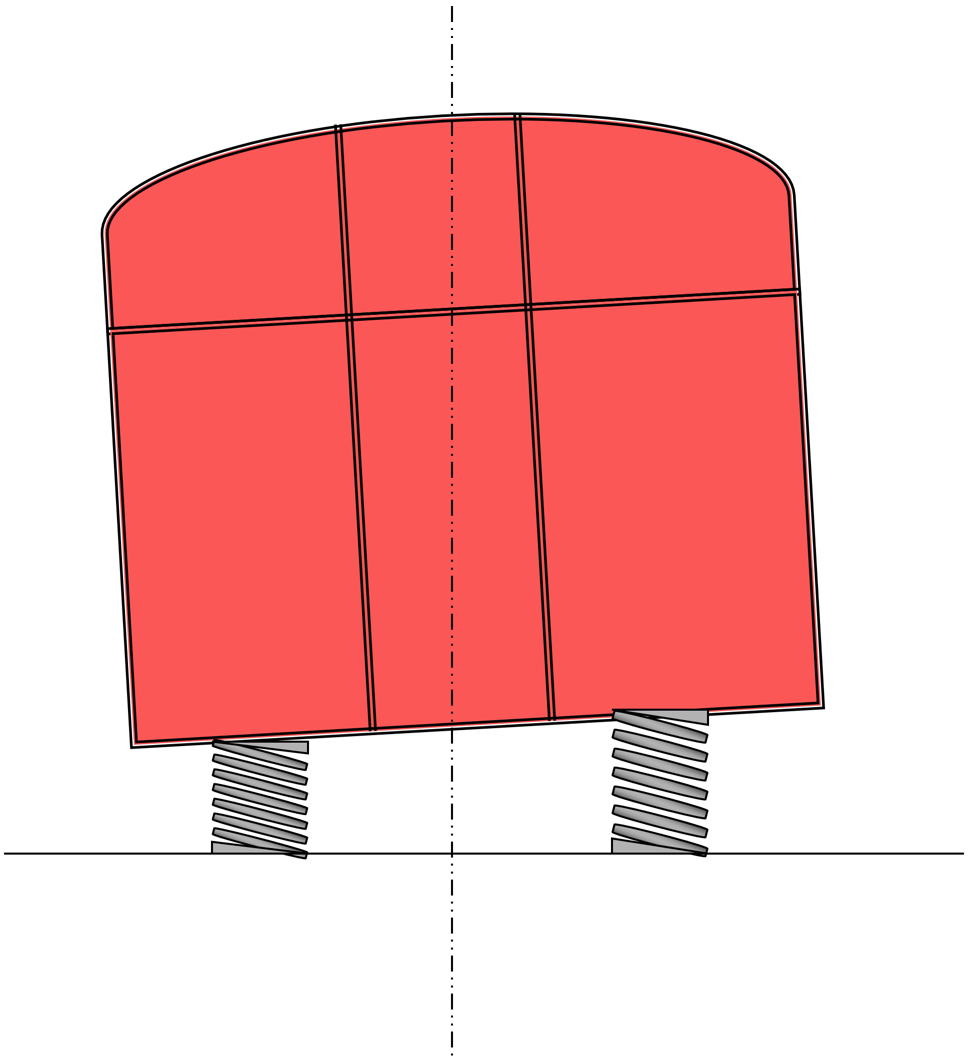
SHUTTLING ABOUT THE LONGITUDINAL AXIS

Compressive forces along the length of the train



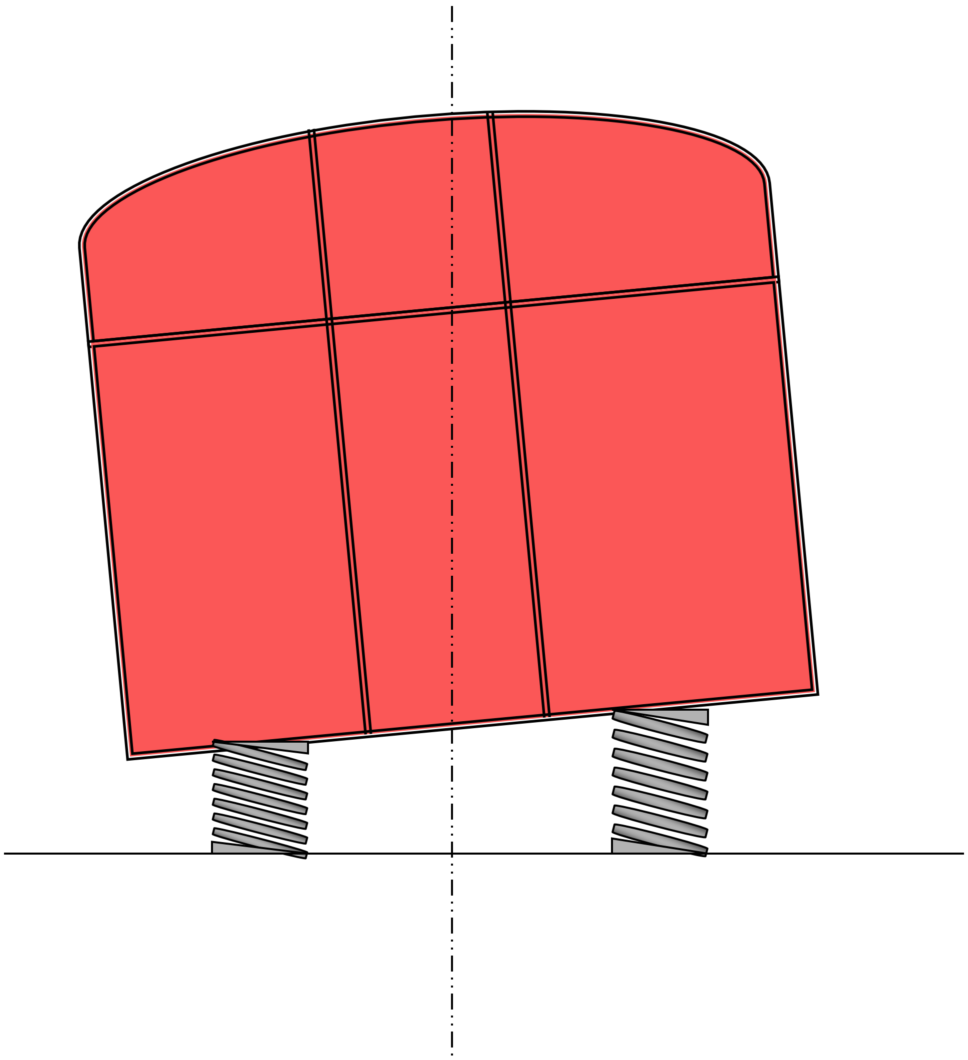
ROLLING ABOUT THE LONGITUDINAL AXIS

Reduction in instantaneous wheel load



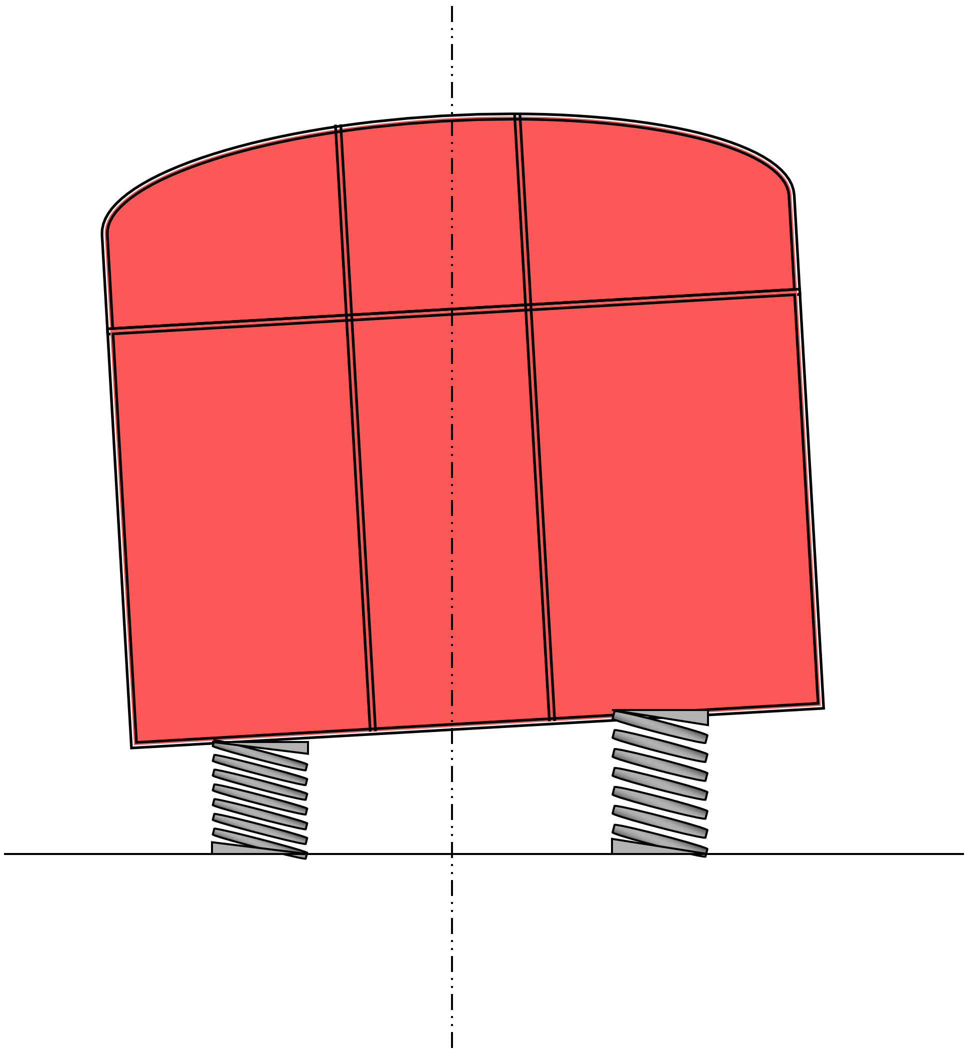
ROLLING ABOUT THE LONGITUDINAL AXIS

Reduction in instantaneous wheel load



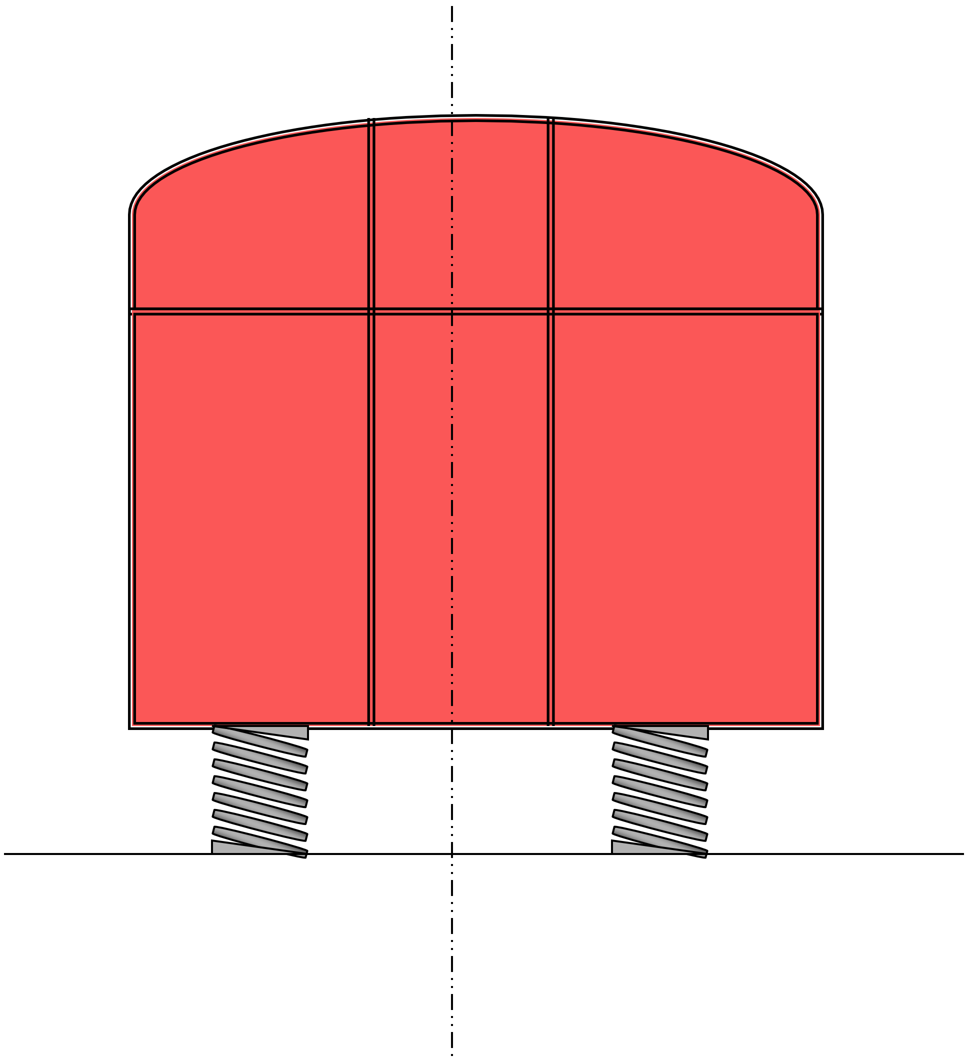
ROLLING ABOUT THE LONGITUDINAL AXIS

Reduction in instantaneous wheel load



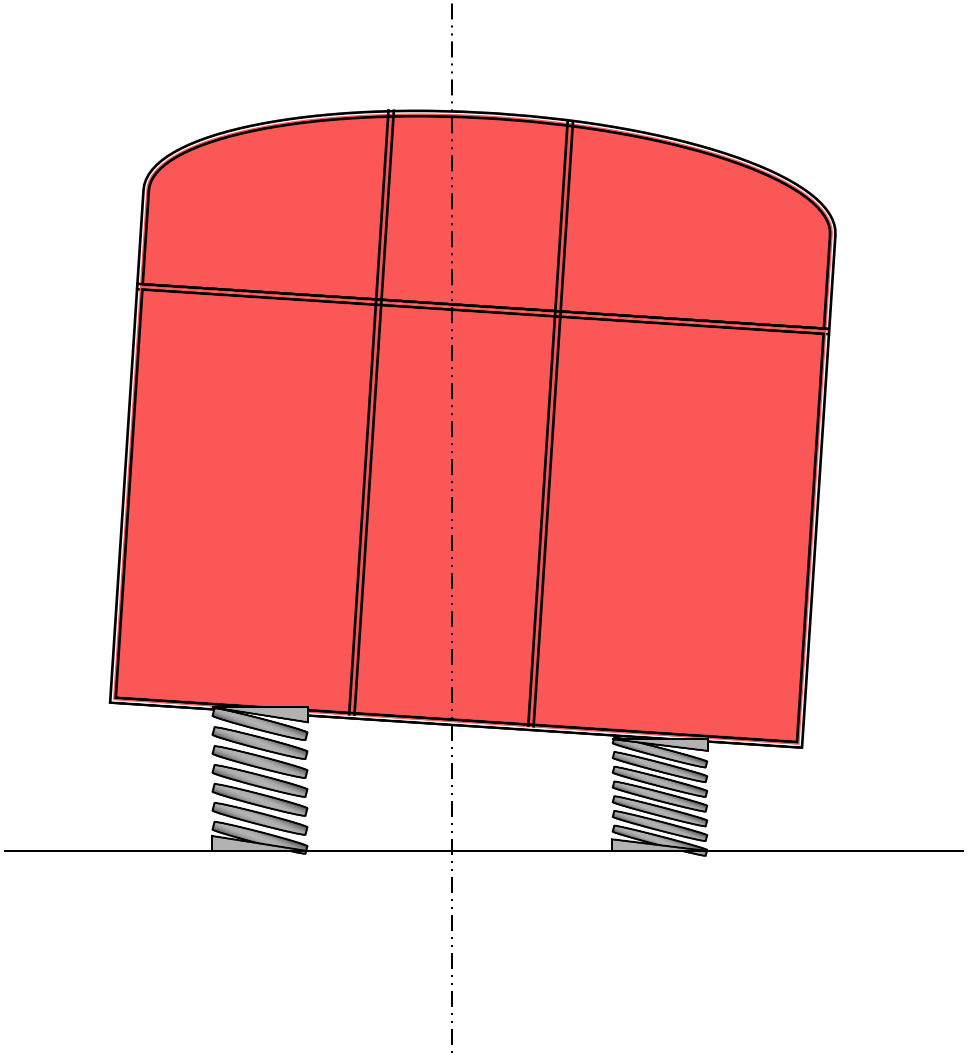
ROLLING ABOUT THE LONGITUDINAL AXIS

Reduction in instantaneous wheel load



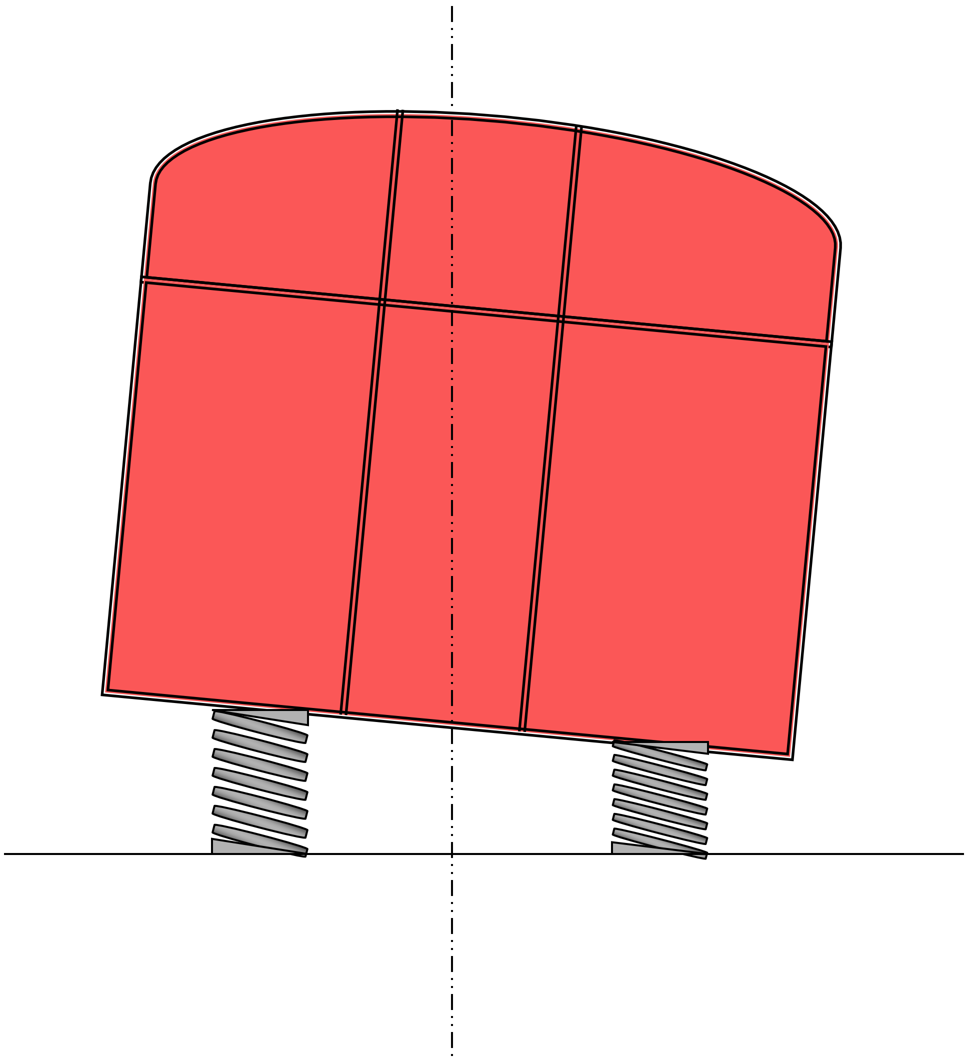
ROLLING ABOUT THE LONGITUDINAL AXIS

Reduction in instantaneous wheel load



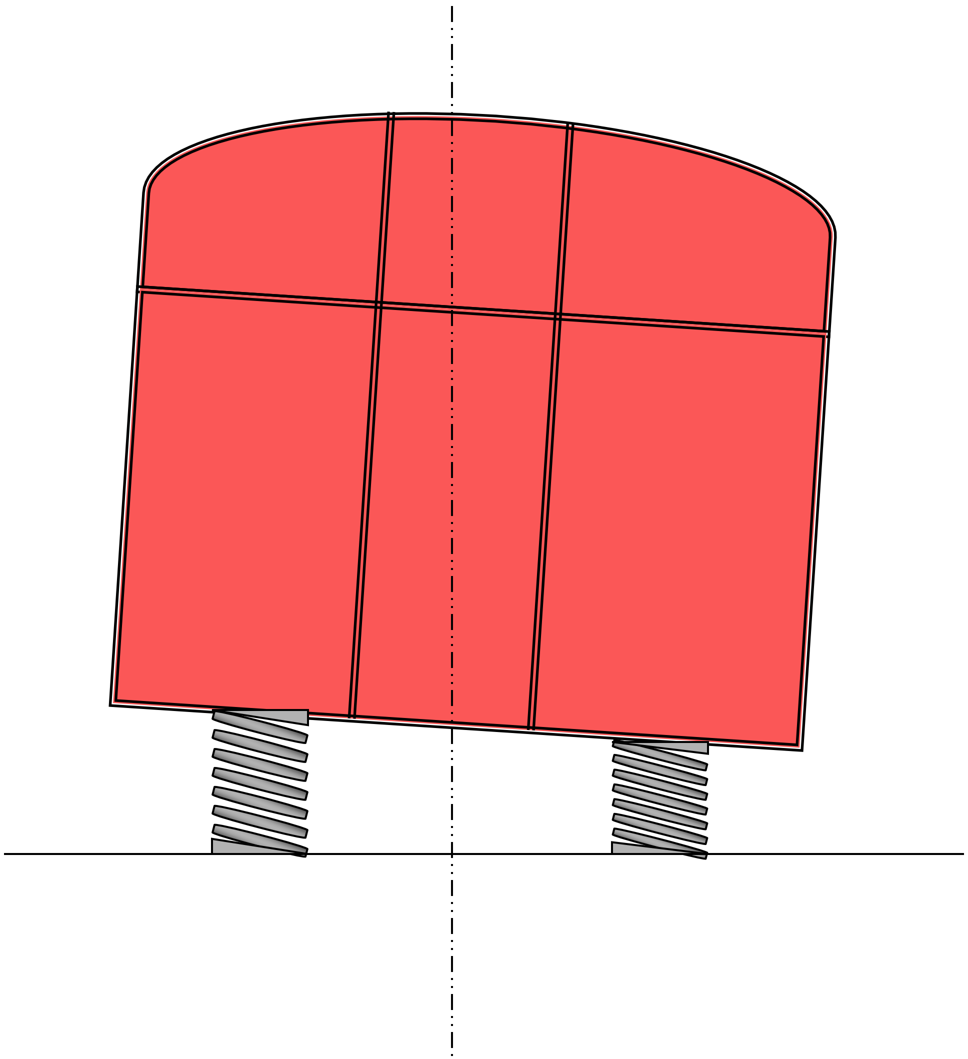
ROLLING ABOUT THE LONGITUDINAL AXIS

Reduction in instantaneous wheel load



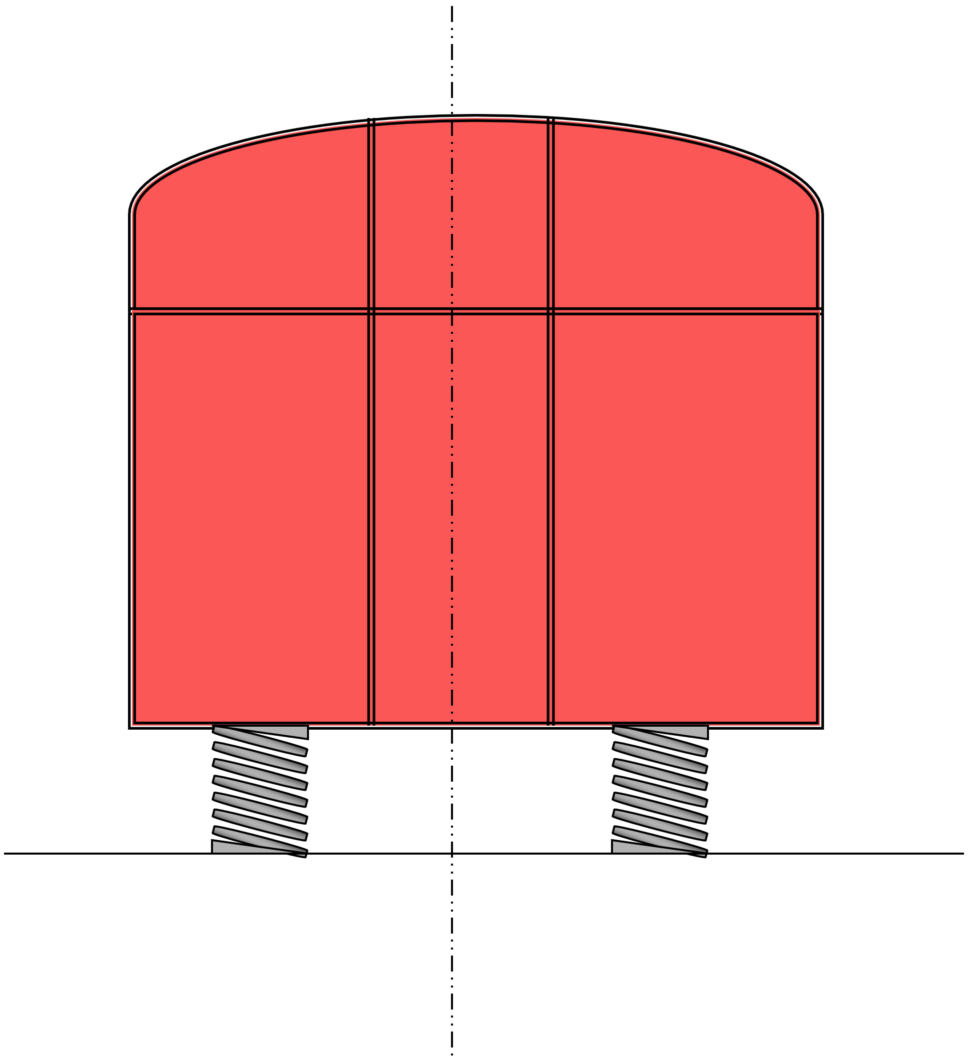
ROLLING ABOUT THE LONGITUDINAL AXIS

Reduction in instantaneous wheel load



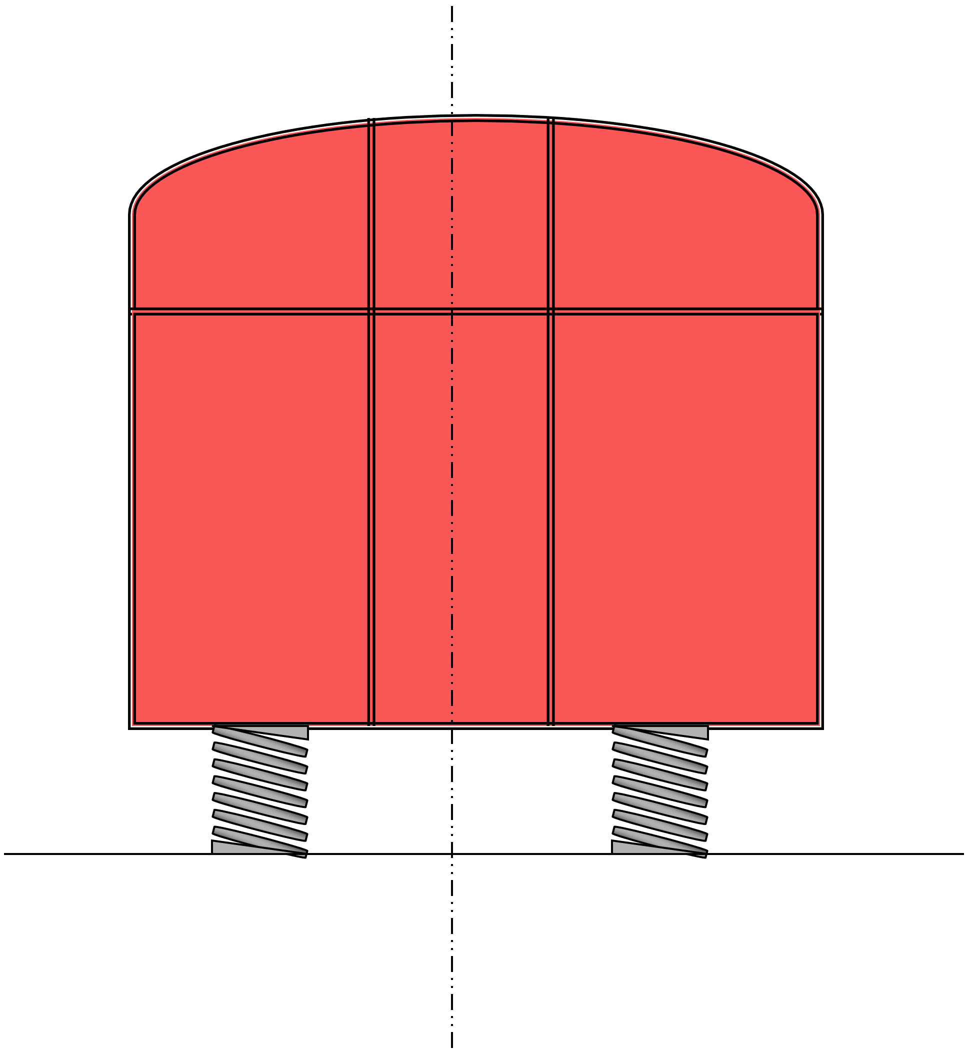
ROLLING ABOUT THE LONGITUDINAL AXIS

Reduction in instantaneous wheel load



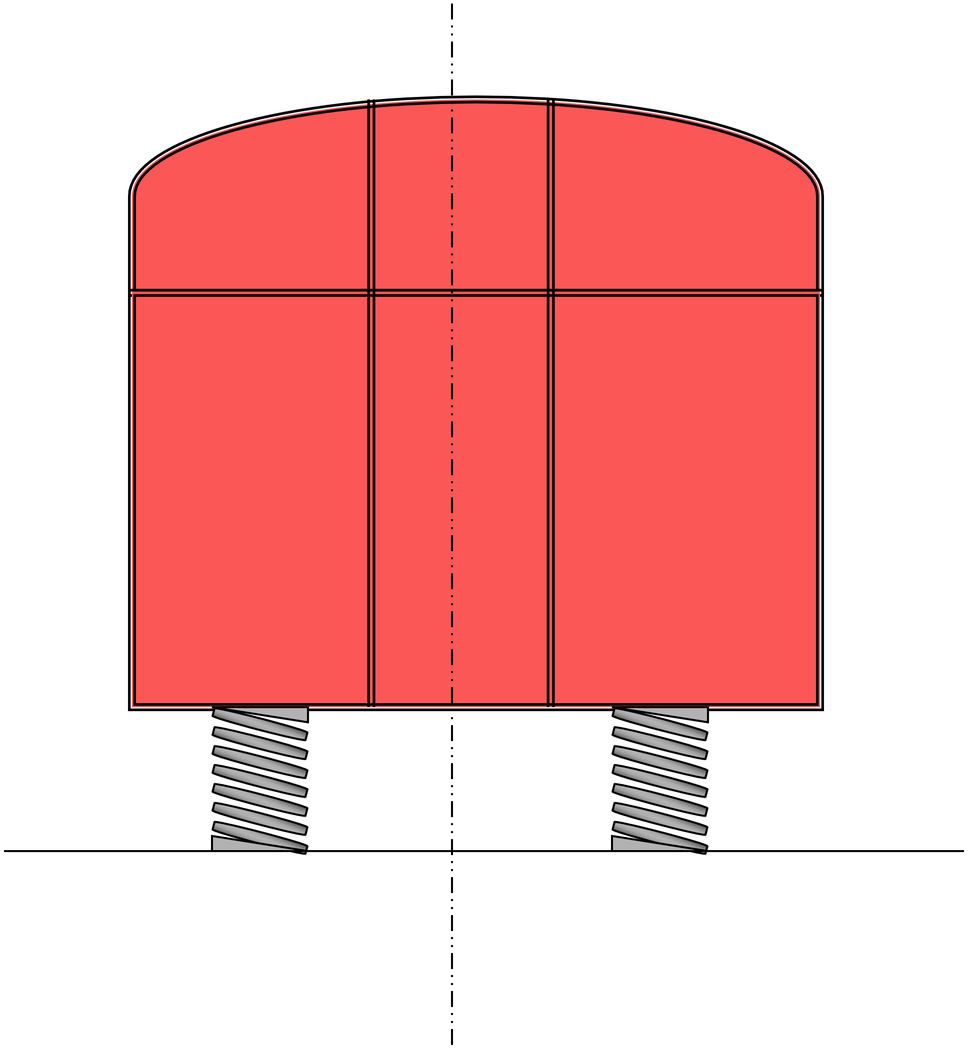
ROLLING ABOUT THE LONGITUDINAL AXIS

Reduction in instantaneous wheel load



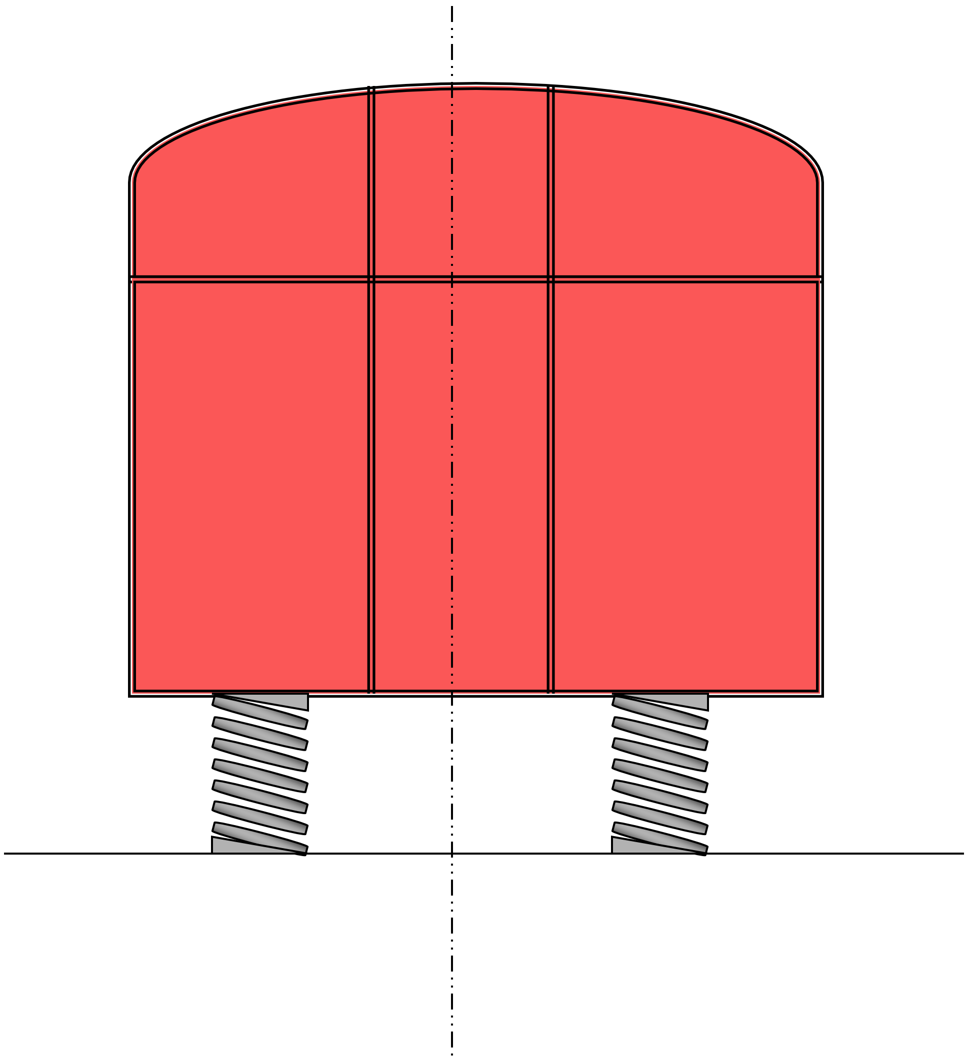
BOUNCING ABOUT THE VERTICAL AXIS

Reduction in instantaneous wheel load



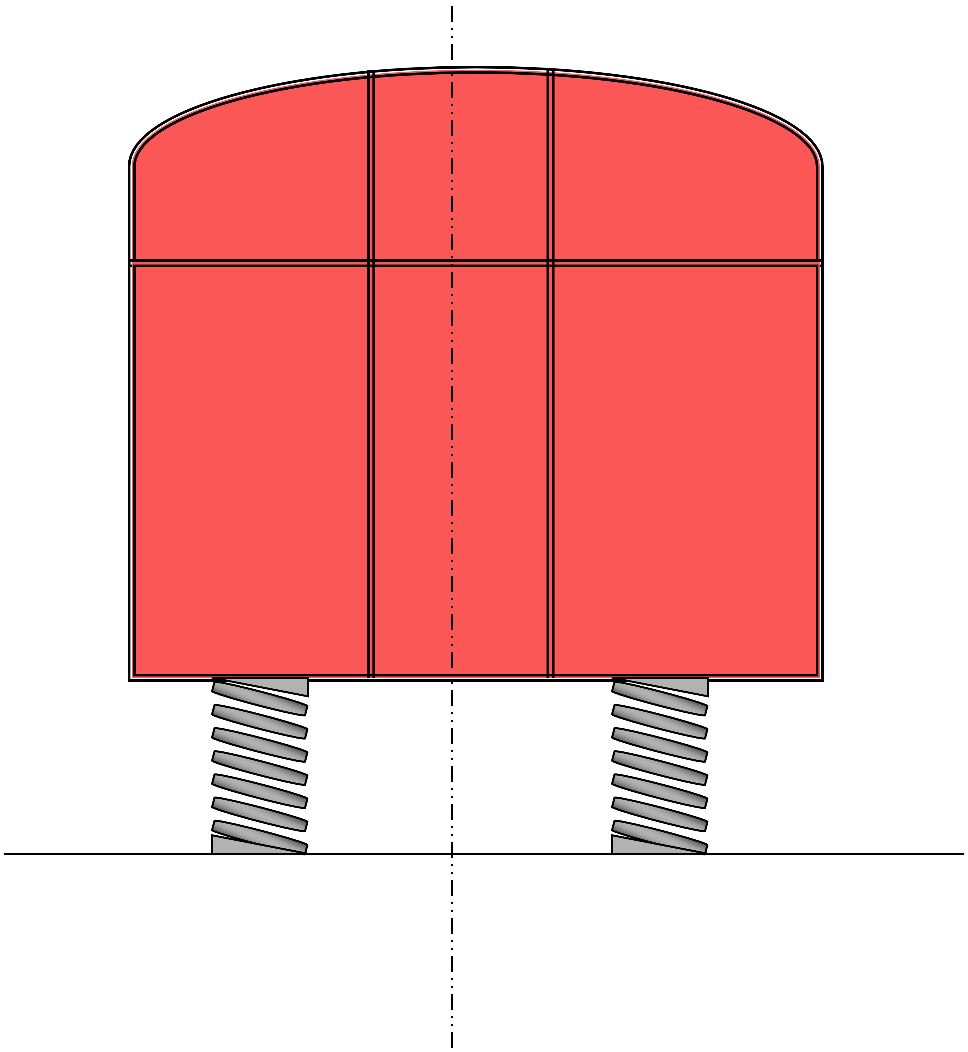
BOUNCING ABOUT THE VERTICAL AXIS

Reduction in instantaneous wheel load



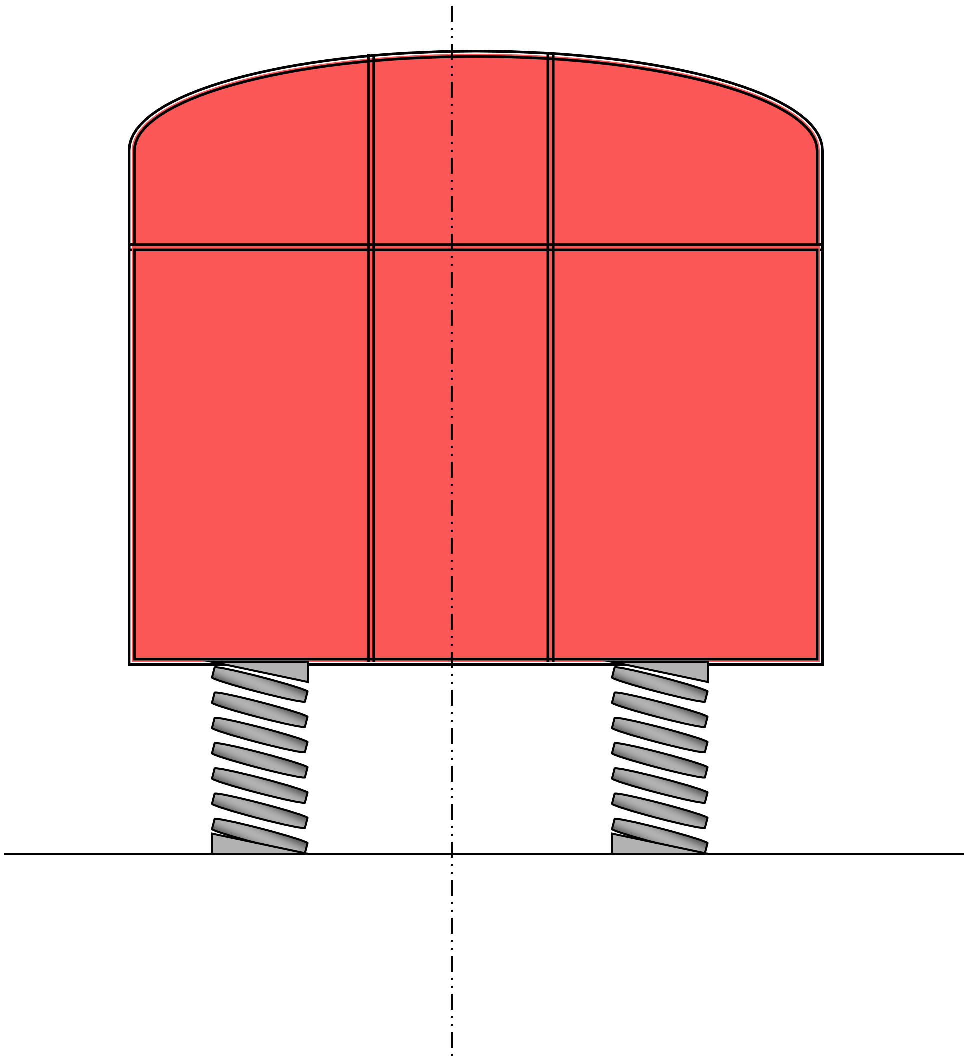
BOUNCING ABOUT THE VERTICAL AXIS

Reduction in instantaneous wheel load



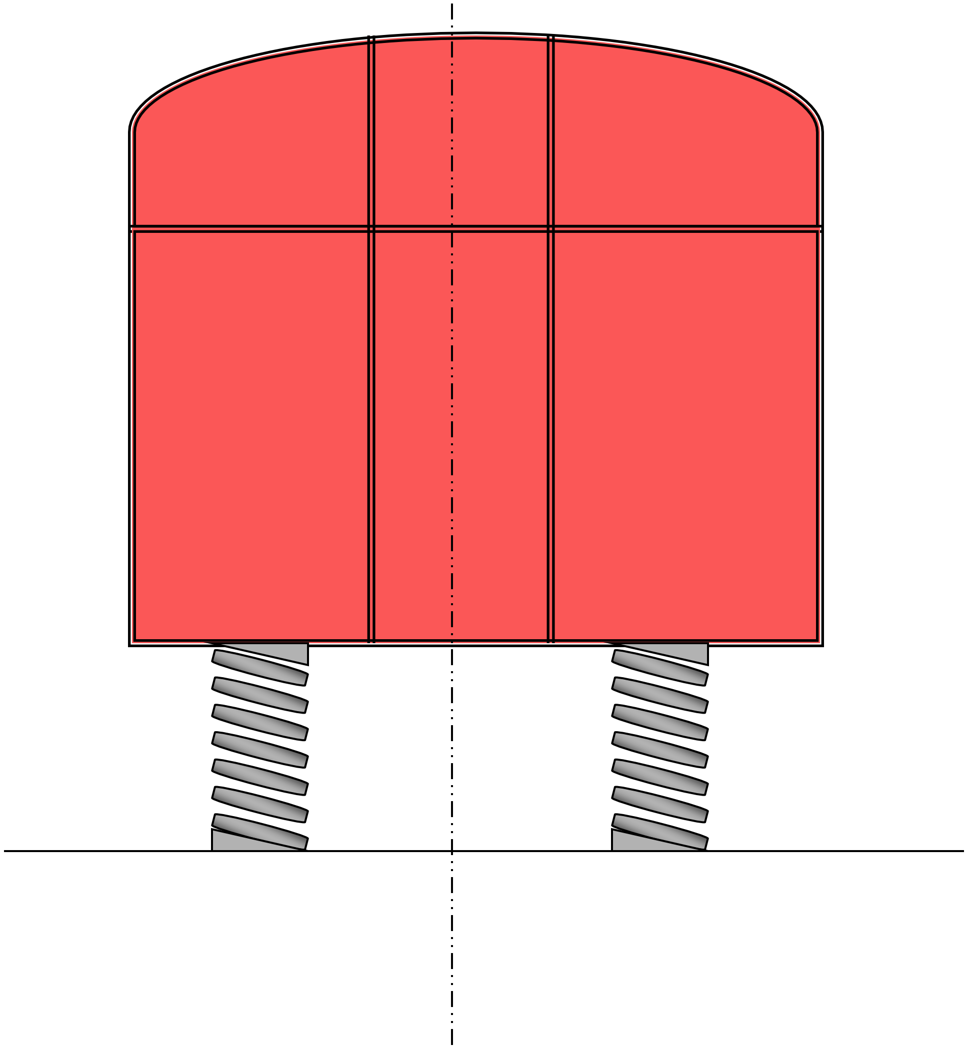
BOUNCING ABOUT THE VERTICAL AXIS

Reduction in instantaneous wheel load



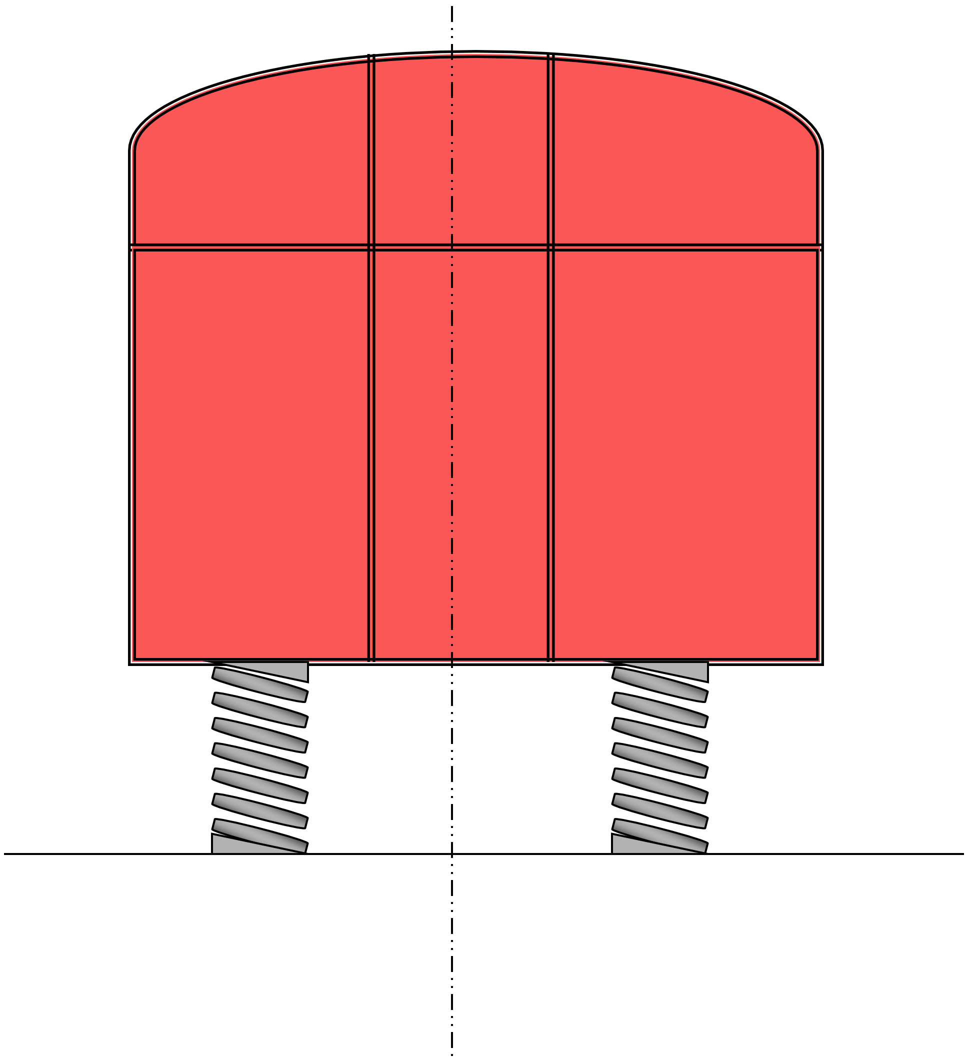
BOUNCING ABOUT THE VERTICAL AXIS

Reduction in instantaneous wheel load



BOUNCING ABOUT THE VERTICAL AXIS

Reduction in instantaneous wheel load



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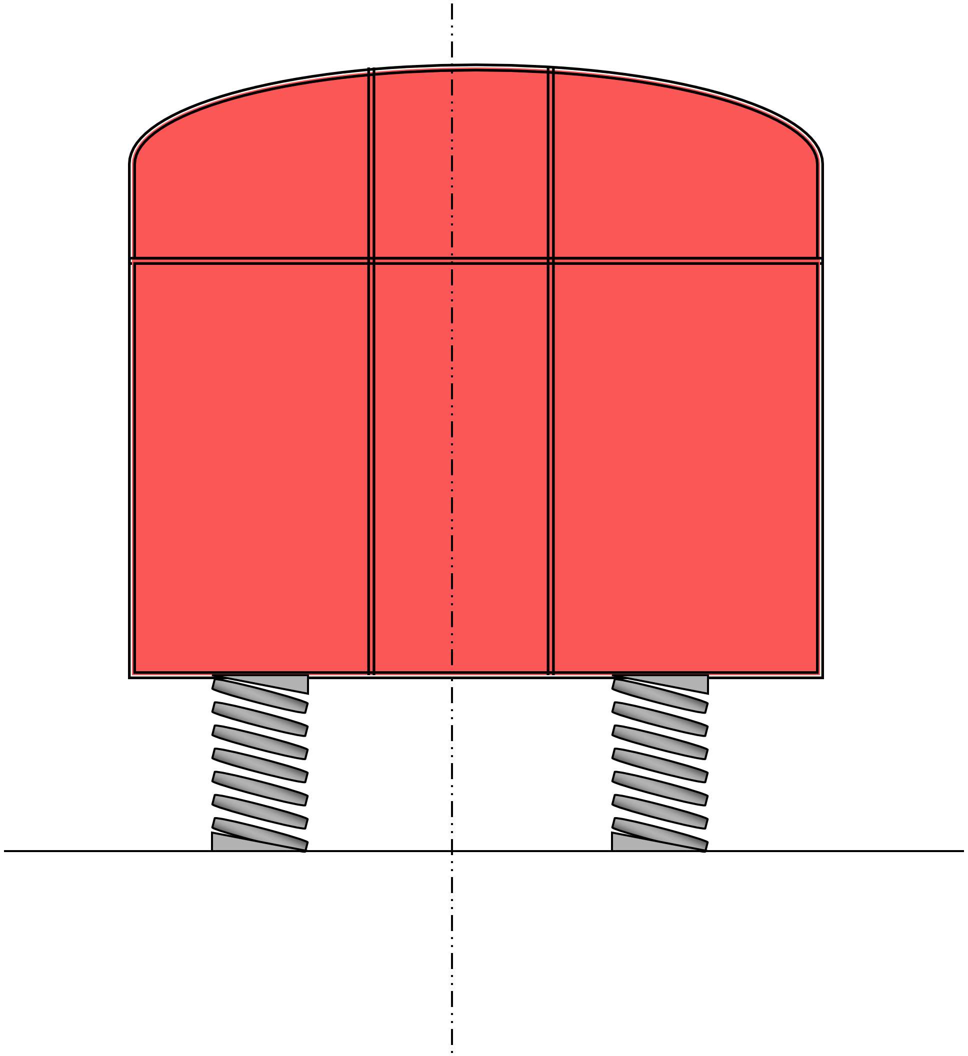
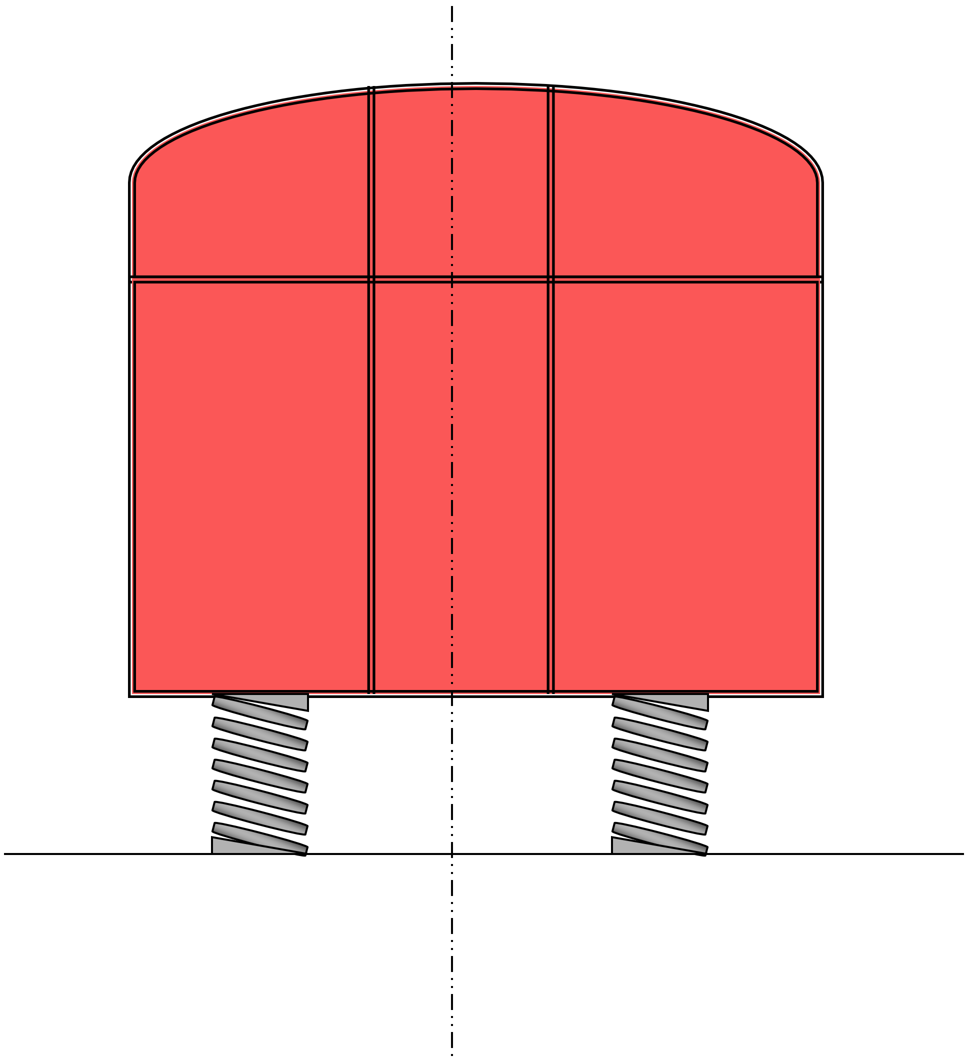
Reduction in instantaneous wheel load



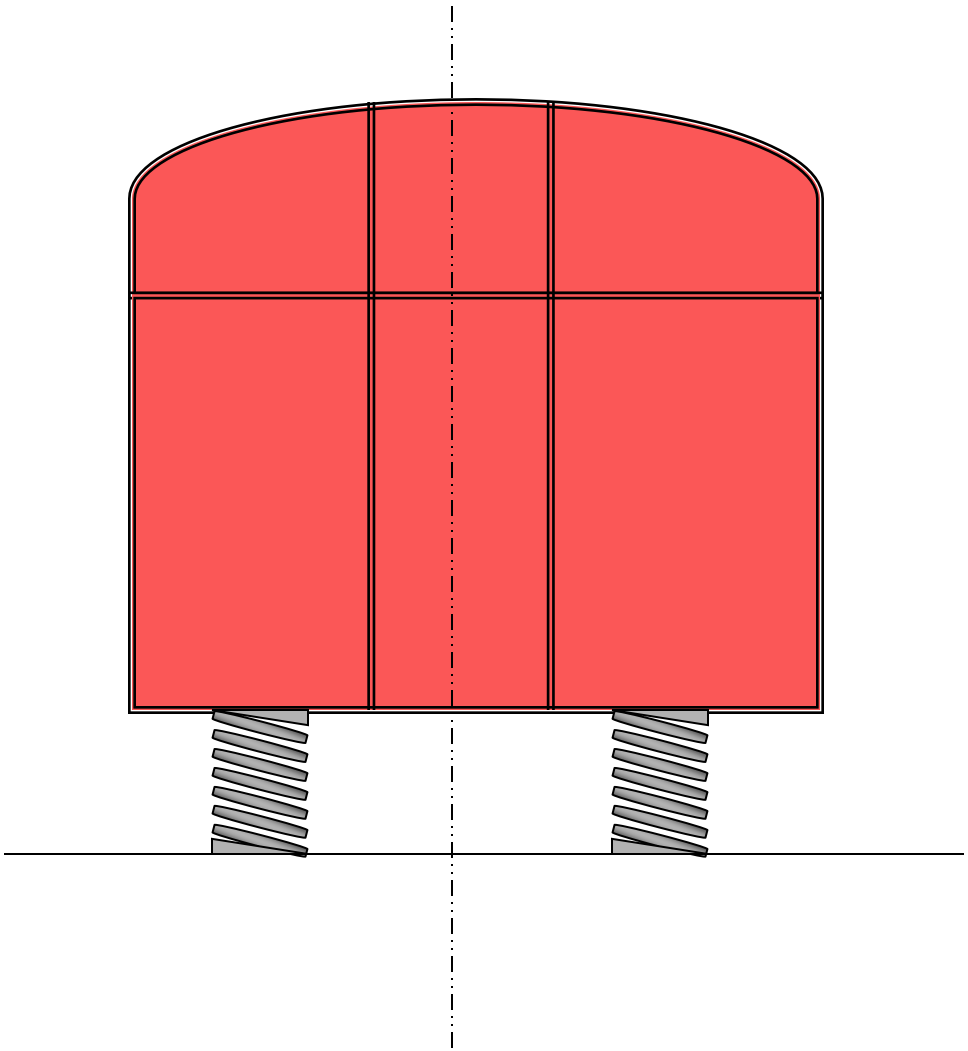
BOUNCING ABOUT THE VERTICAL AXIS

Reduction in instantaneous wheel load



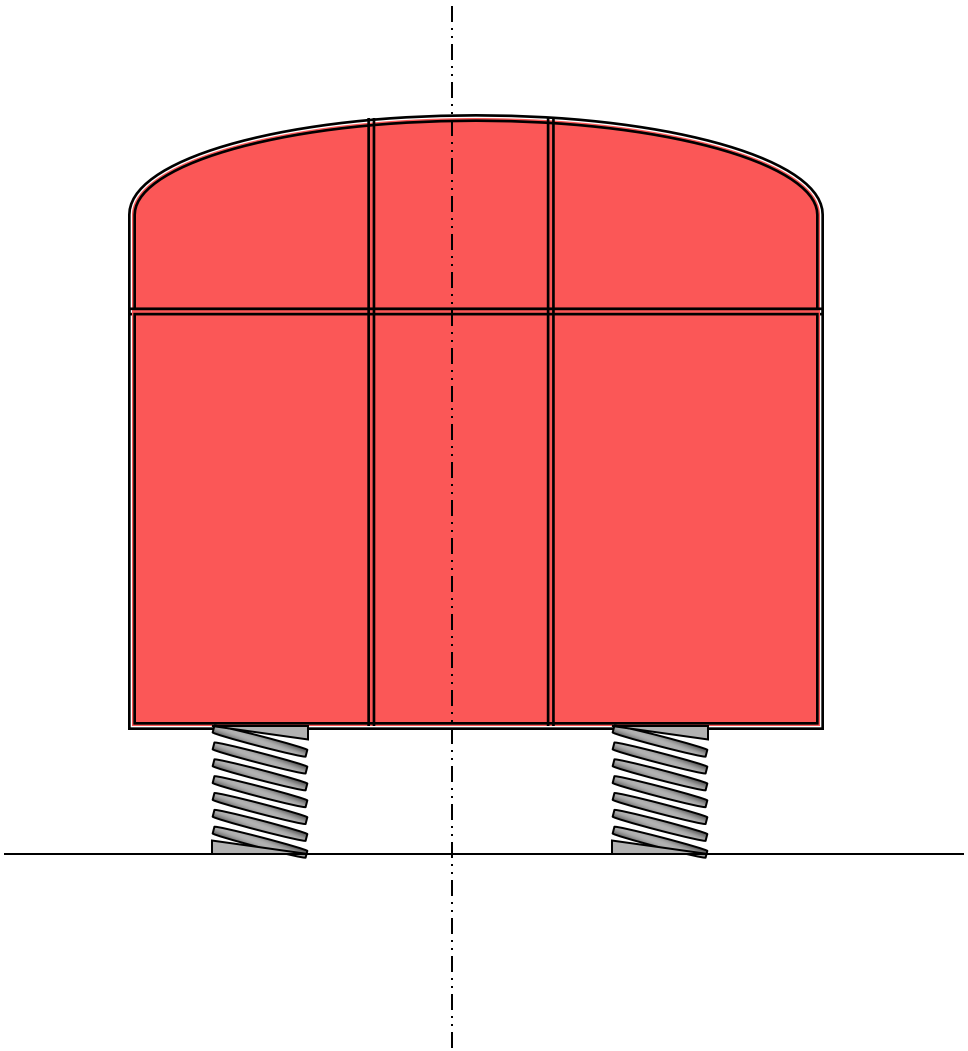
BOUNCING ABOUT THE VERTICAL AXIS

Reduction in instantaneous wheel load



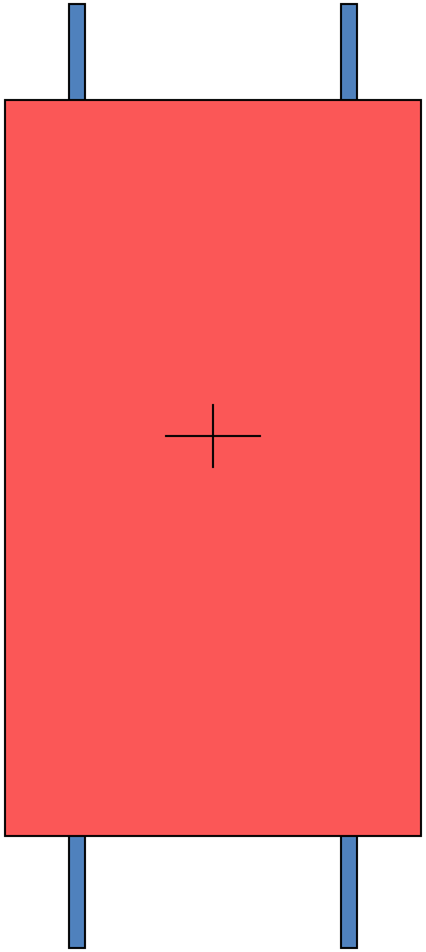
BOUNCING ABOUT THE VERTICAL AXIS

Reduction in instantaneous wheel load



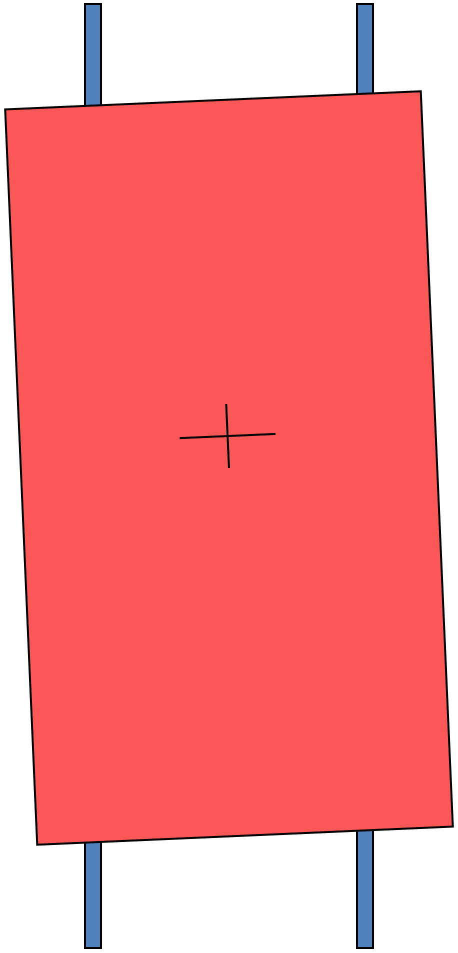
BOUNCING ABOUT THE VERTICAL AXIS

Reduction in instantaneous wheel load



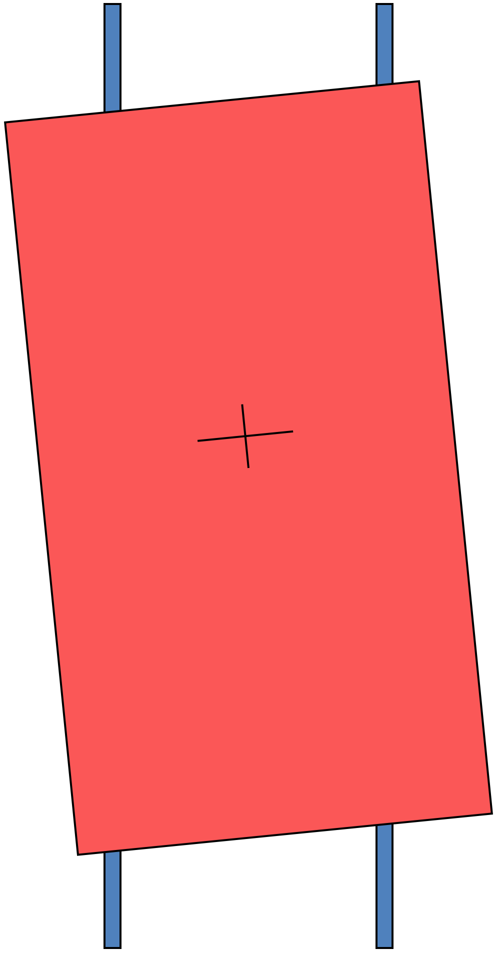
NOSING ABOUT THE VERTICAL AXIS

Increase in flange force



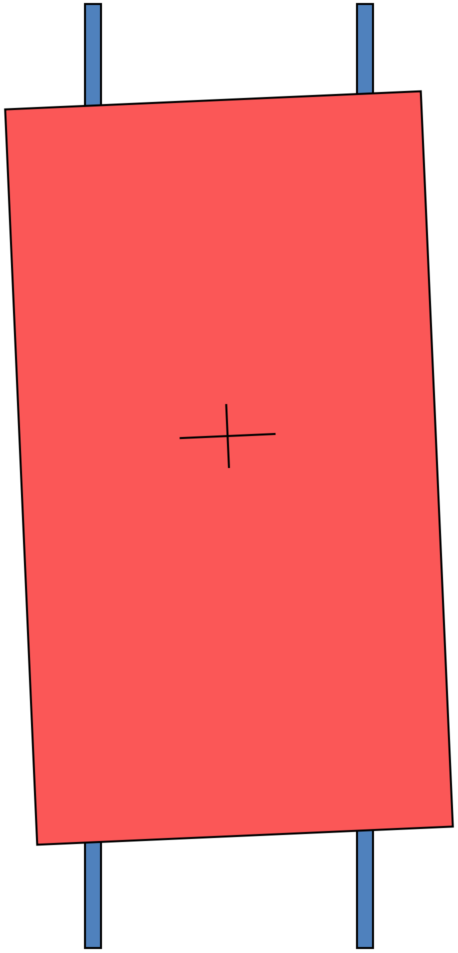
NOSING ABOUT THE VERTICAL AXIS

Increase in flange force



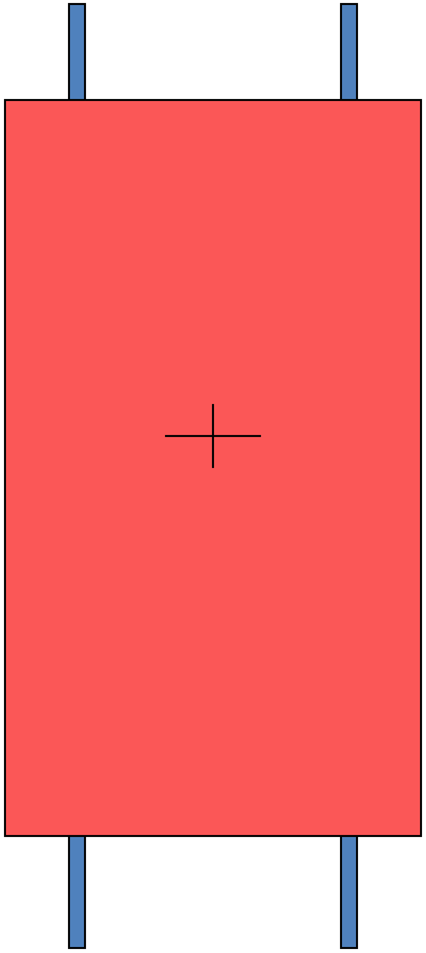
NOSING ABOUT THE VERTICAL AXIS

Increase in flange force



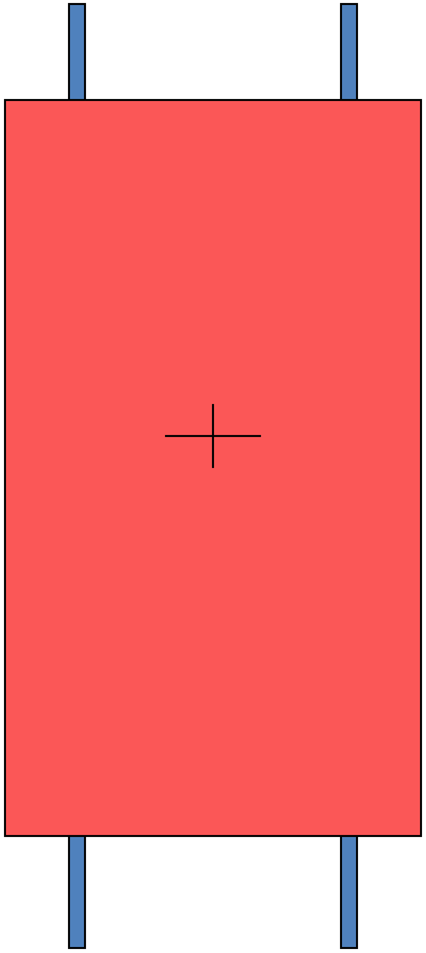
NOSING ABOUT THE VERTICAL AXIS

Increase in flange force



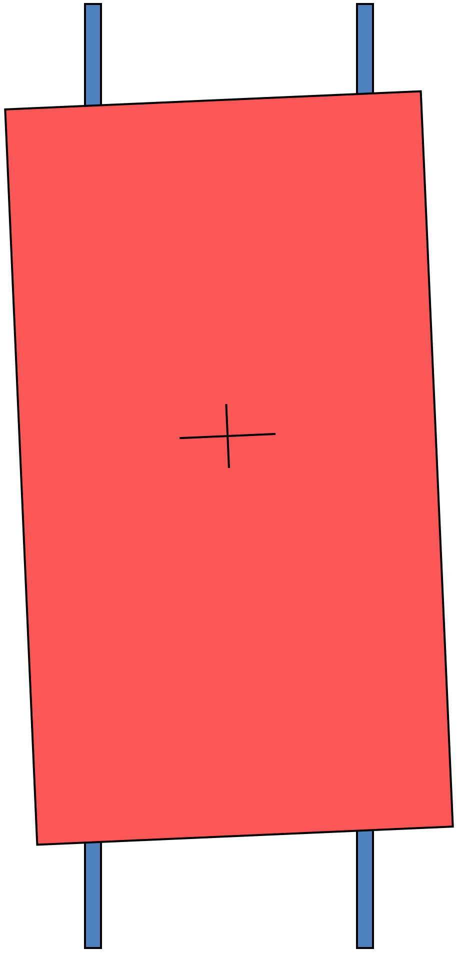
NOSING ABOUT THE VERTICAL AXIS

Increase in flange force



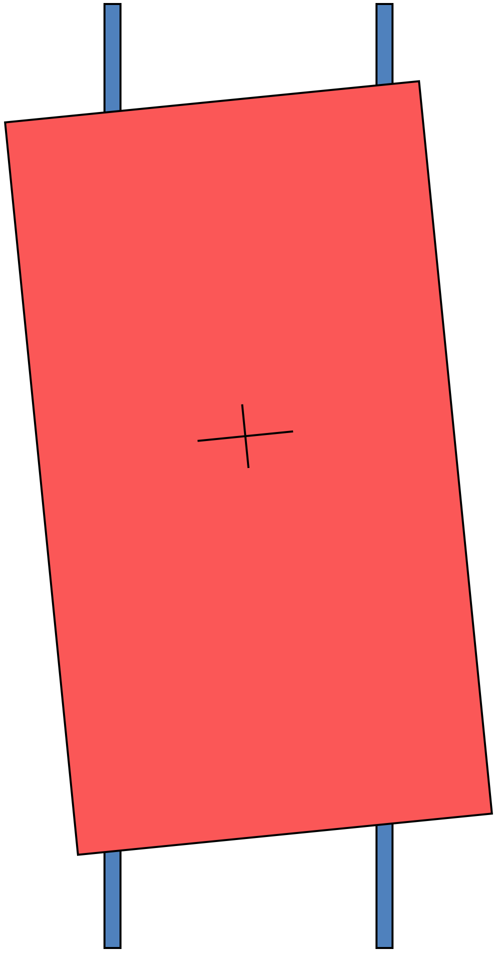
NOSING ABOUT THE VERTICAL AXIS

Increase in flange force



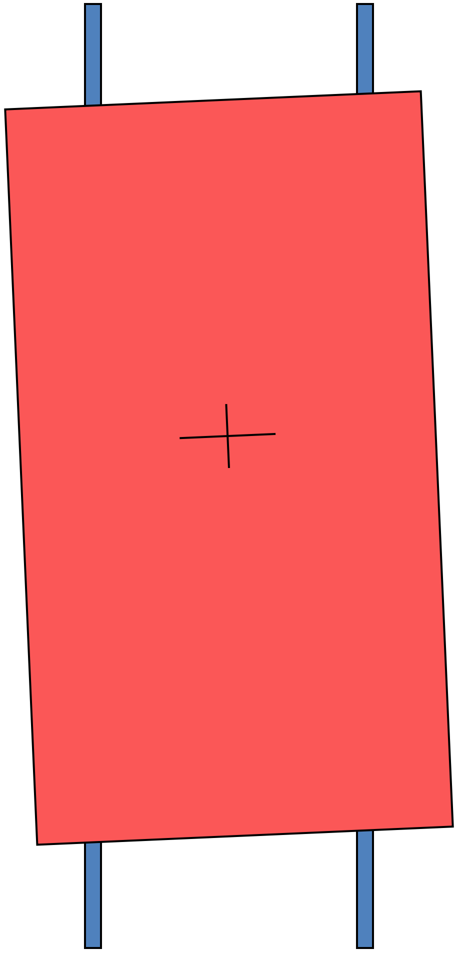
NOSING ABOUT THE VERTICAL AXIS

Increase in flange force



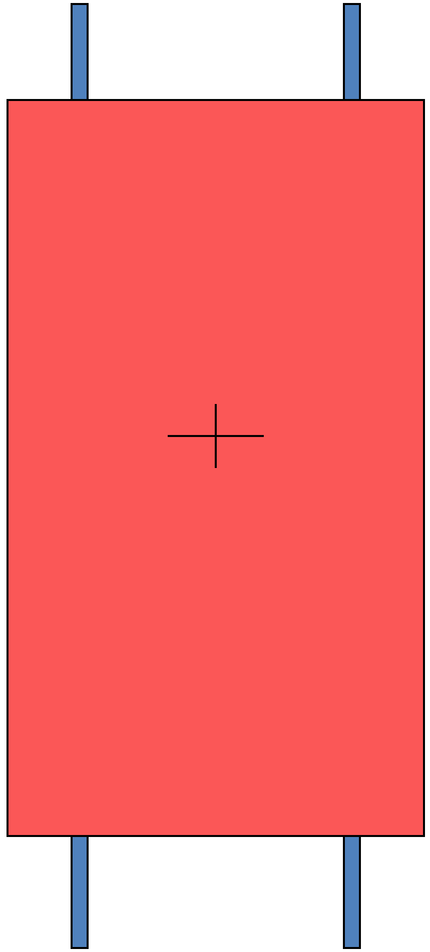
NOSING ABOUT THE VERTICAL AXIS

Increase in flange force



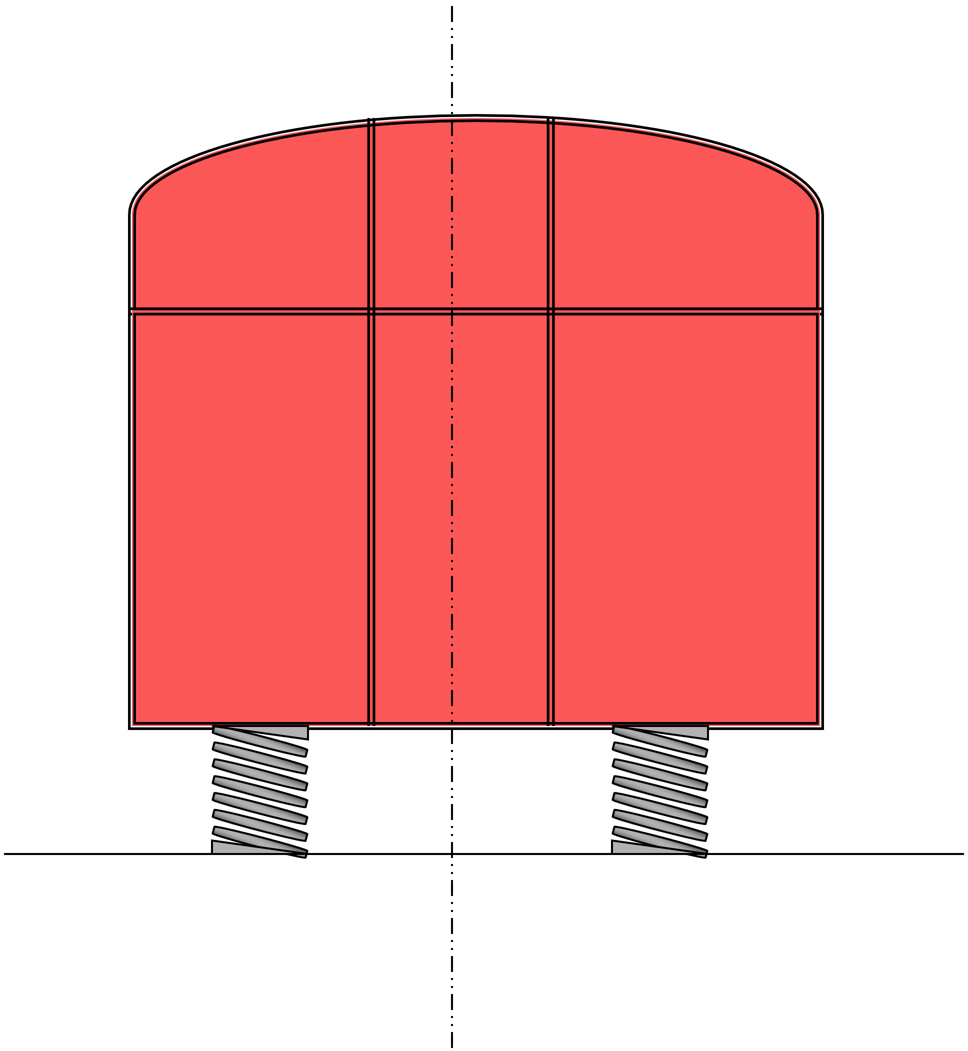
NOSING ABOUT THE VERTICAL AXIS

Increase in flange force



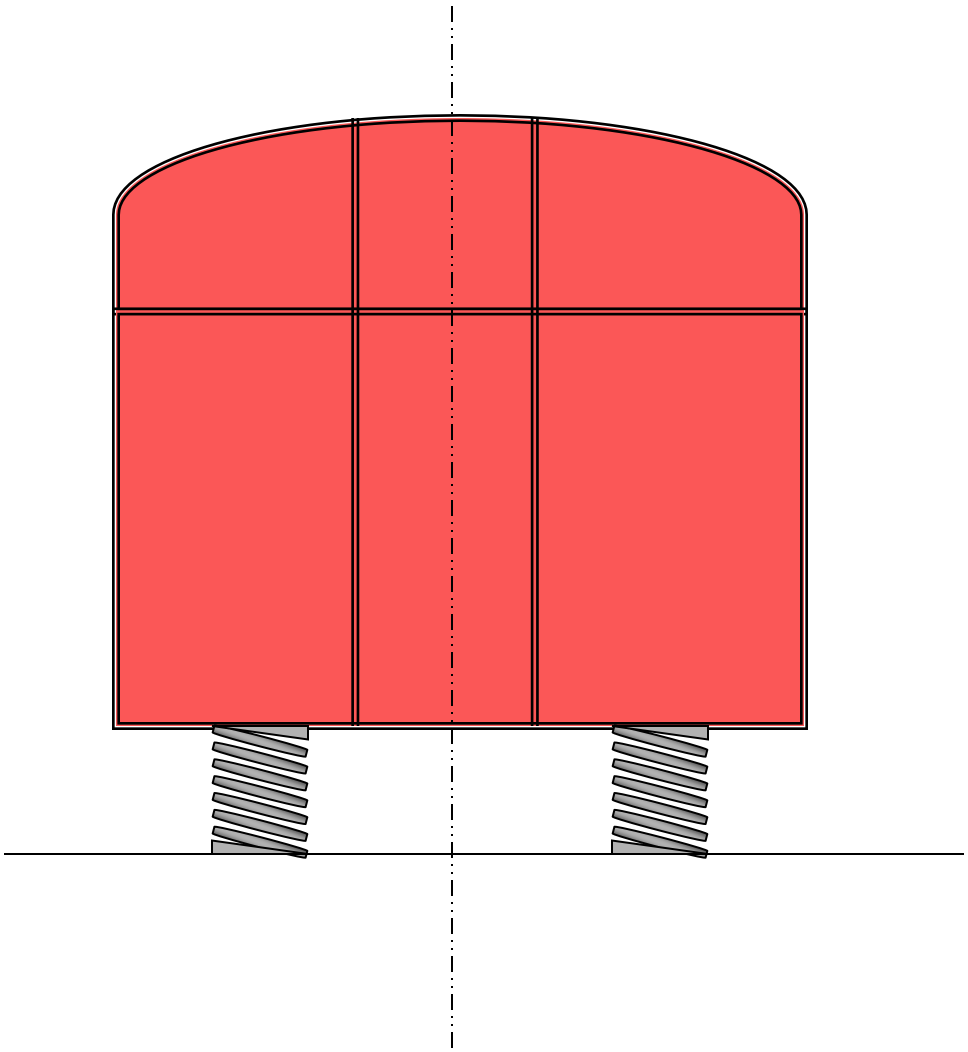
NOSING ABOUT THE VERTICAL AXIS

Increase in flange force



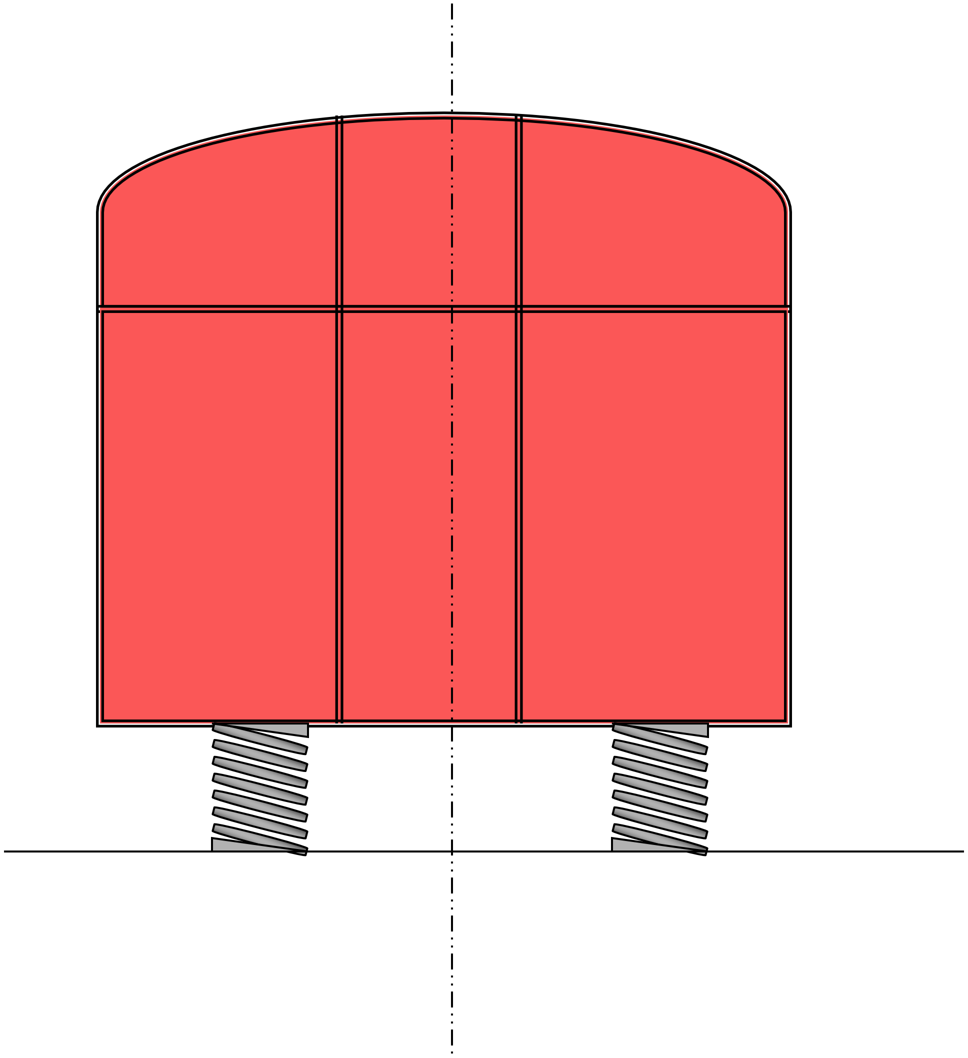
LURCHING ABOUT THE LATERAL AXIS

Increase in flange force



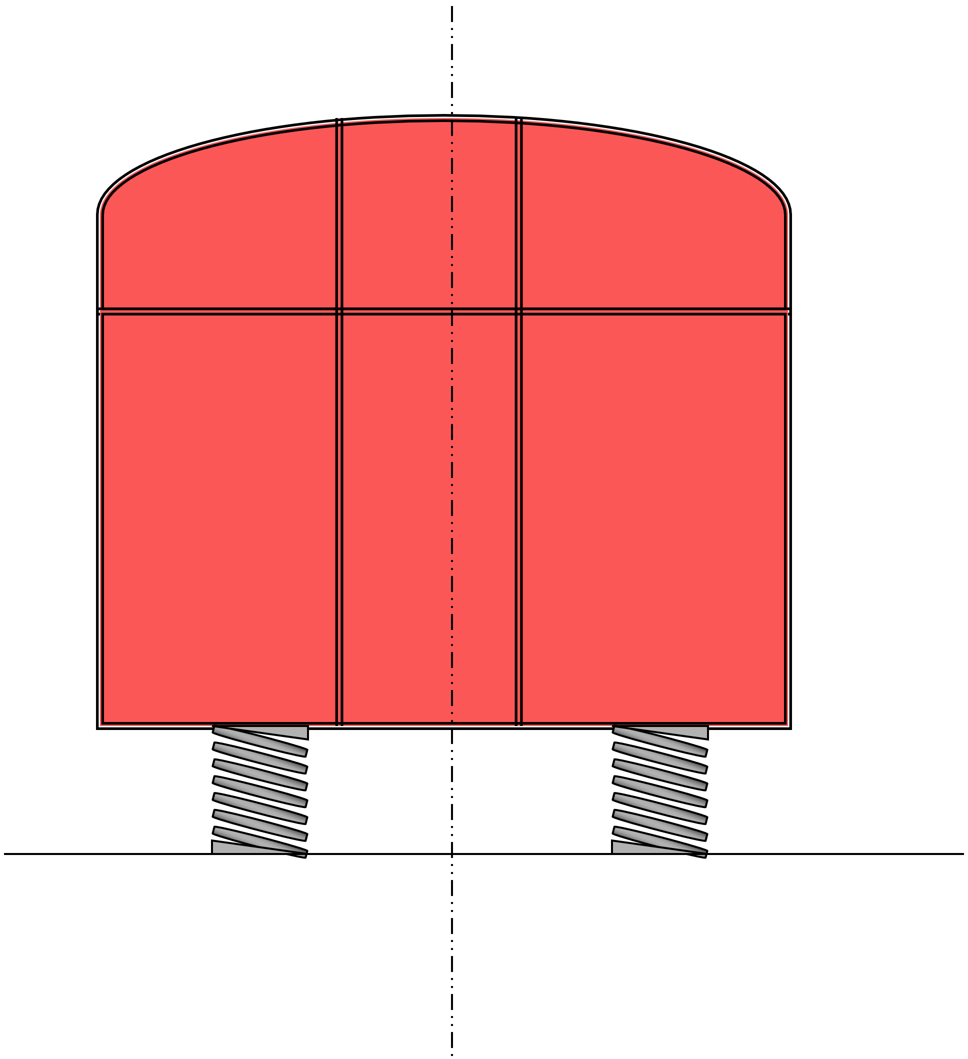
LURCHING ABOUT THE LATERAL AXIS

Increase in flange force



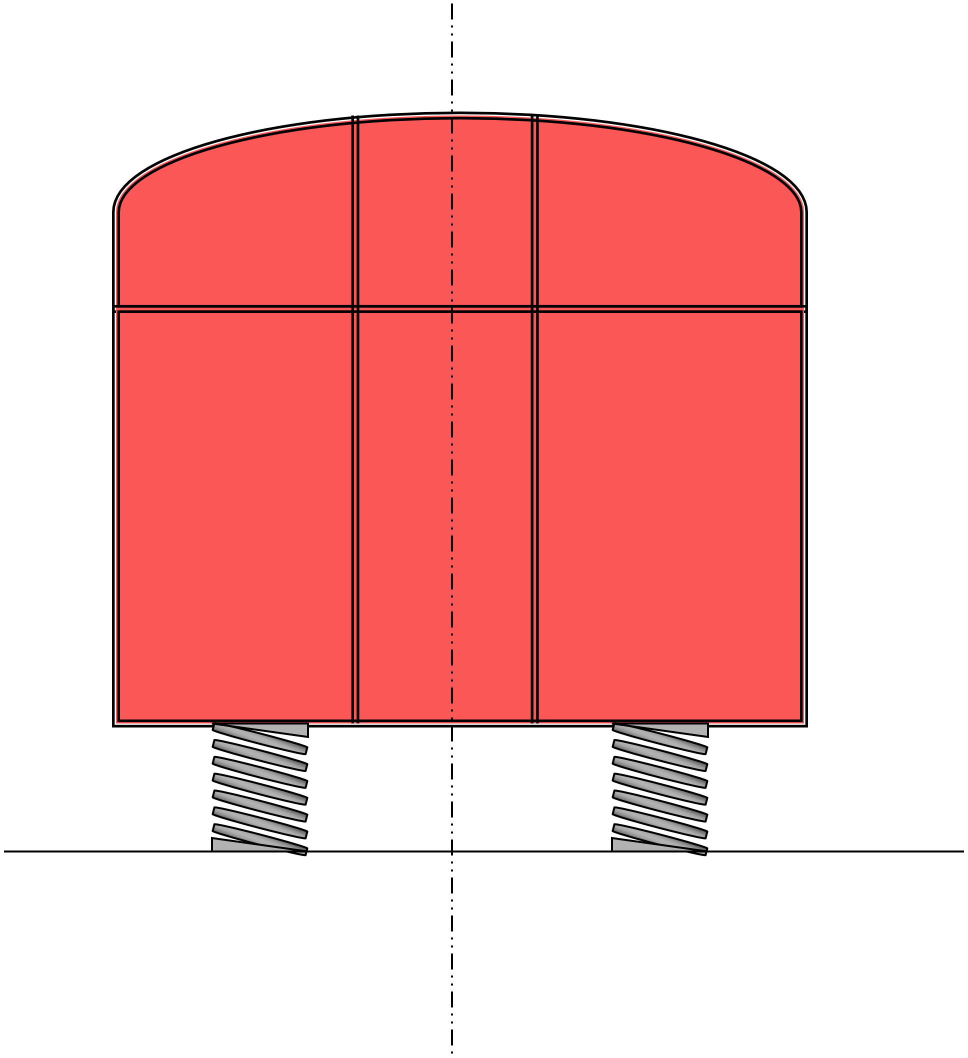
LURCHING ABOUT THE LATERAL AXIS

Increase in flange force



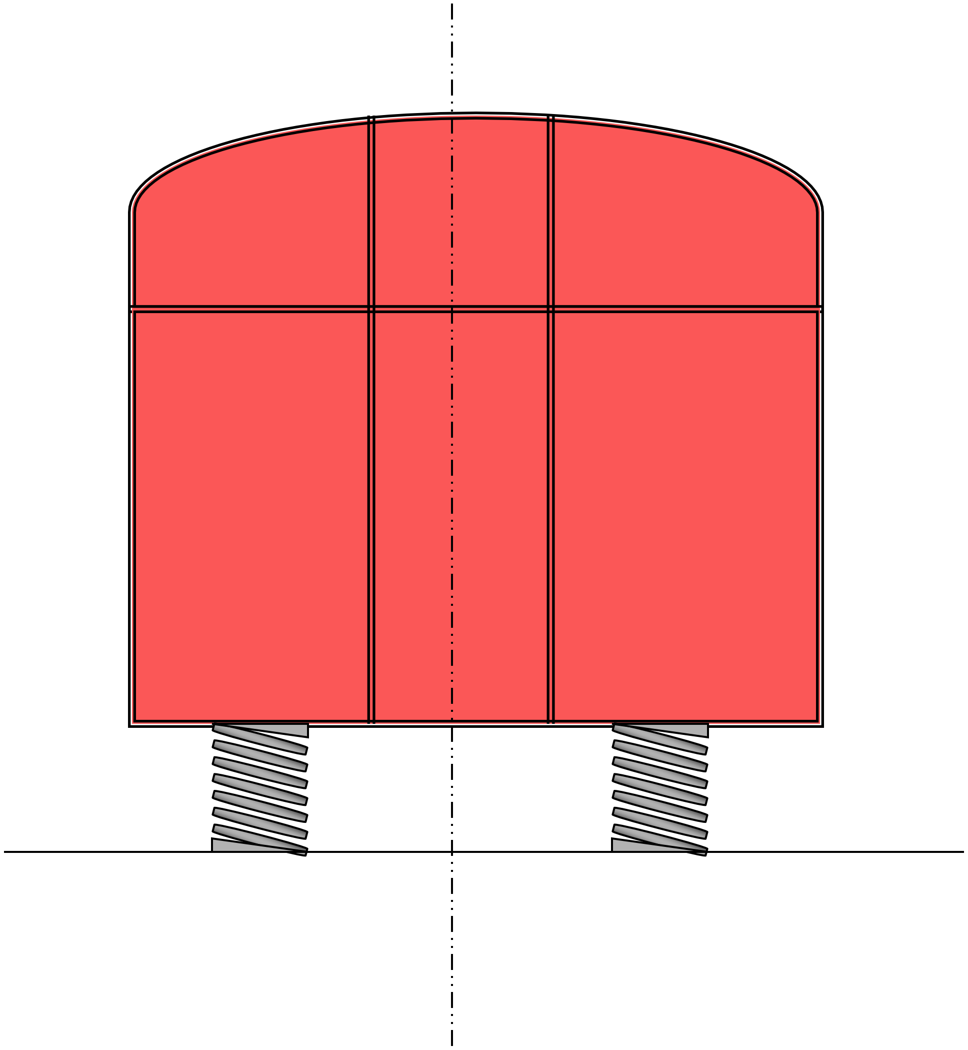
LURCHING ABOUT THE LATERAL AXIS

Increase in flange force



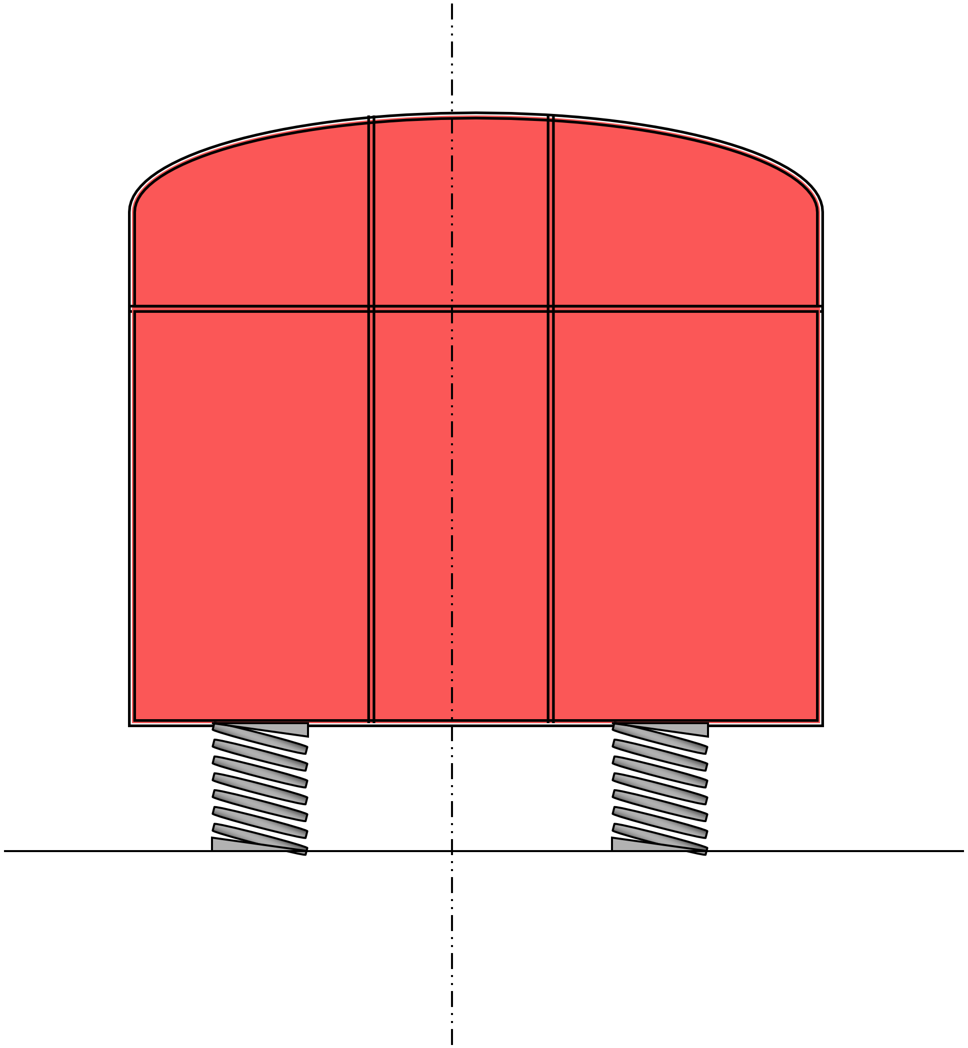
LURCHING ABOUT THE LATERAL AXIS

Increase in flange force



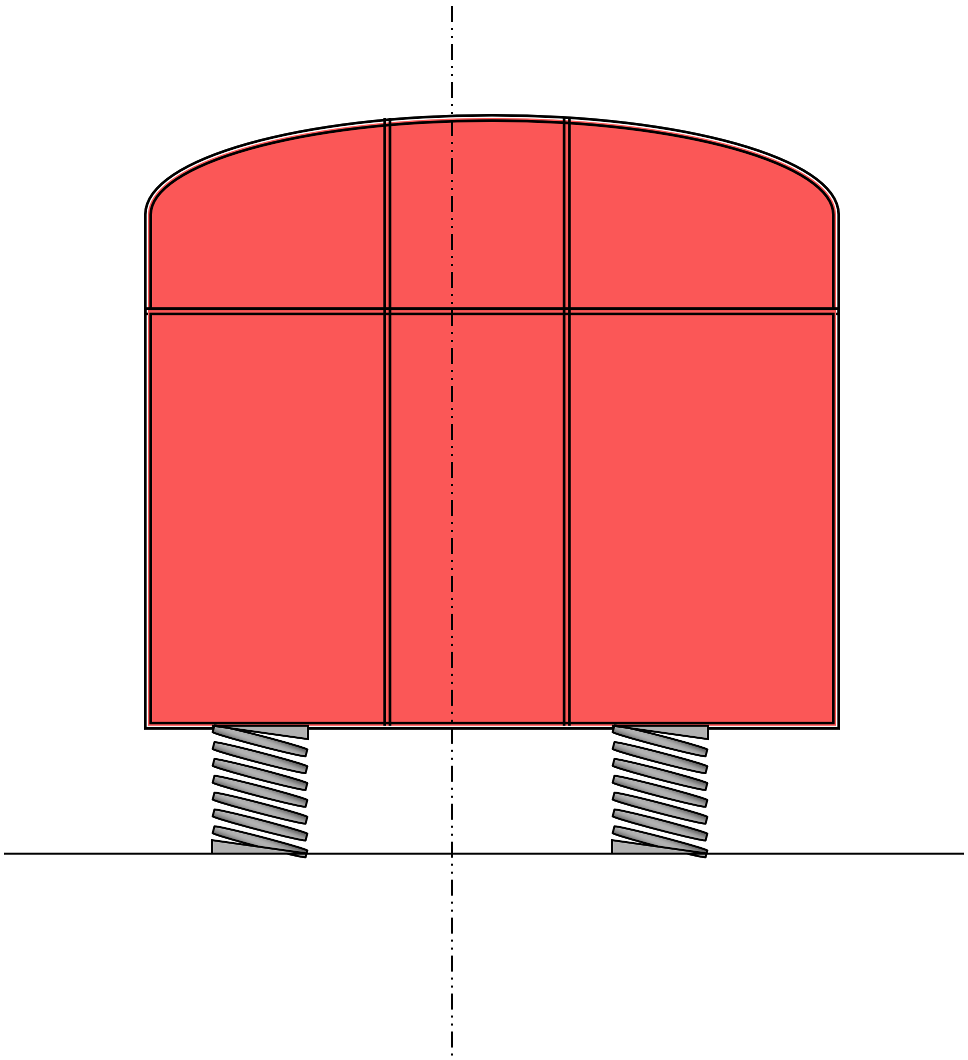
LURCHING ABOUT THE LATERAL AXIS

Increase in flange force



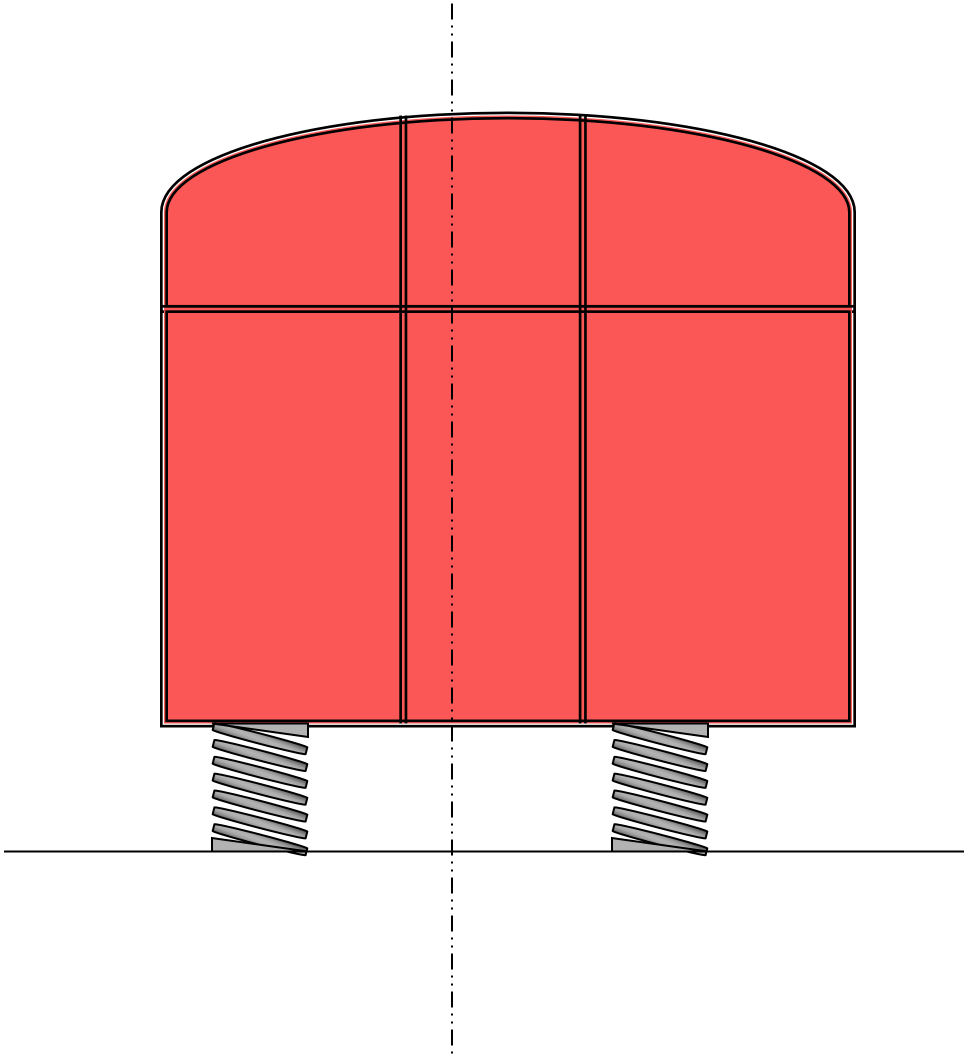
LURCHING ABOUT THE LATERAL AXIS

Increase in flange force



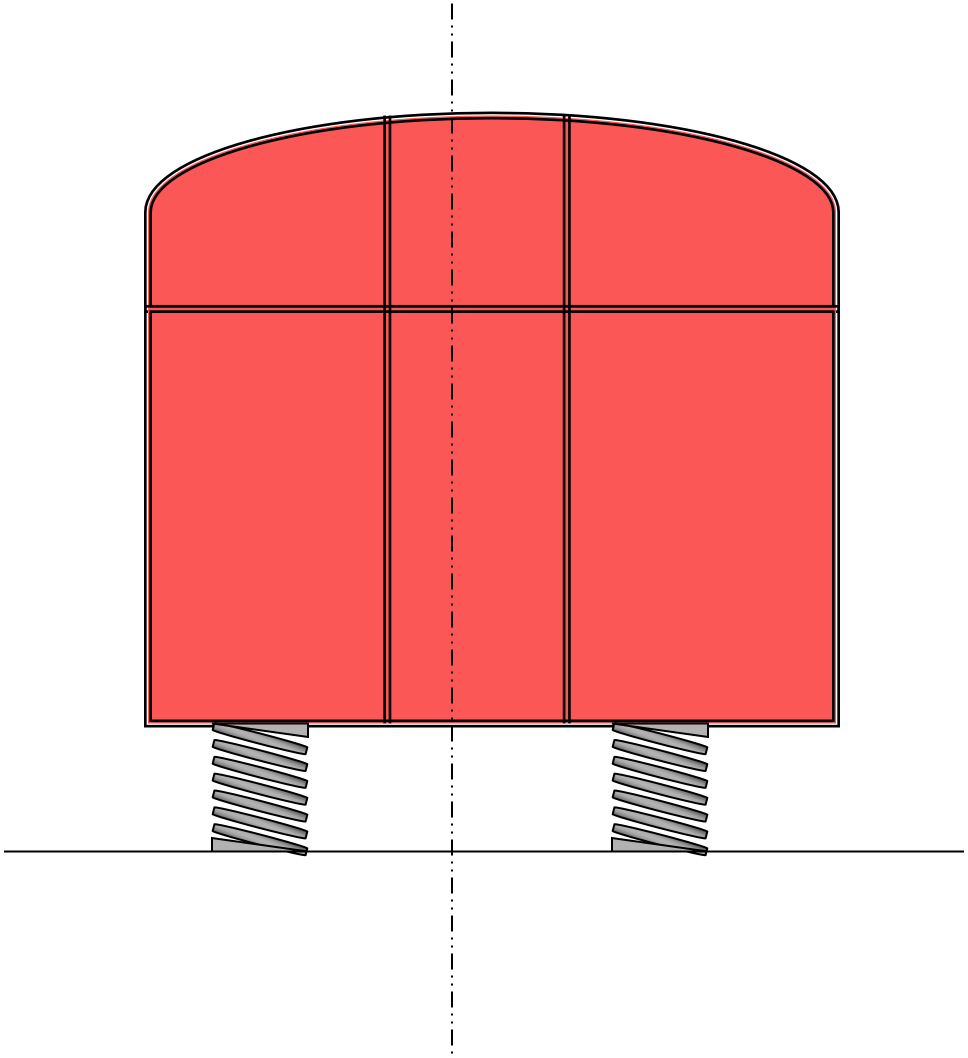
LURCHING ABOUT THE LATERAL AXIS

Increase in flange force



LURCHING ABOUT THE LATERAL AXIS

Increase in flange force



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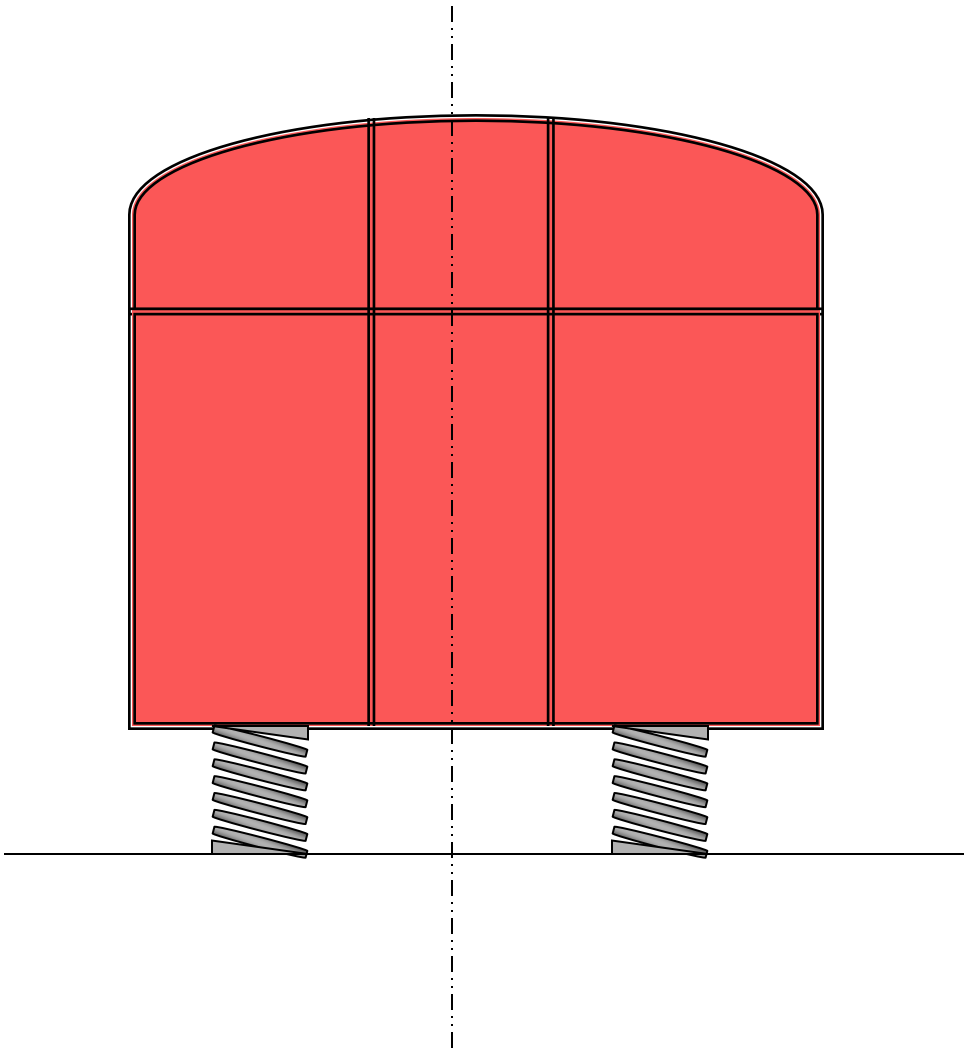
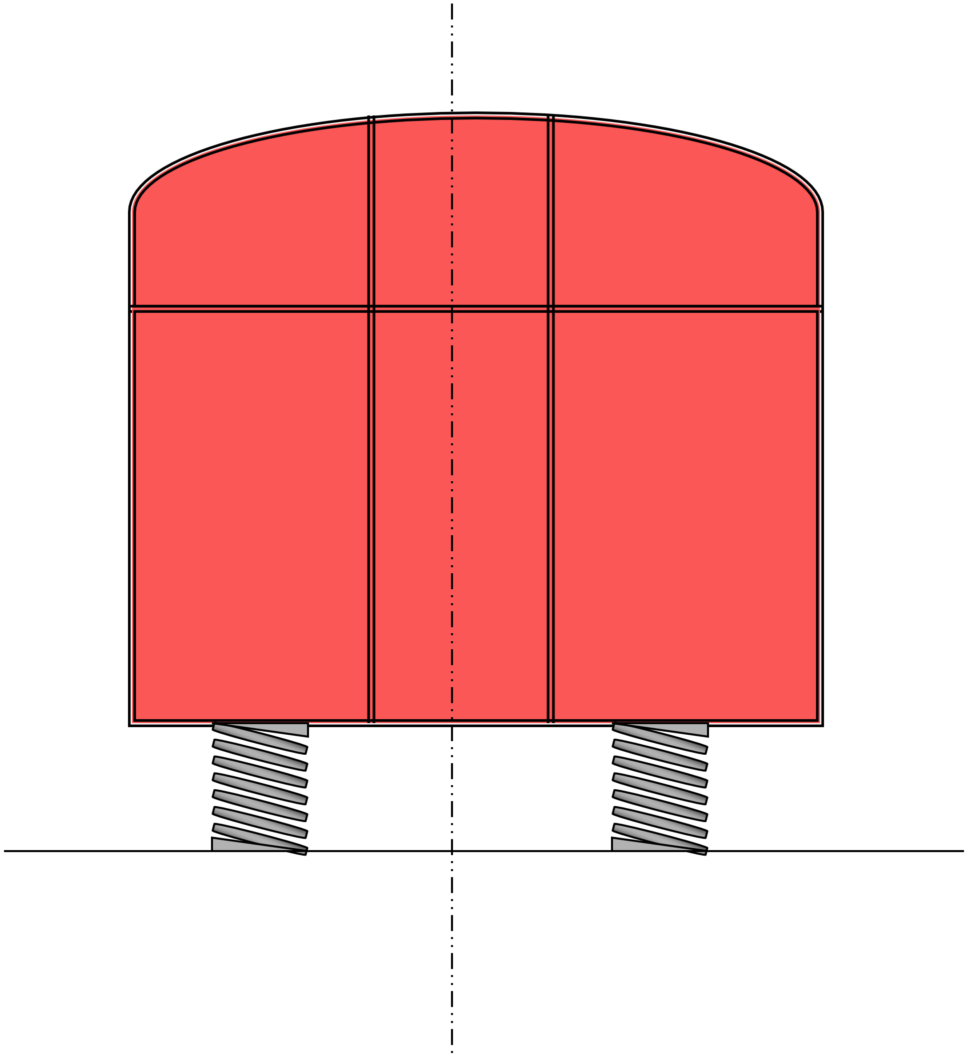
Increase in flange force



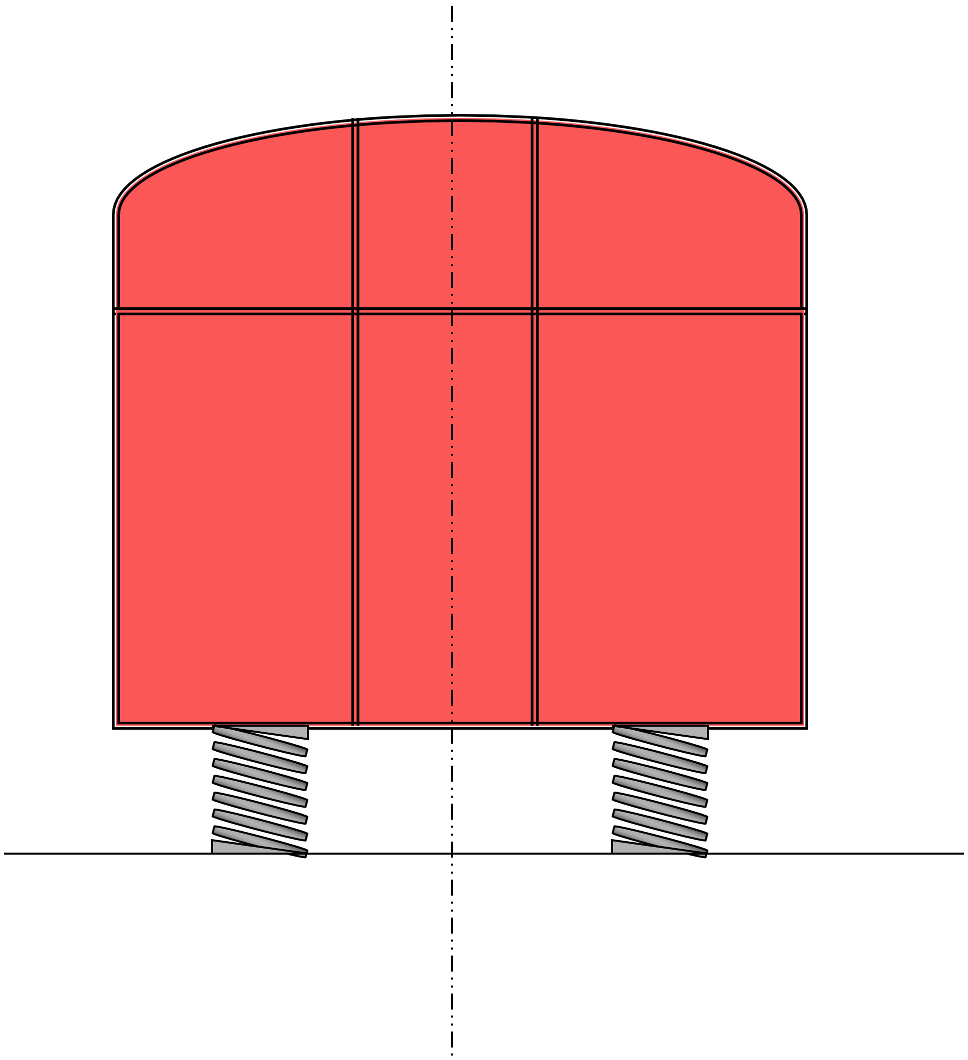
LURCHING ABOUT THE LATERAL AXIS

Increase in flange force



LURCHING ABOUT THE LATERAL AXIS

Increase in flange force



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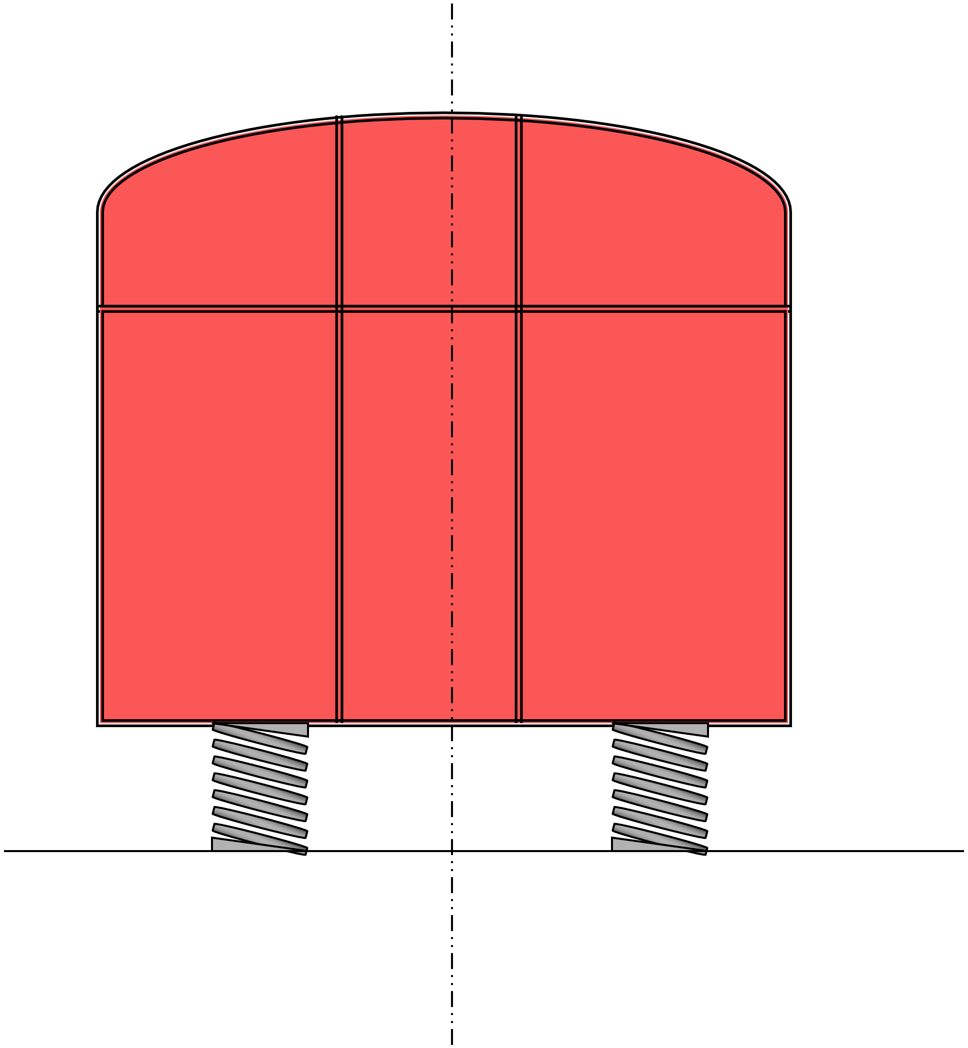
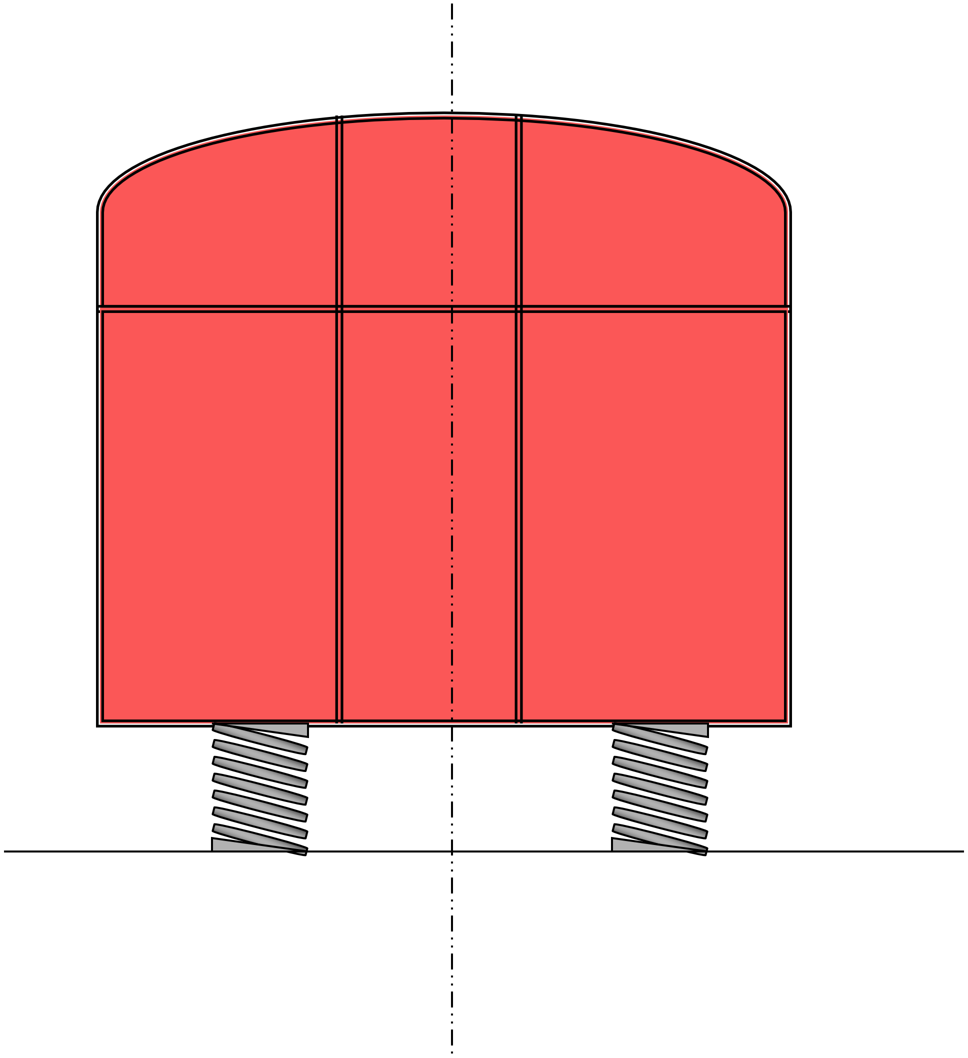
Increase in flange force



LURCHING ABOUT THE LATERAL AXIS

Increase in flange force



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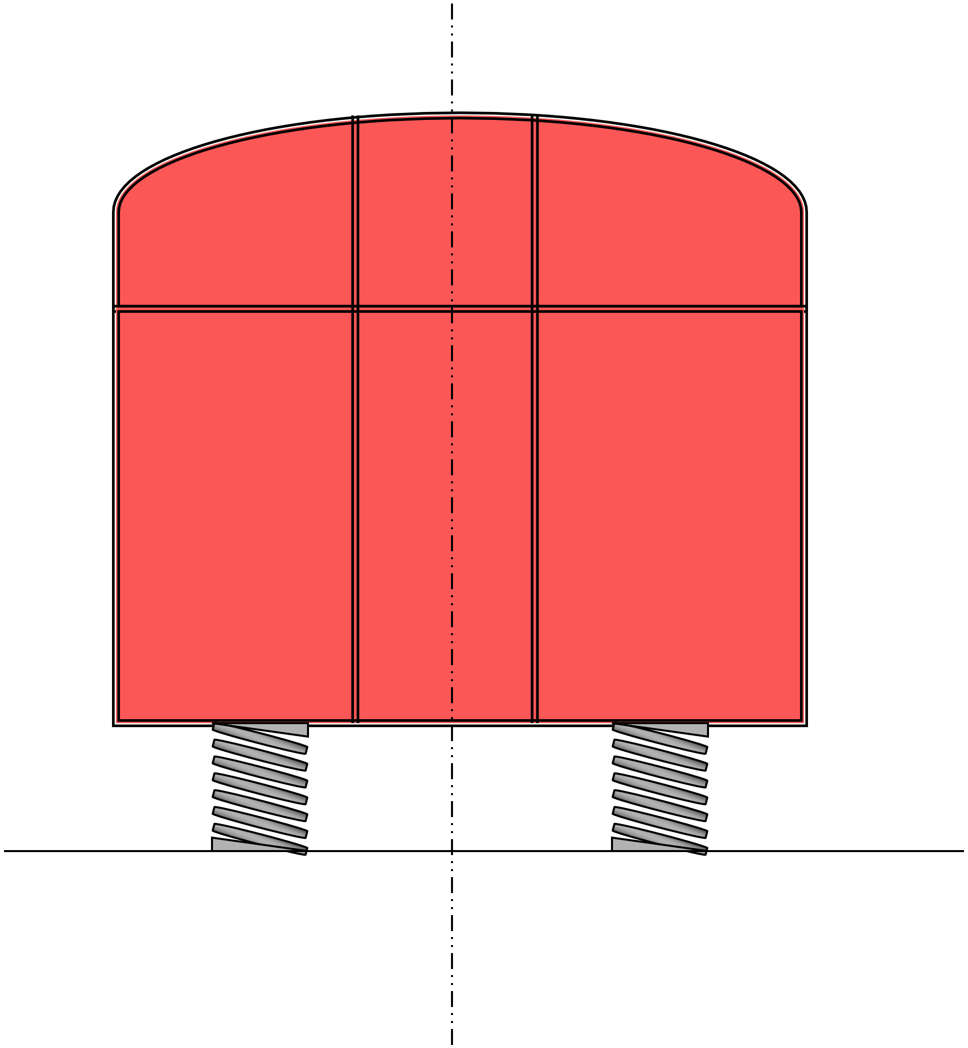
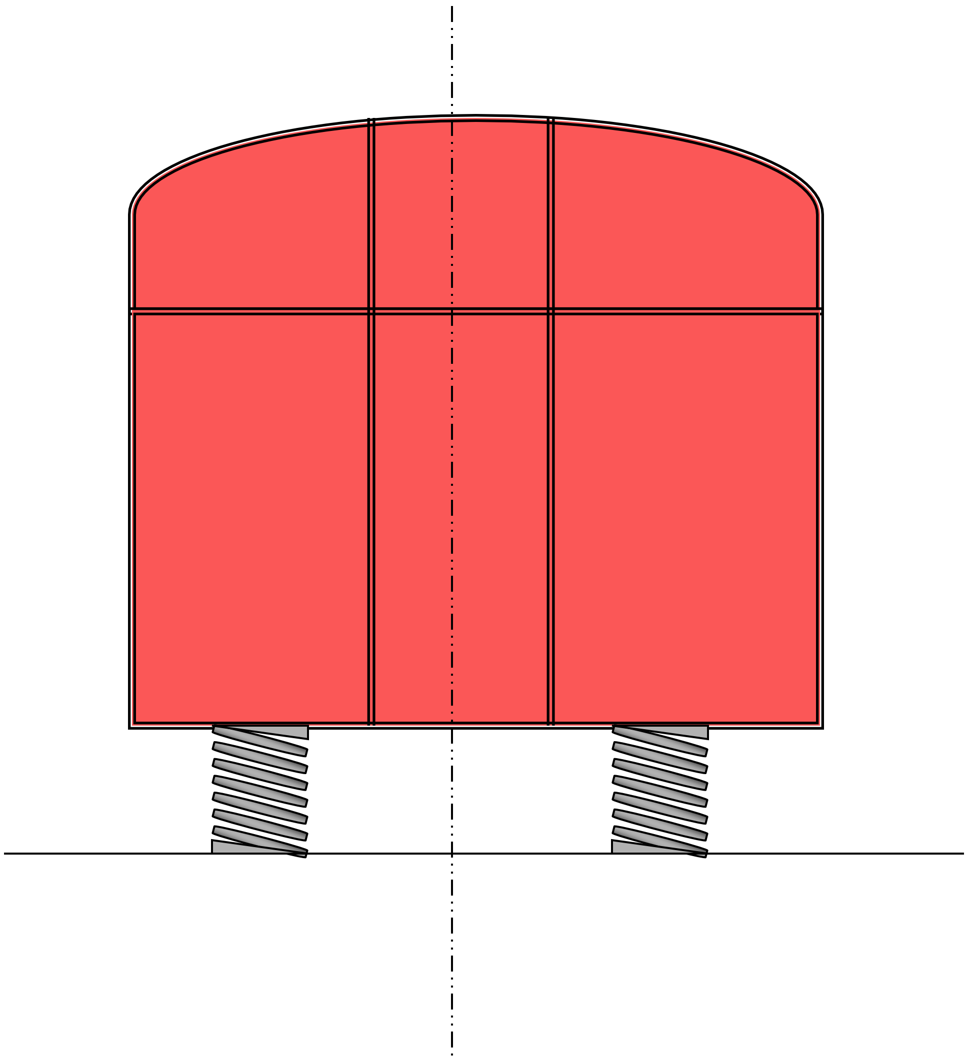
Increase in flange force



LURCHING ABOUT THE LATERAL AXIS

Increase in flange force



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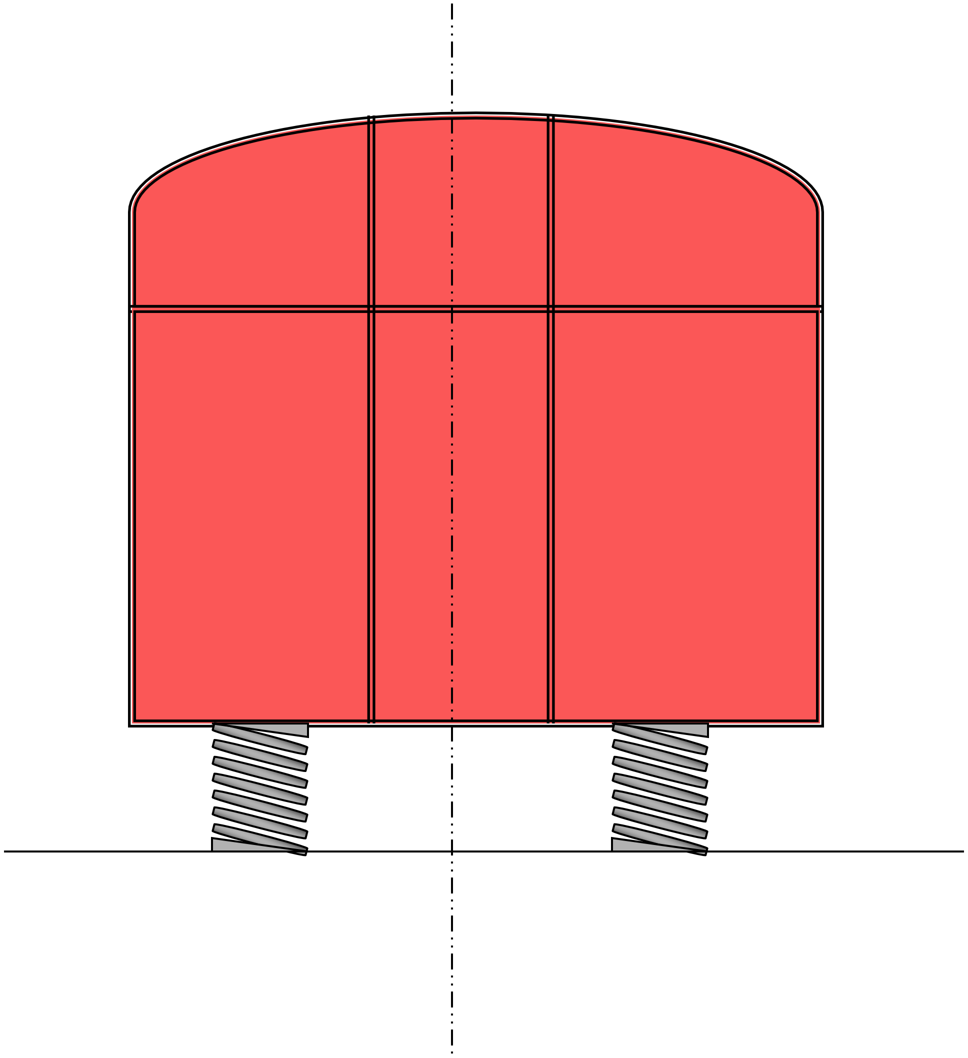
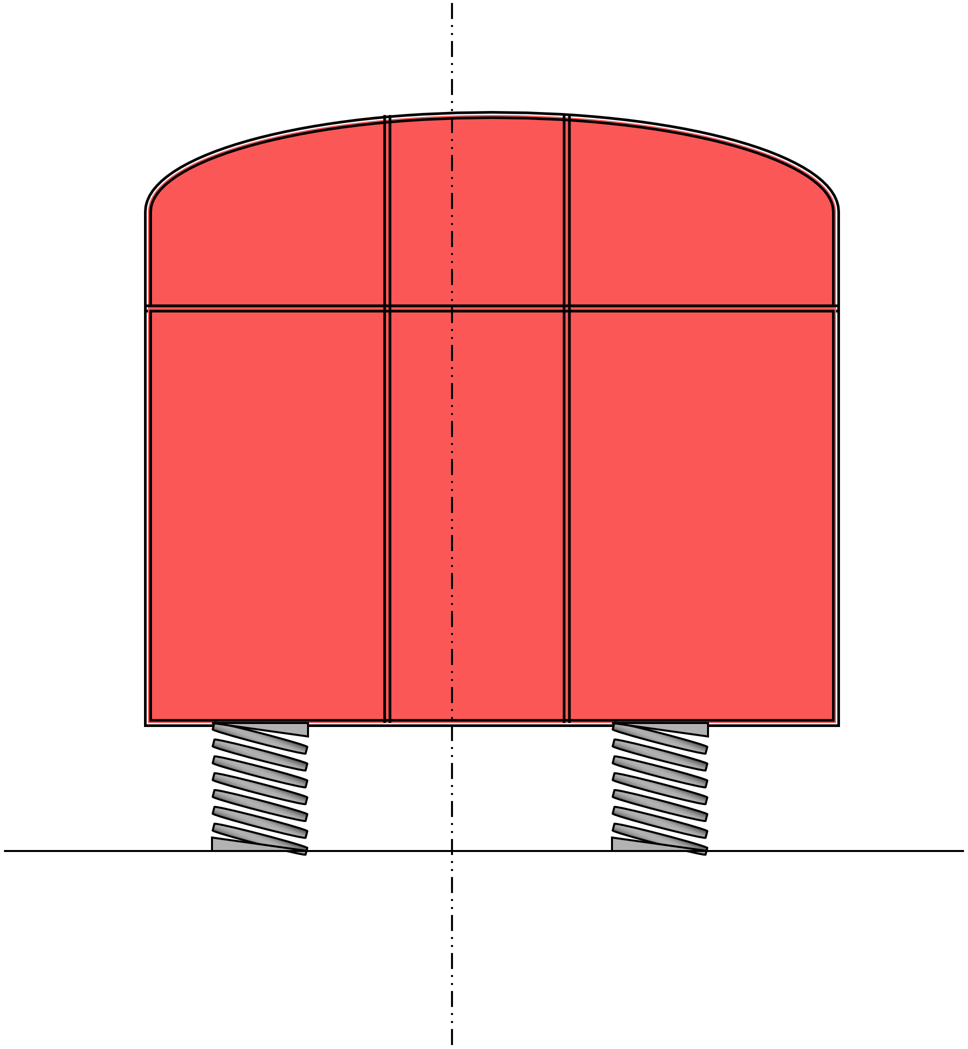
Increase in flange force



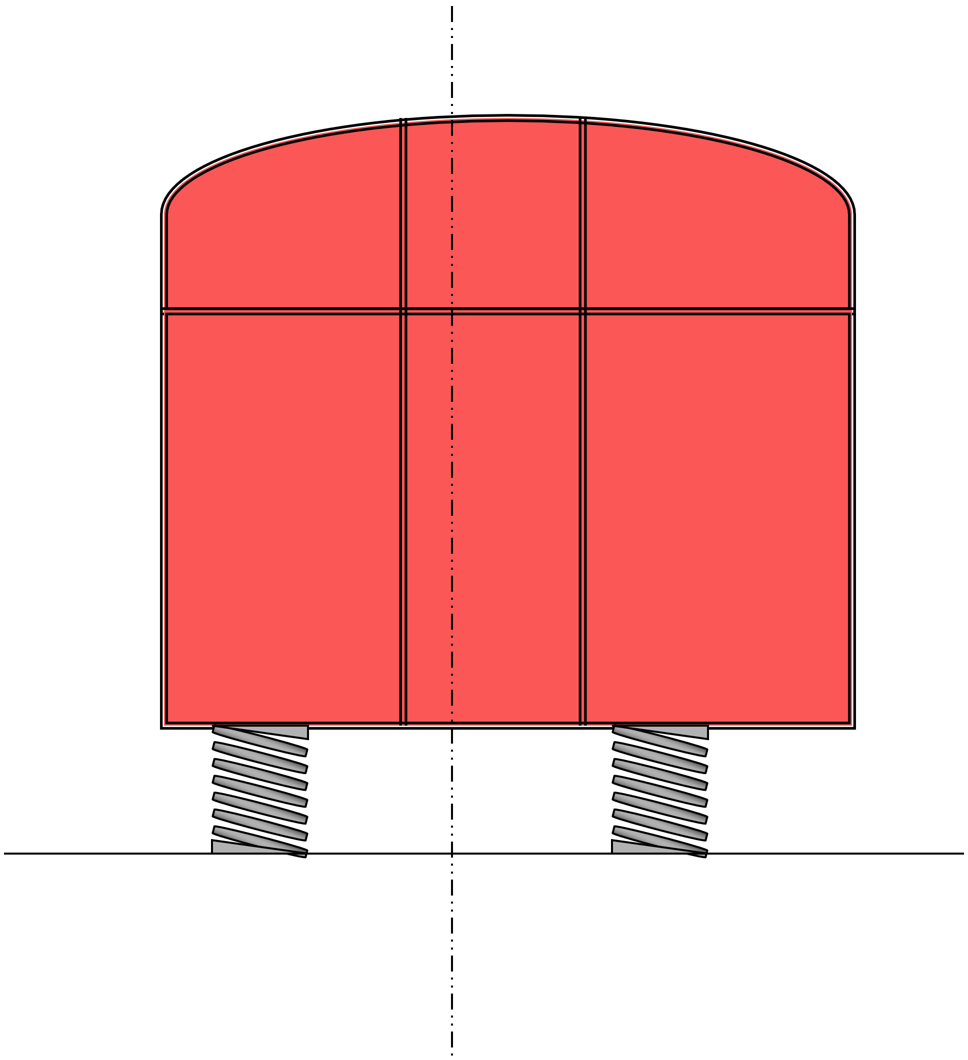
LURCHING ABOUT THE LATERAL AXIS

Increase in flange force



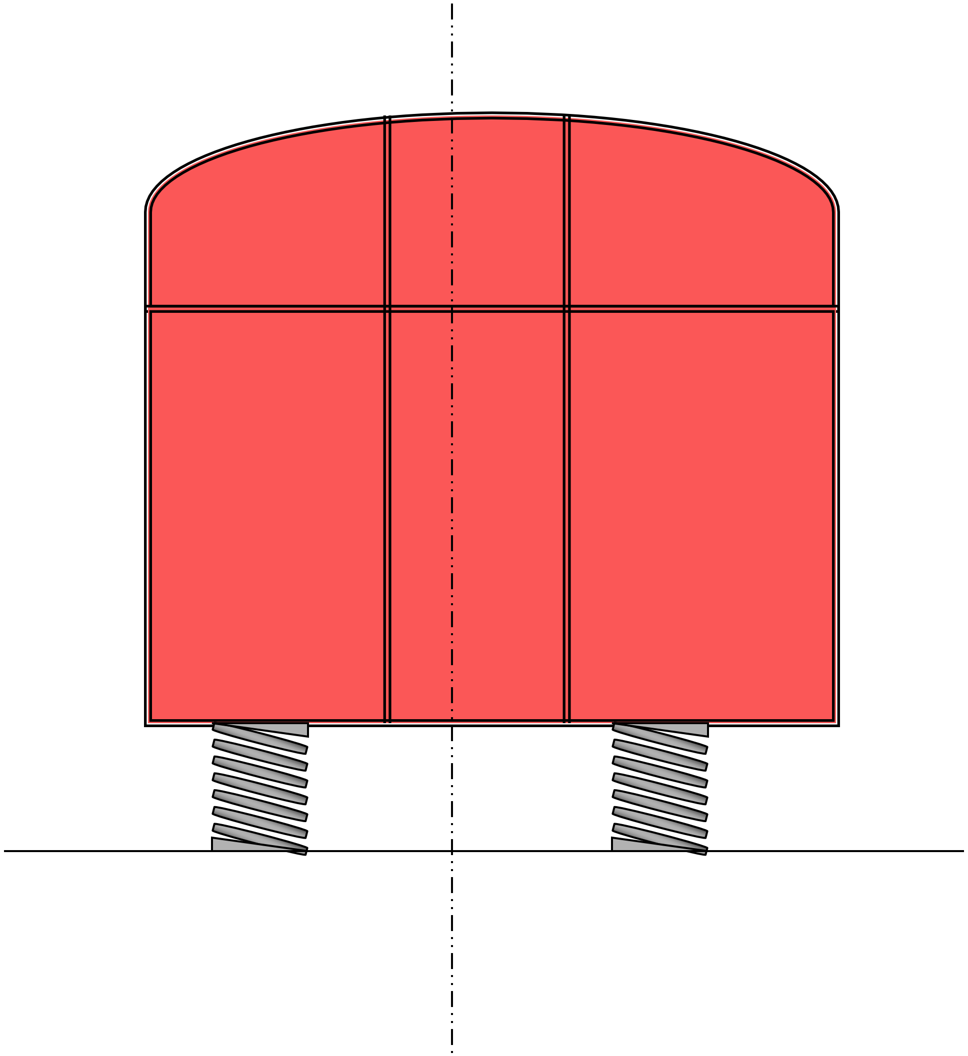
LURCHING ABOUT THE LATERAL AXIS

Increase in flange force



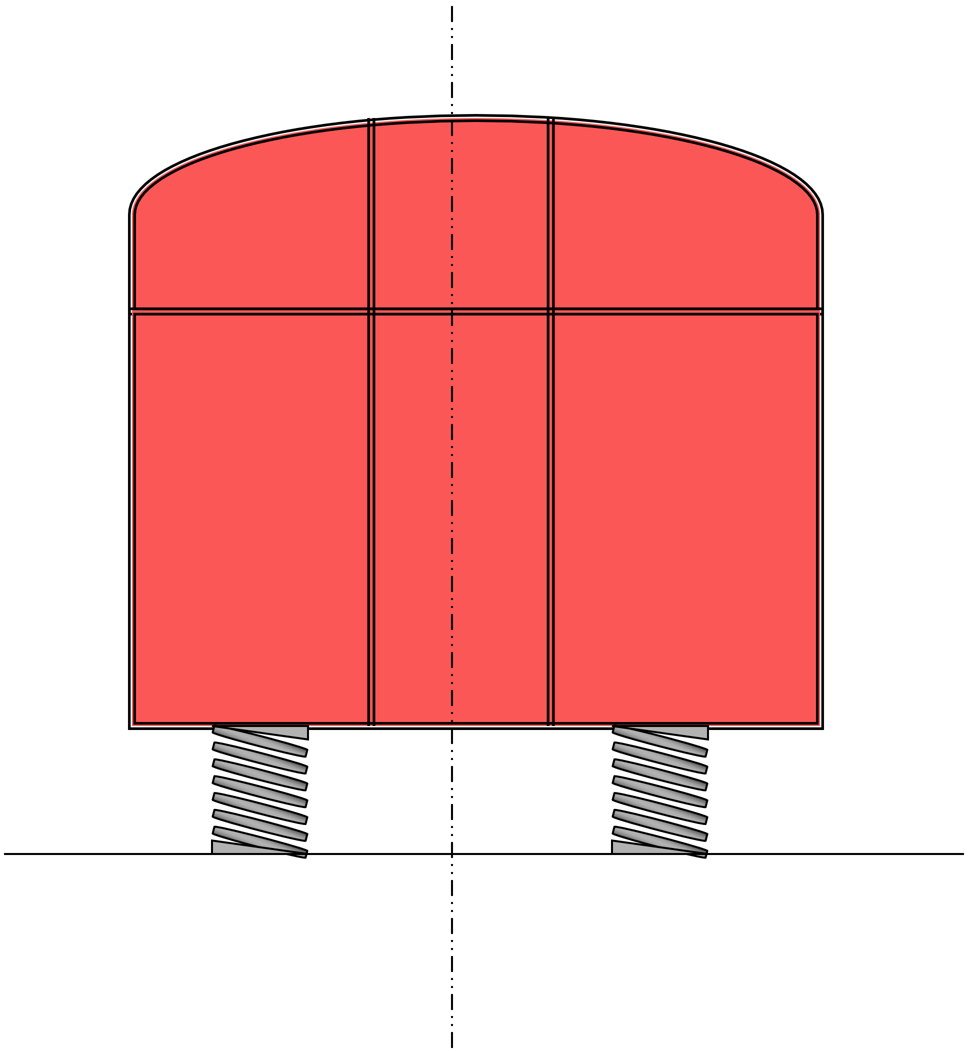
LURCHING ABOUT THE LATERAL AXIS

Increase in flange force



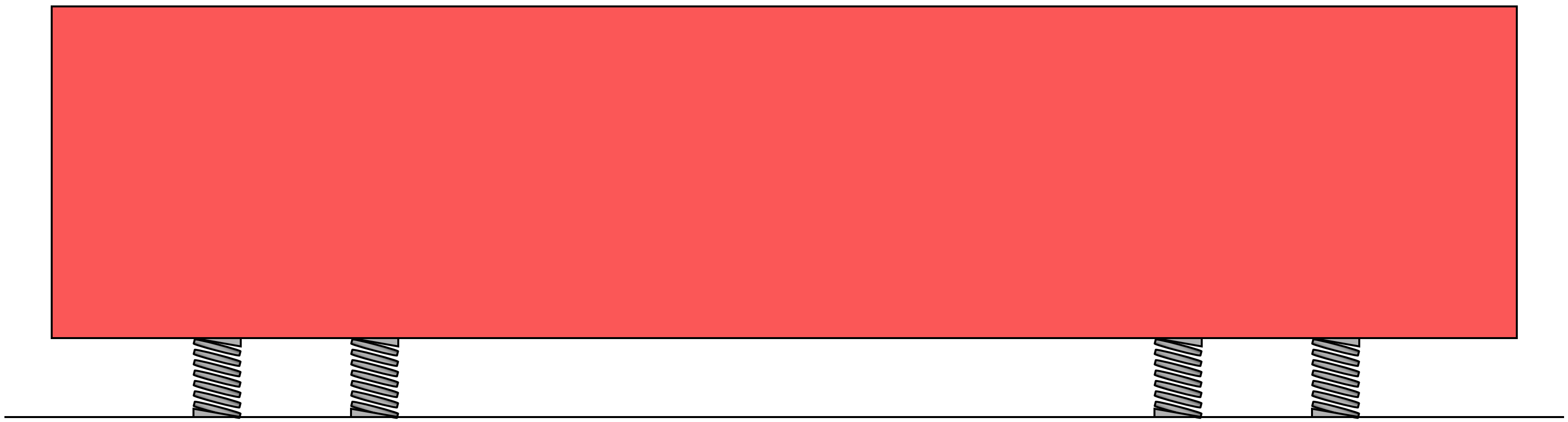
LURCHING ABOUT THE LATERAL AXIS

Increase in flange force



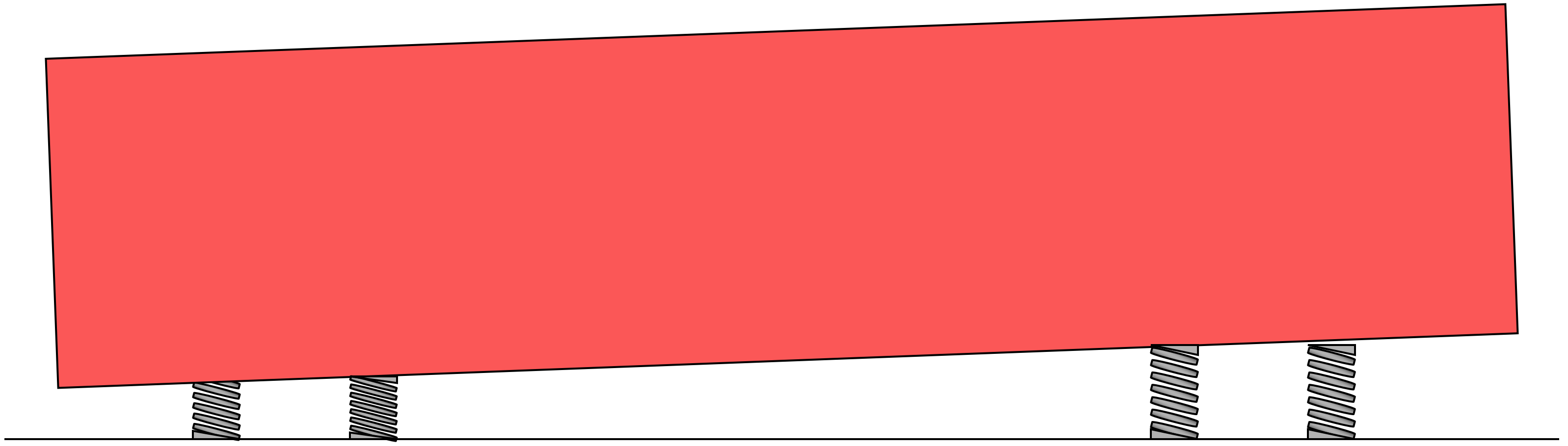
LURCHING ABOUT THE LATERAL AXIS

Increase in flange force



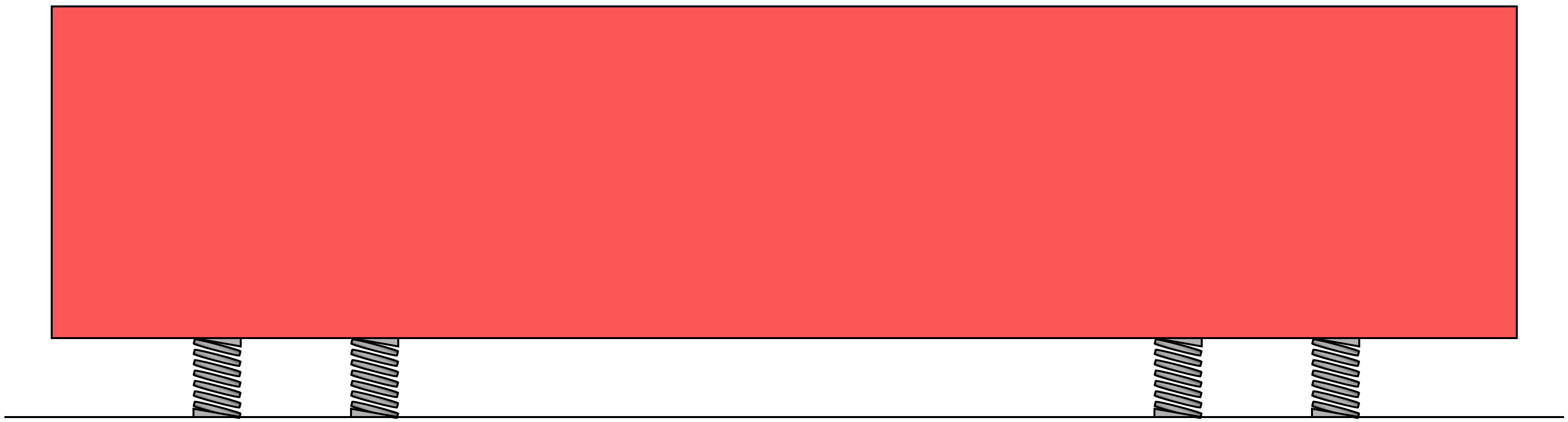
PITCHING ABOUT THE LATERAL AXIS

Reduction in instantaneous wheel load



PITCHING ABOUT THE LATERAL AXIS

Reduction in instantaneous wheel load



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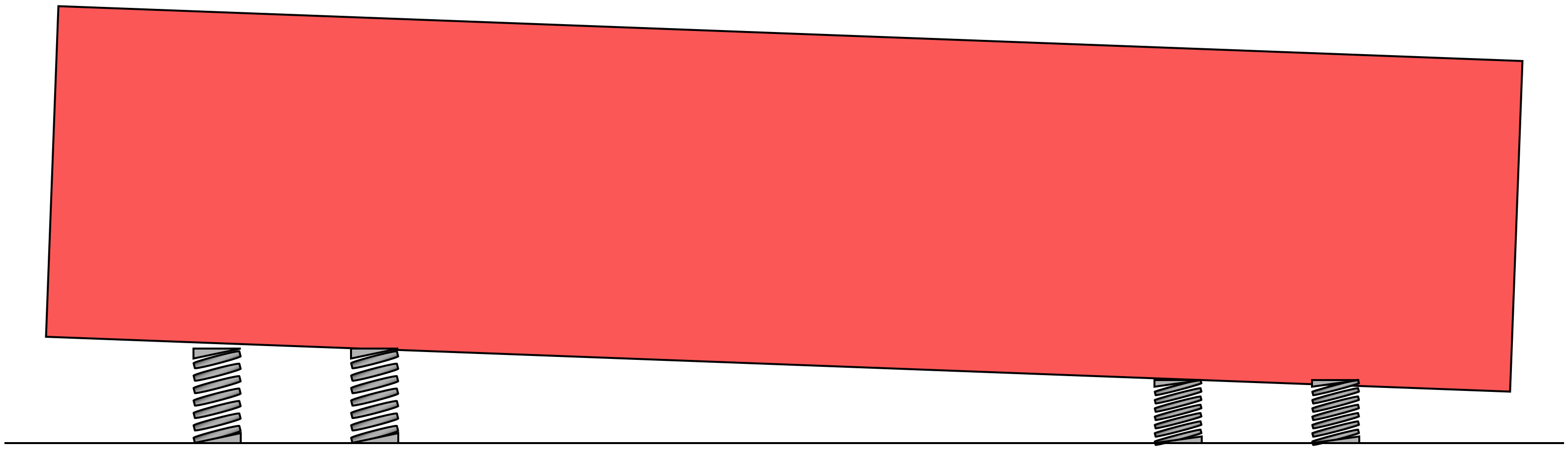
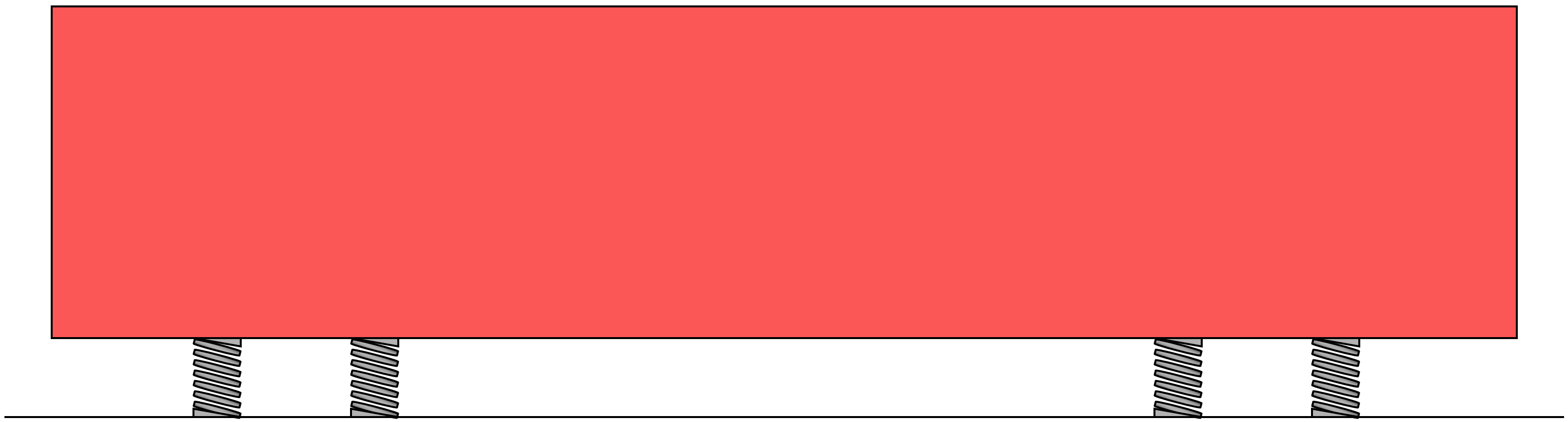
Reduction in instantaneous wheel load



PITCHING ABOUT THE LATERAL AXIS

Reduction in instantaneous wheel load



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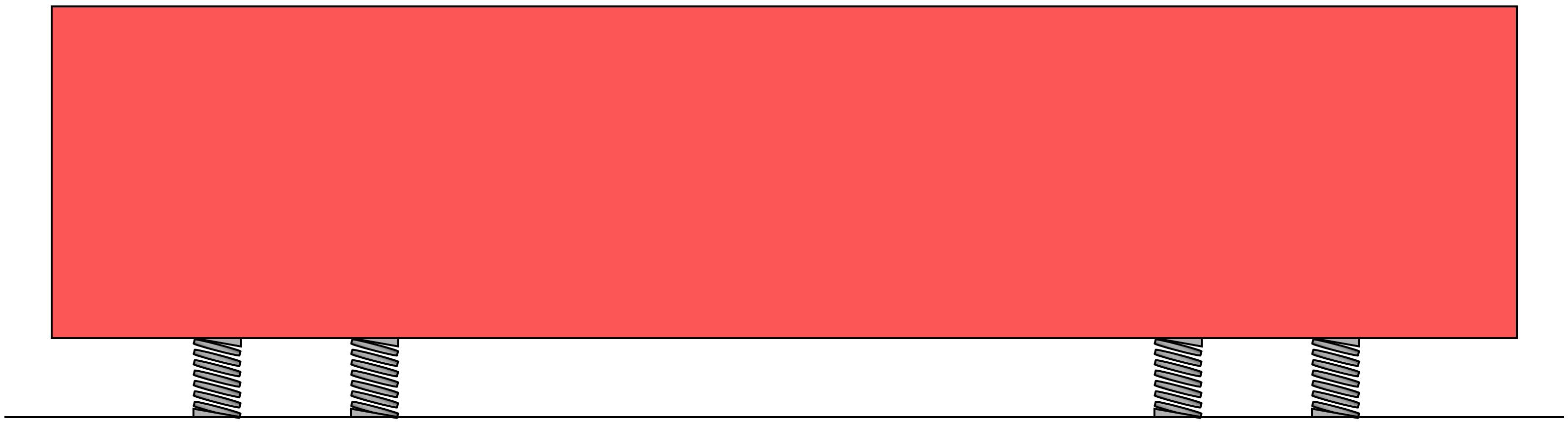
Reduction in instantaneous wheel load



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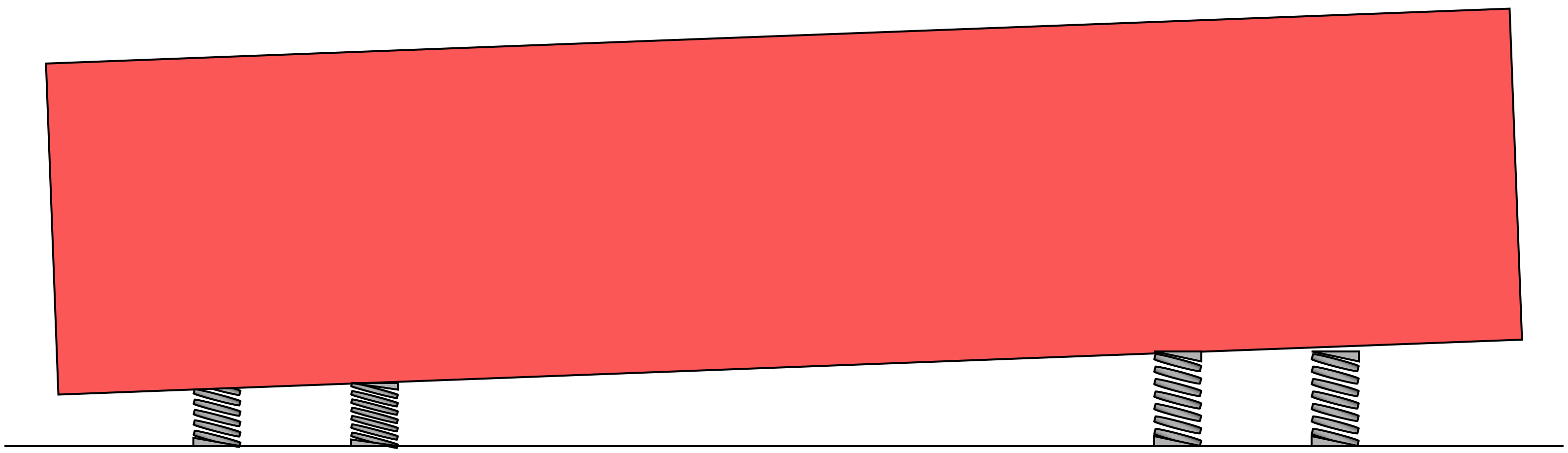
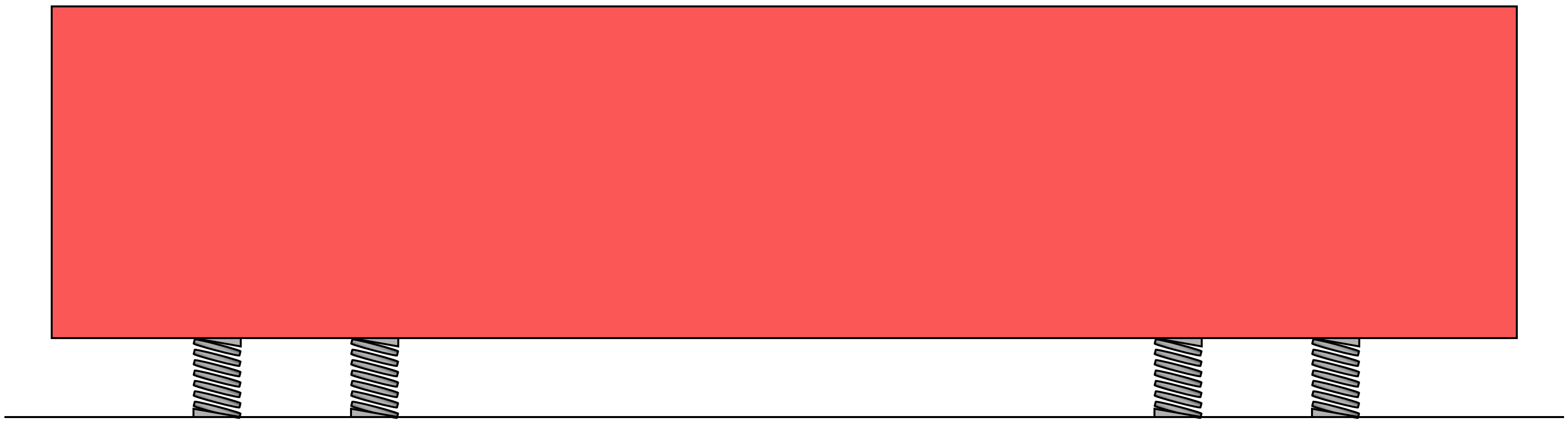
Reduction in instantaneous wheel load



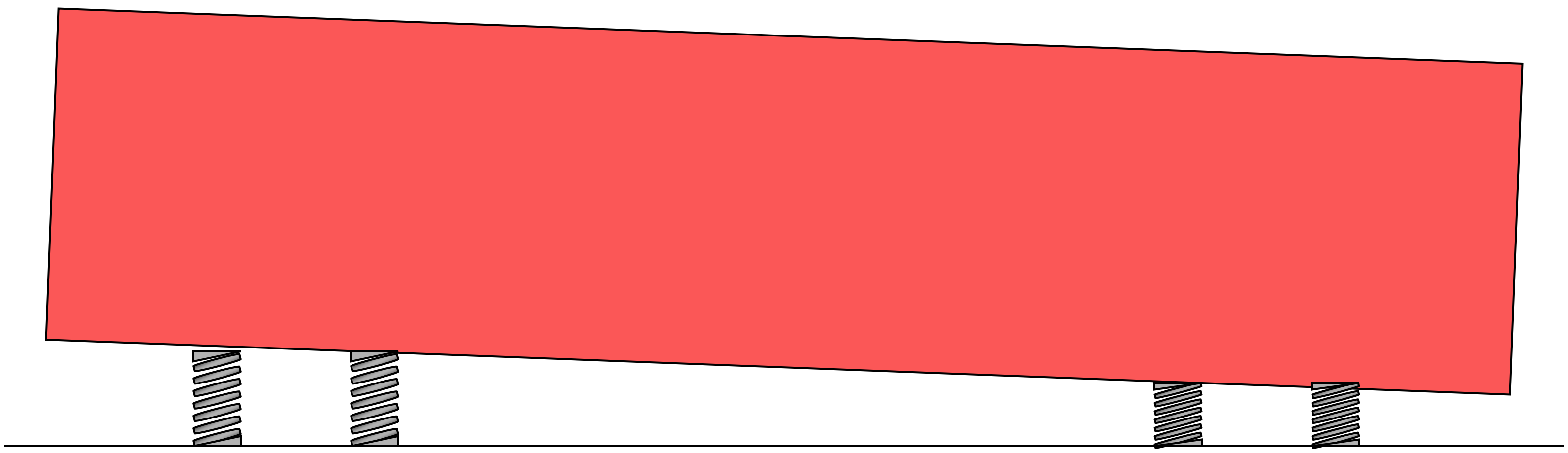
PITCHING ABOUT THE LATERAL AXIS

Reduction in instantaneous wheel load



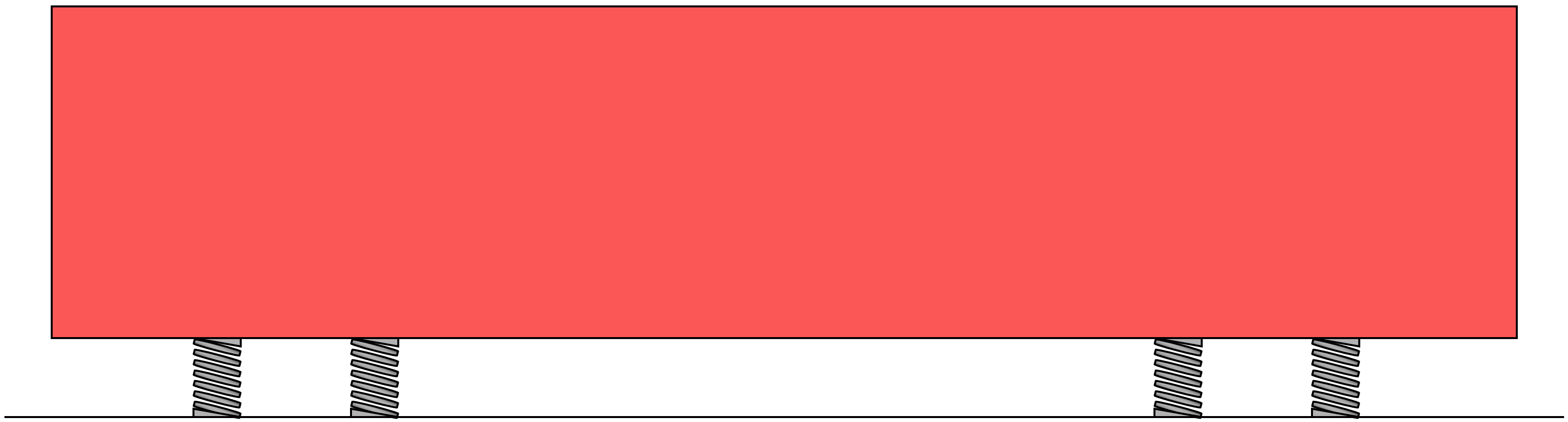
PITCHING ABOUT THE LATERAL AXIS

Reduction in instantaneous wheel load



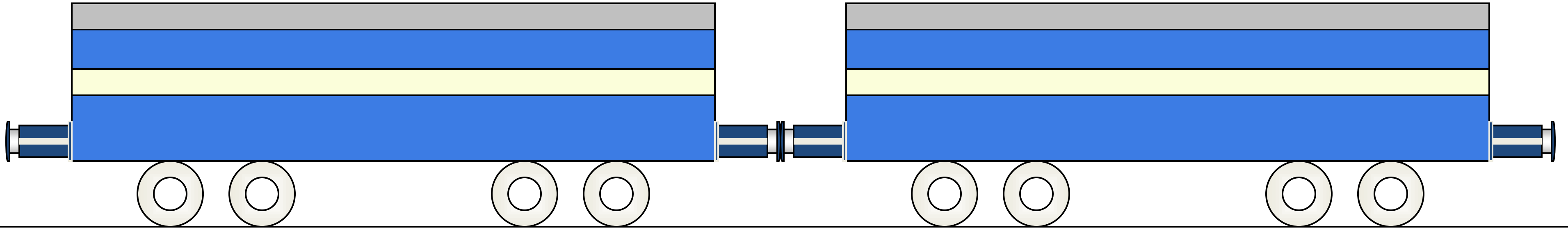
PITCHING ABOUT THE LATERAL AXIS

Reduction in instantaneous wheel load

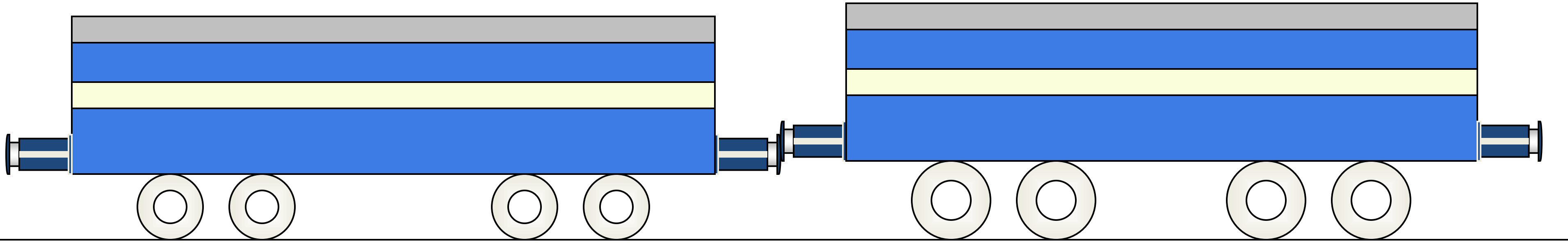


PITCHING ABOUT THE LATERAL AXIS

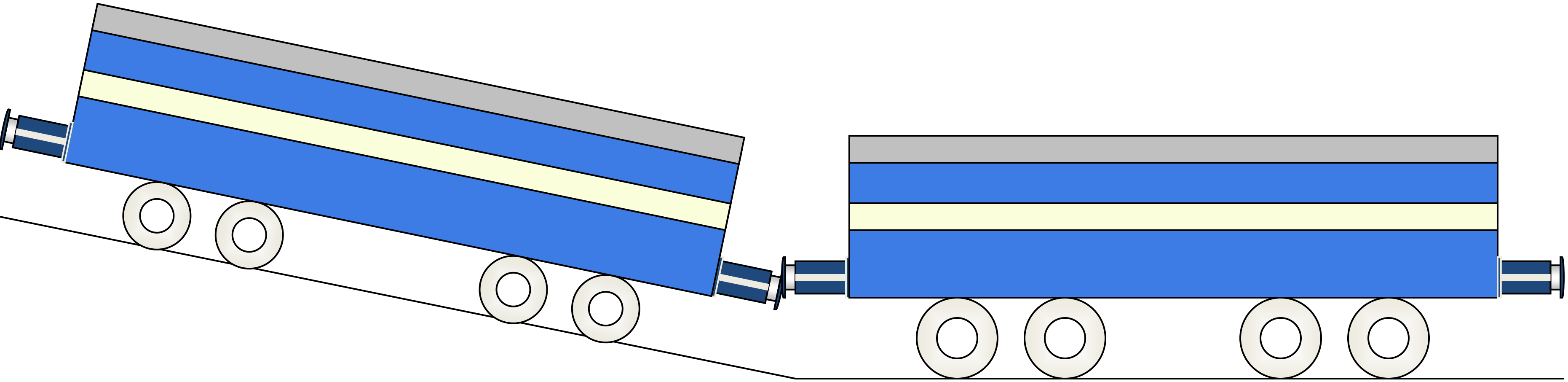
Reduction in instantaneous wheel load



BUFFER HEIGHTS OF BOTH VEHICLES WITHIN PERMISSIBLE RANGE

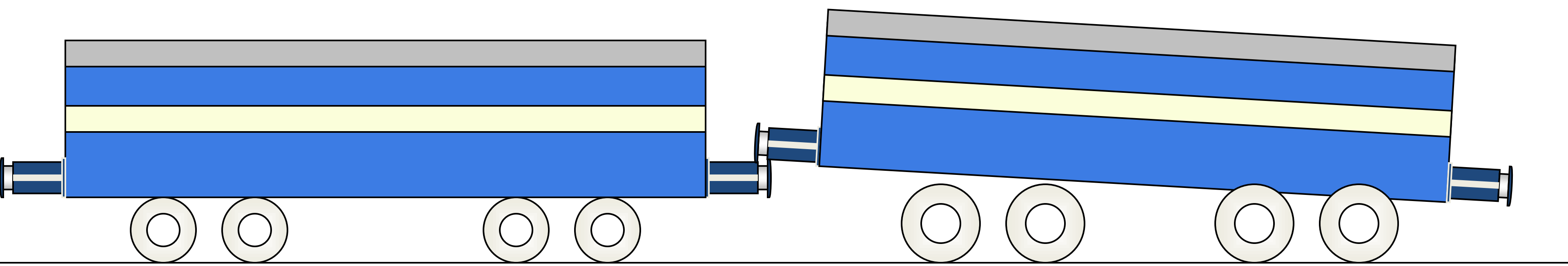


BUFFER HEIGHT OF REAR VEHICLE LOWER THAN PERMISSIBLE RANGE



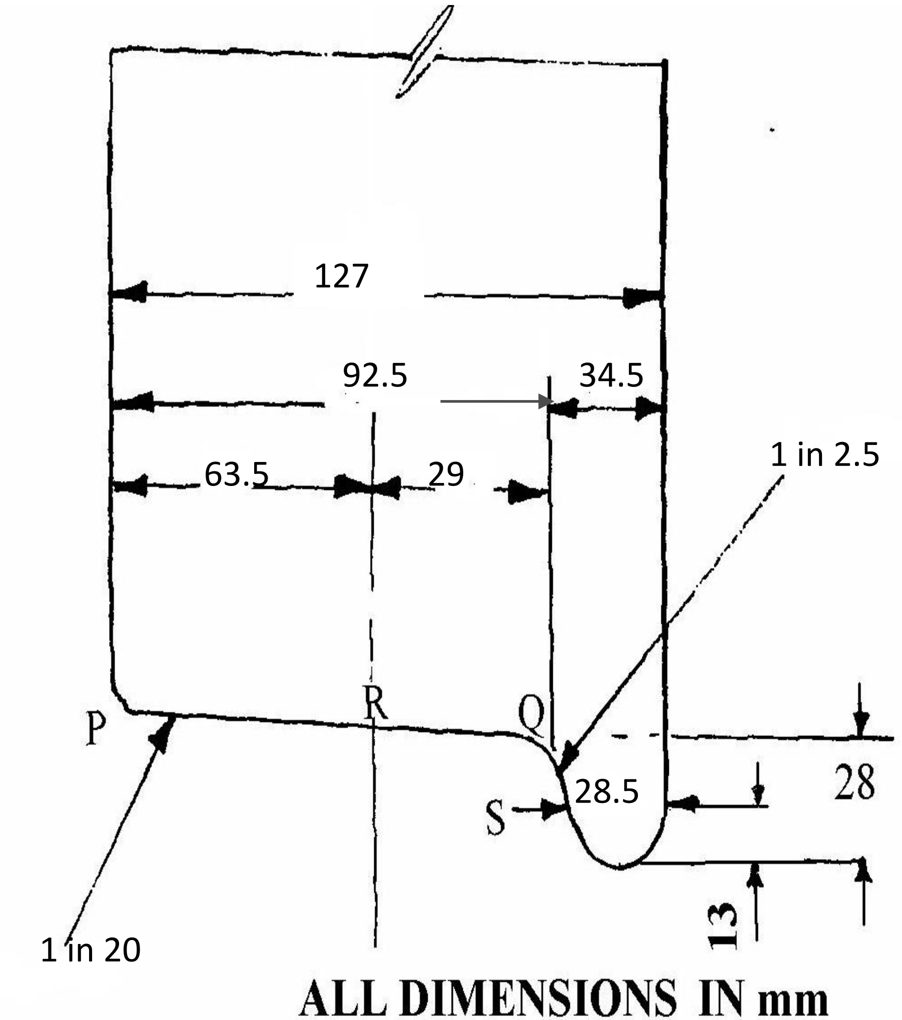
VEHICLES WITH UNEVEN BUFFER LEVELS ON A GRADIENT DEVELOPING

BUFFER INTERLOCKING



VEHICLES WITH UNEVEN BUFFER LEVELS IN BUFFER INTERLOCKED CONDITION

CONICITY OF WHEEL TREAD



Dia at R……. D 'say'

Dia at P……. D – (65÷20)x 2 or D – 6.5

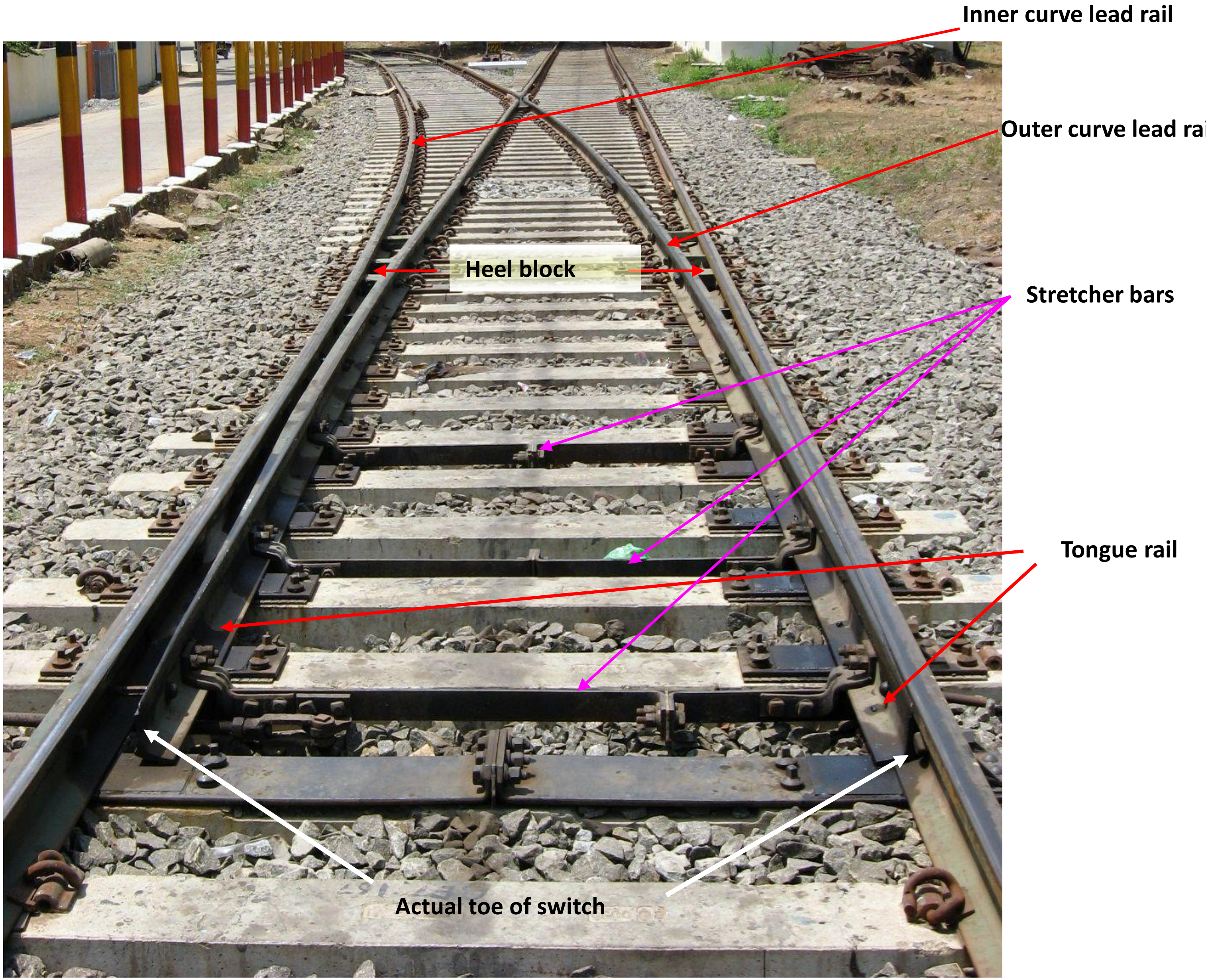
Dia at Q…… D + (31÷20)x 2 or D + 3.1

For a new wheel, thickness of flange at S = 28.5

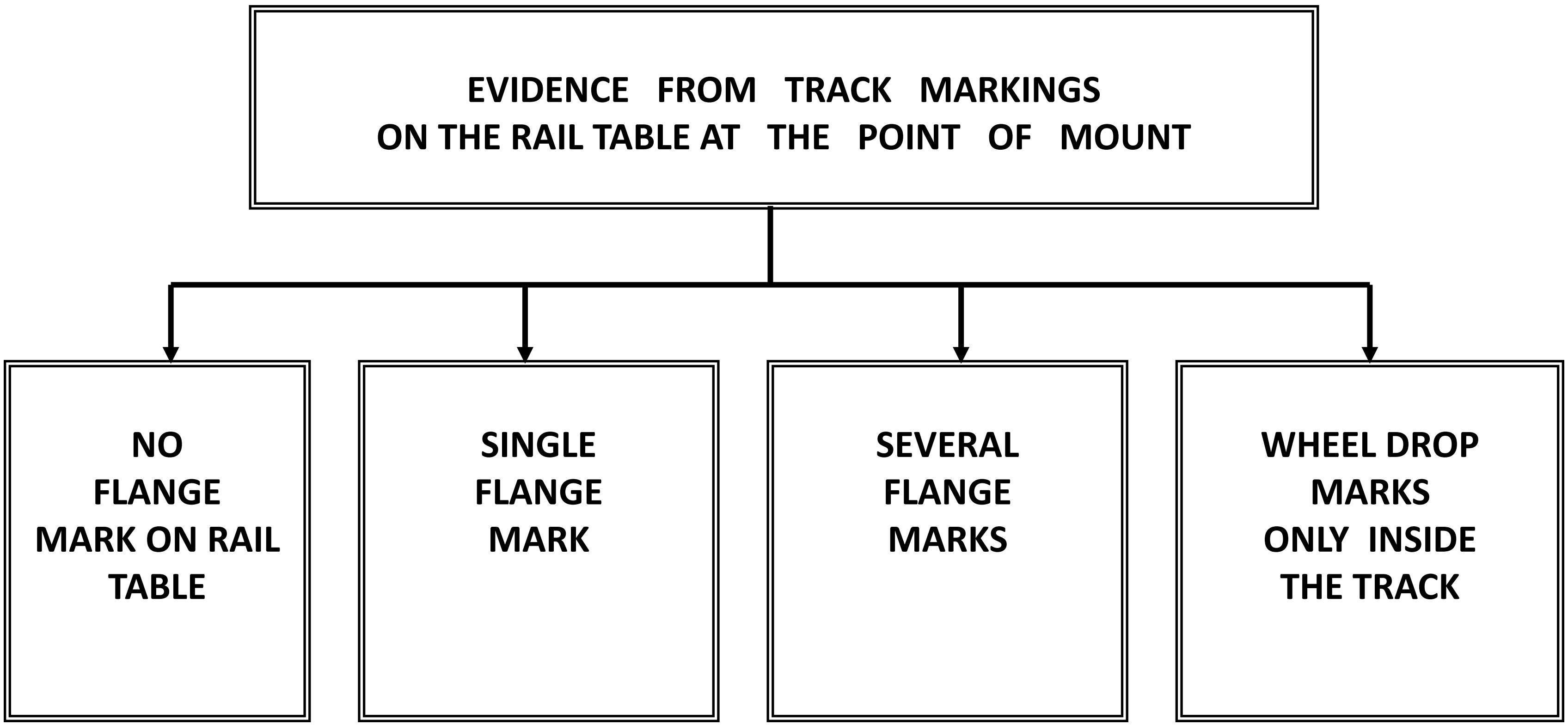
Thickness of flange at Q…

28.5 +[(28-13) ÷2.5]

= 34.5



Inner curve lead rail
Outer curve lead rail
Heel block
Stretcher bars
Tongue rail
Actual toe of switch


EVIDENCE FROM TRACK MARKINGS
ON THE RAIL TABLE AT THE POINT OF MOUNT
NO FLANGE MARK ON RAIL TABLE
SINGLE FLANGE MARK
SEVERAL FLANGE MARKS
WHEEL DROP MARKS ONLY INSIDE THE TRACK

Derailment

- **Definition** – Derailment of rolling stock is defined as a wheel or set of wheels leaving their due place from the rail top surface.

Theoretical Aspects

1. **Derailment mechanism**
2. **Wheel off loading**
3. **Vehicle oscillation**
4. **Lateral stability of track**

Reasons for Derailment

- P. way defect
- C&W defect
- Signal defect
- Loco defect
- Operational defect
- etc.
- etc.

Derailment Mechanism

- μ Frictional force
- Q Stabilising load
- Y Lateral force

- Y/Q has a major contribution in determining derailing tendency of the rolling stock.

Type of derailments:

(a) **Sudden derailments** –

Instant dismounting of wheel from track.

(b) **Gradual derailments** –

Gradual climbing of flange on the rail.

Sudden derailments

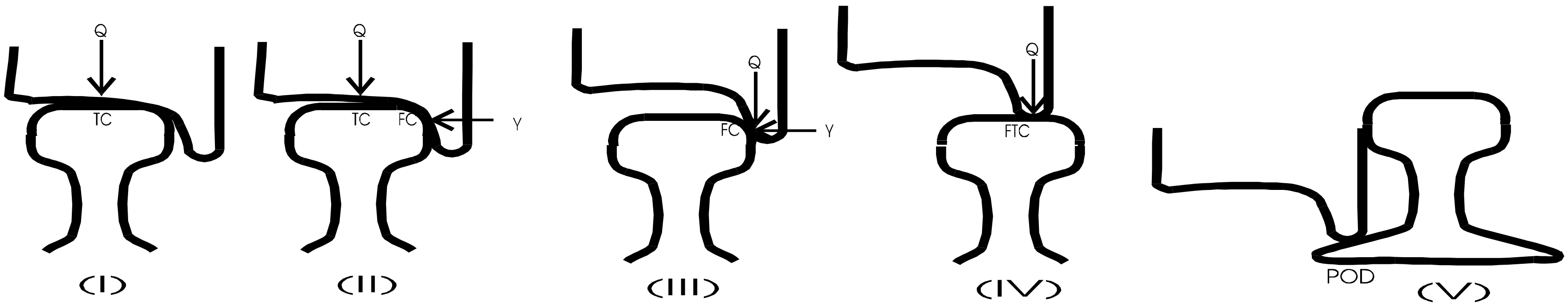
Causes –

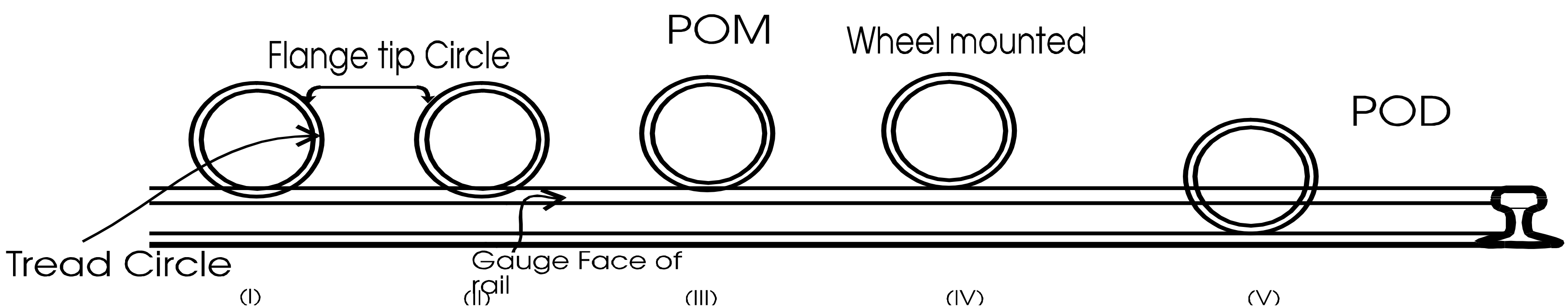
- Sudden shifting of load
- Improper loaded vehicle
- Excessive speed on curve or turn out
- Sudden variation in draw bar forces induced due to improper train operations(sudden braking or acceleration)
- Broken wheels/springs or suspension gear components.
- Failure of track or vehicle component
- Obstruction on track.

Gradual derailment

- The cause of accident may be singly or normally jointly any of the following:
  - (i) Track defects
  - (ii) Vehicle defects
  - (iii) Unfavorable operating features

Stages of Flange Climbing in gradual derailment





Gradual Derailment

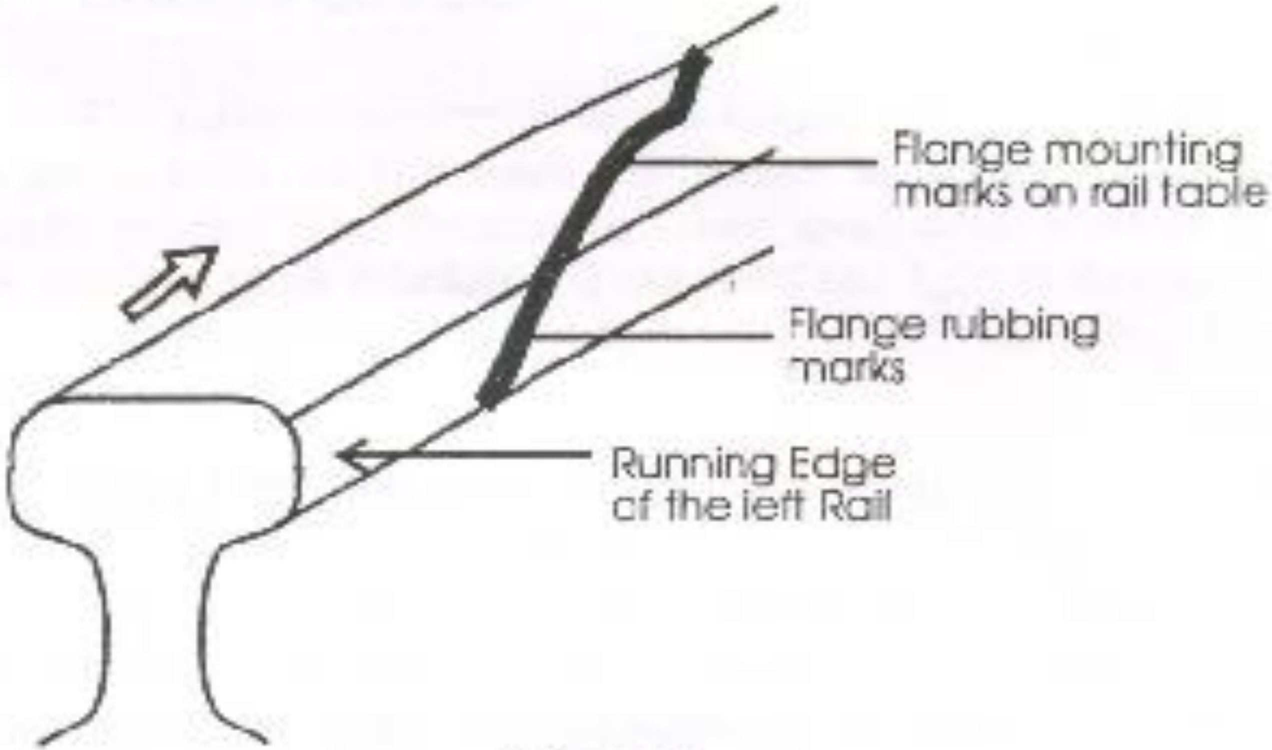


Fig. 4.7

4.5.5 . How To Measure Gauge

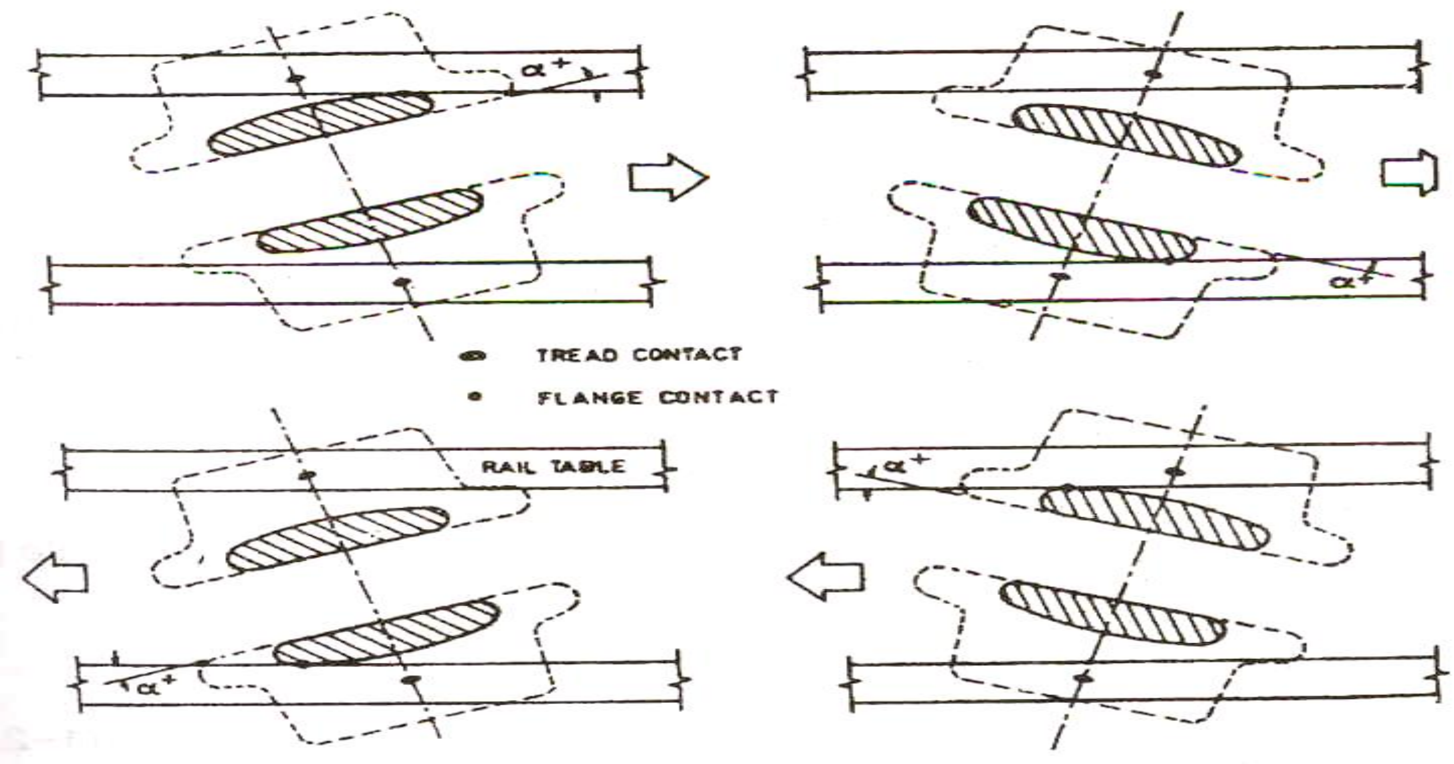
Wheel off loading

- **Nominal wheel load** – It is half the axle load as obtained when defect free vehicle with non eccentric loading on level track with perfect geometry.
- **Instantaneous wheel load**– It is the wheel load at any given instant of time during the motion of a wheel set. It constantly varies time.
- **On loading of wheel**
- **Off loading of wheel**

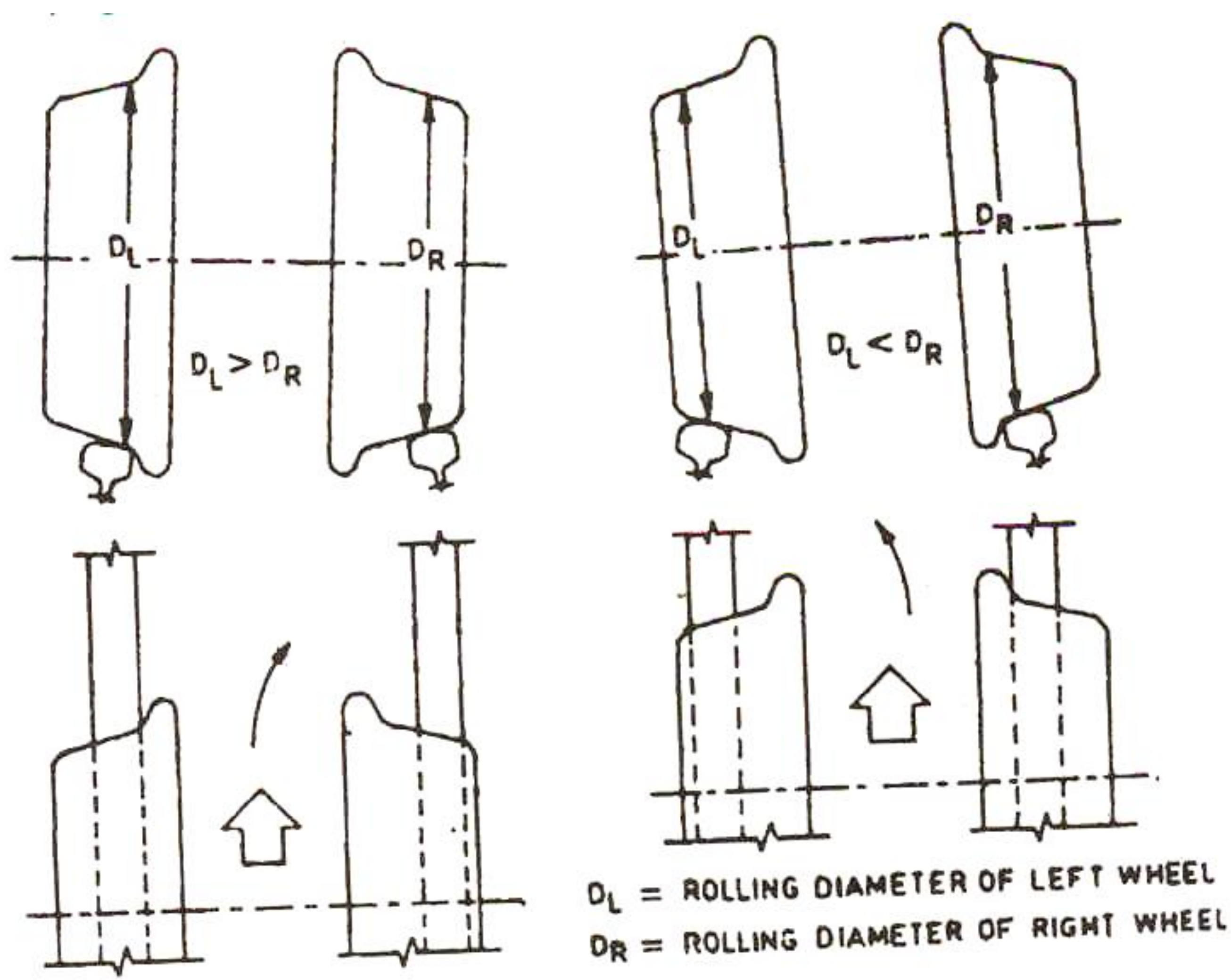
Angle Of Attack

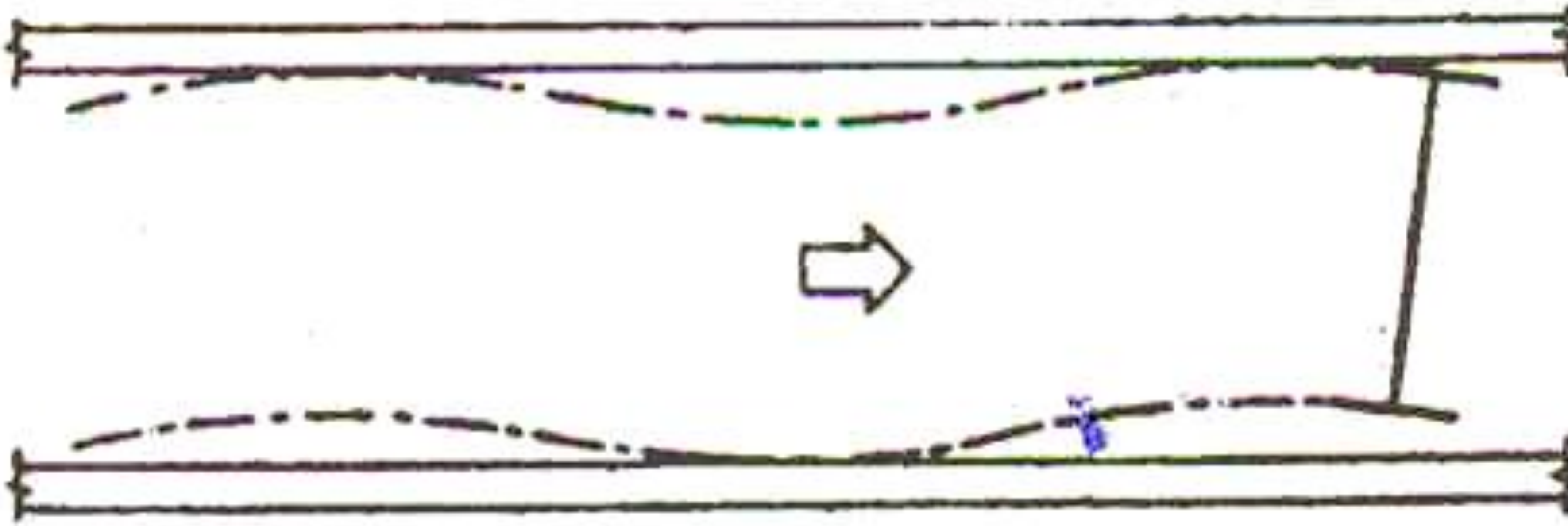
ANGULARITY OF AXLES

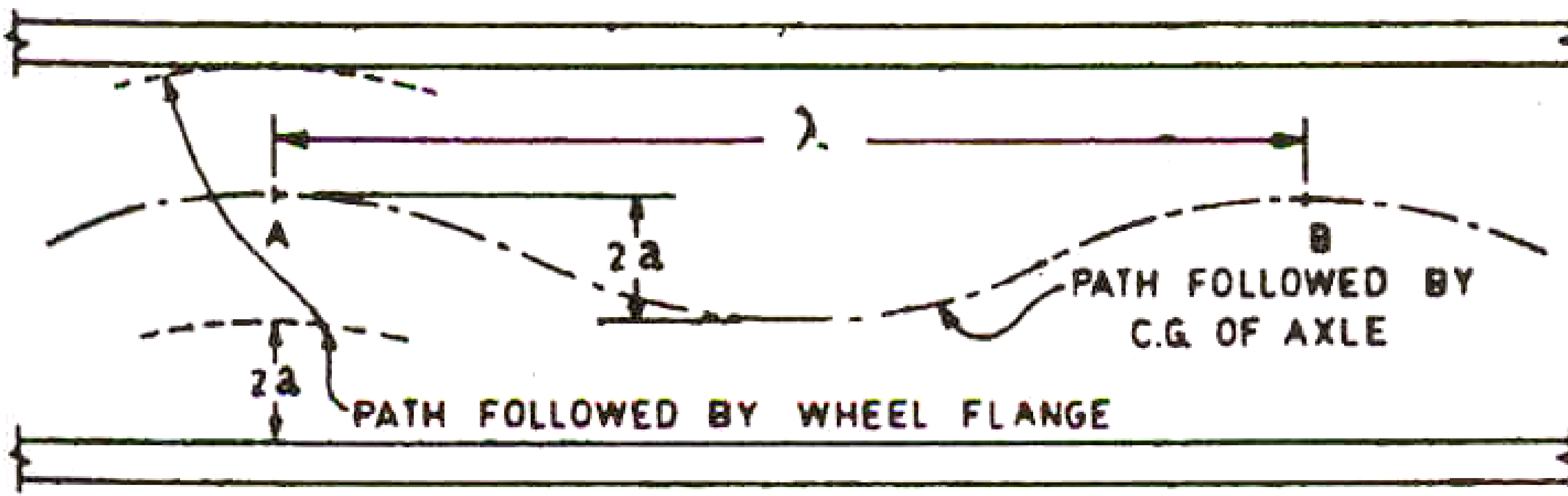
ANGULARITY due to Sinusoidal Motion caused by lateral clearance provided.



SINUSOIDAL MOTION OF FREE ROLLING WHEEL SET






λ
A
B
2a
2a
PATH FOLLOWED BY
C.G. OF AXLE
PATH FOLLOWED BY WHEEL FLANGE

Positive angularity

The flange contact leads the tread contact. It is called a case of leading contact. The longitudinal distance between the tread and flange contacts being called **positive eccentricity.**

Positive angularity

tive angle of attack (see fig. 1.7).

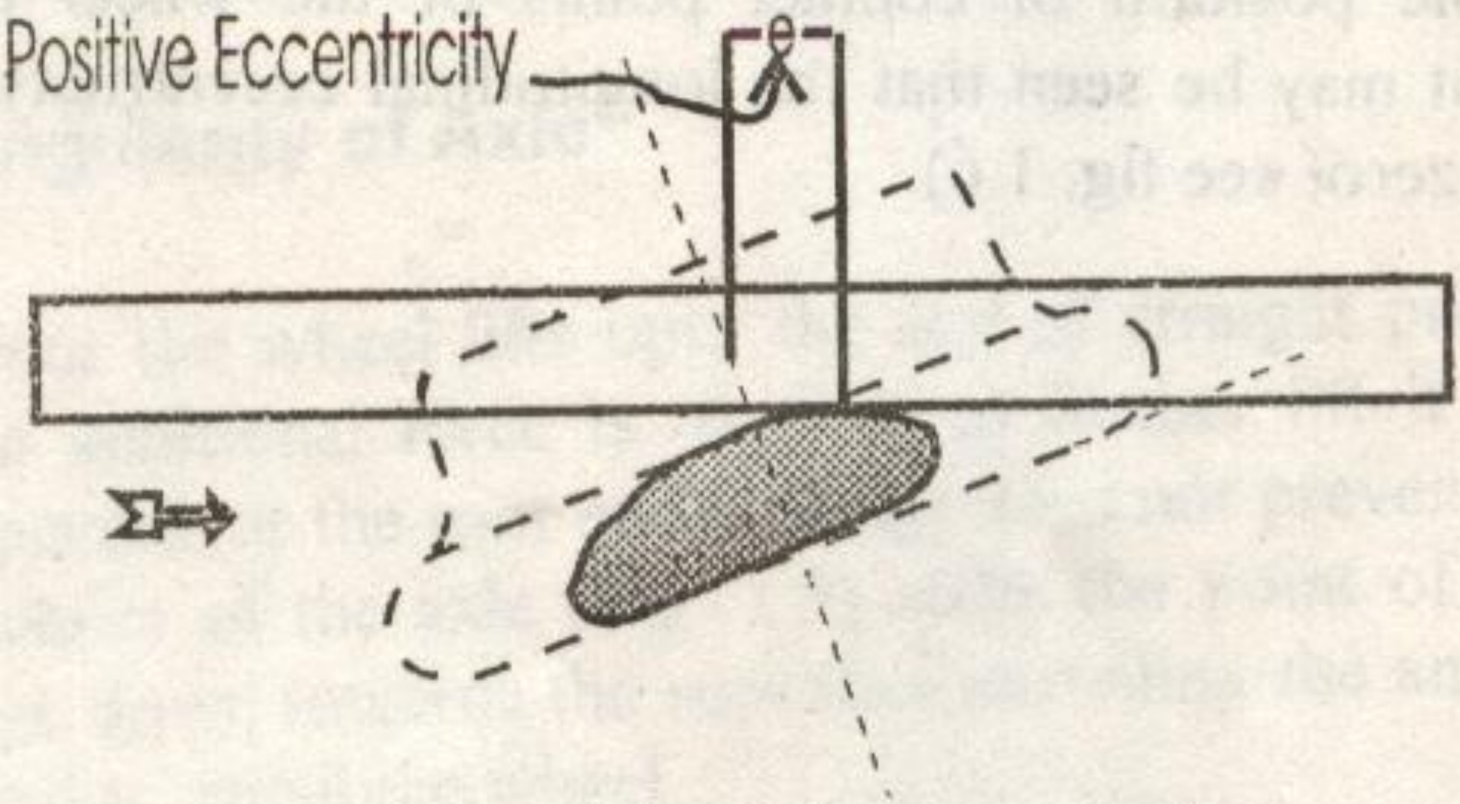


Fig. 1.7 Positive Angularity

Negative angularity

- In this case the wheel set makes flange contact near its trailing edge. The flange contact trails the tread contact. It is a case of trailing contact, the longitudinal distance between the two contacts is called – ve eccentricity.

Negative angularity

1.8).

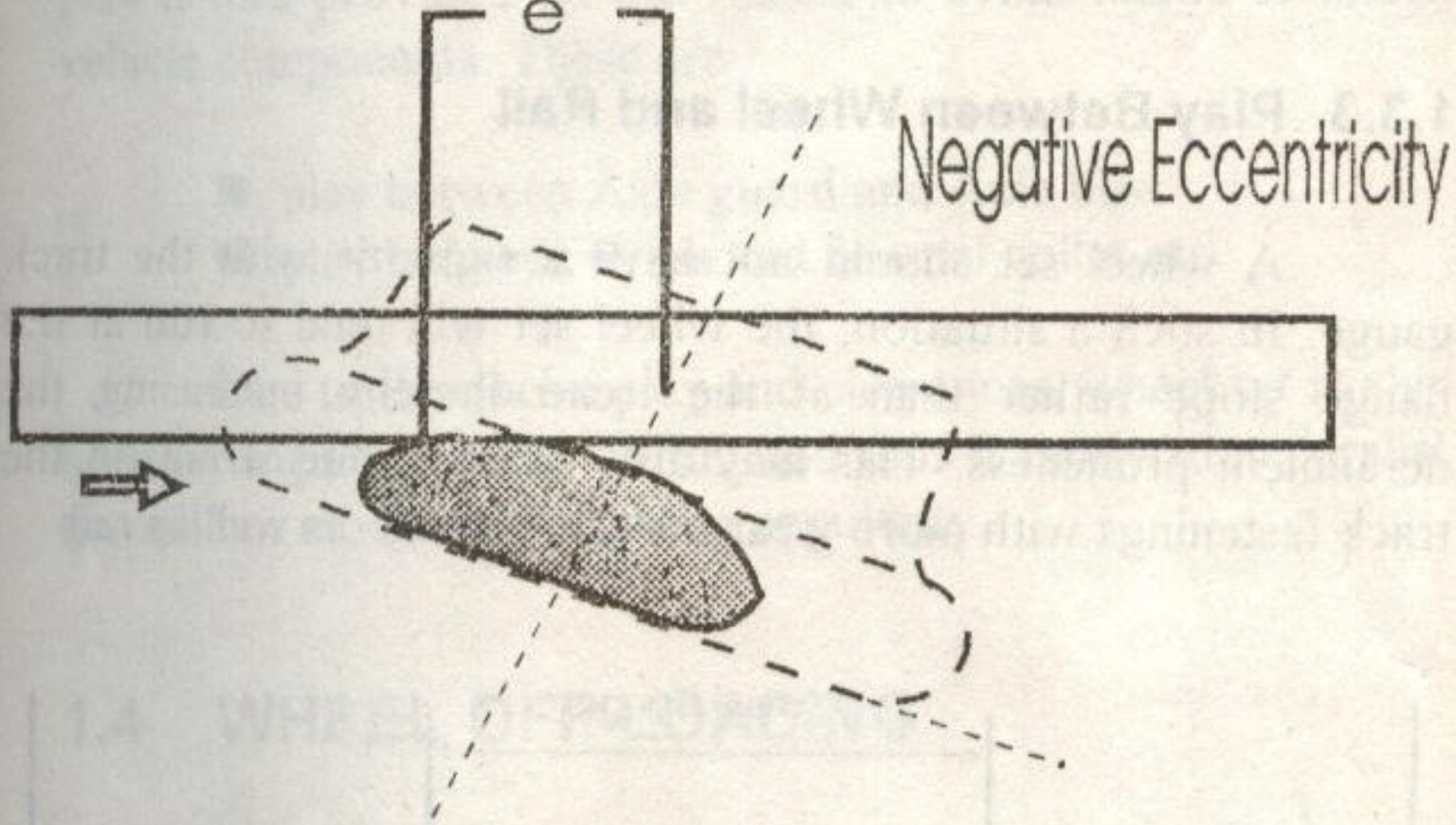


Fig. 1.8 Negative Angularity

Zero angularity

- In this case the frictional force acts horizontally as shown in sketch.

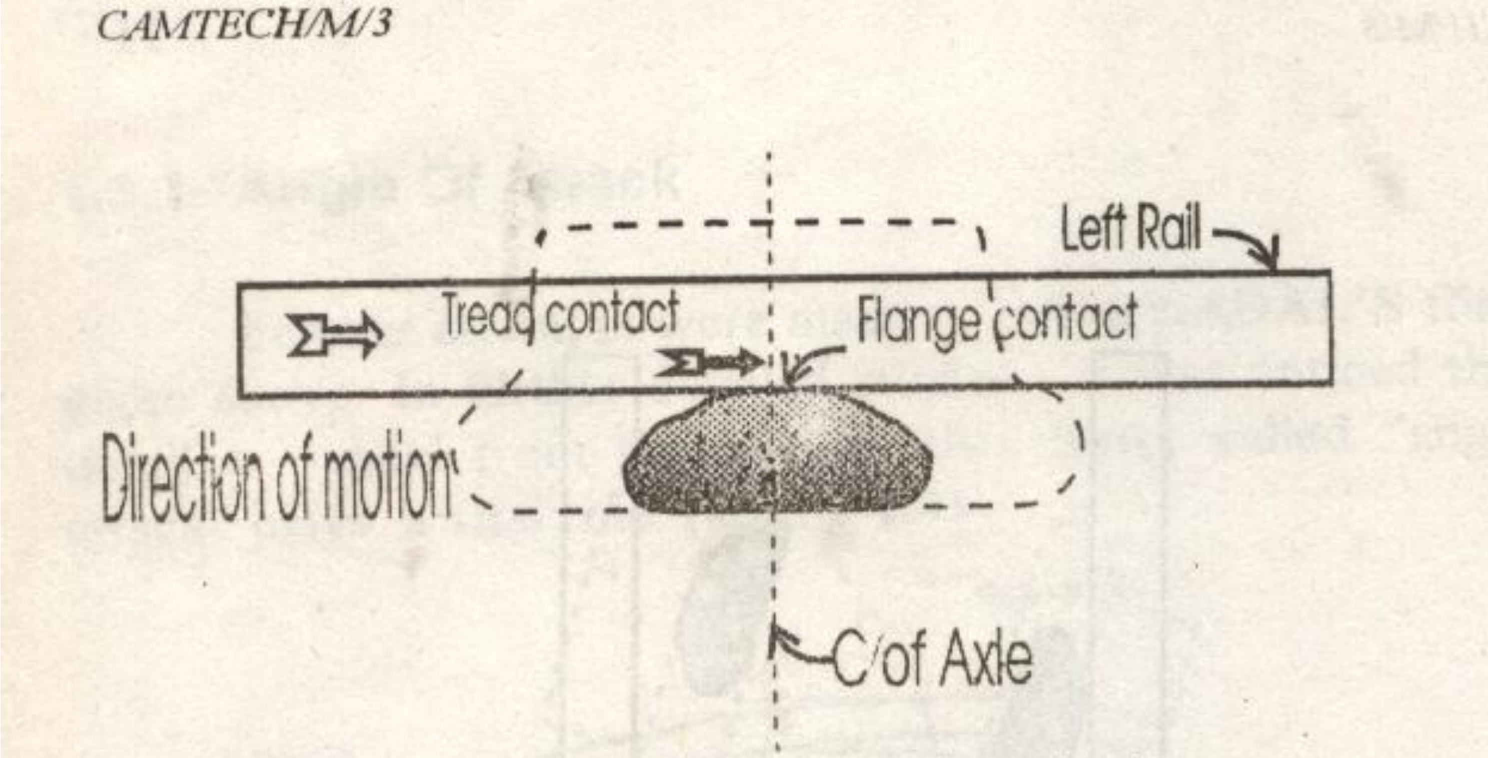


Fig. 1.6 Zero Angularity

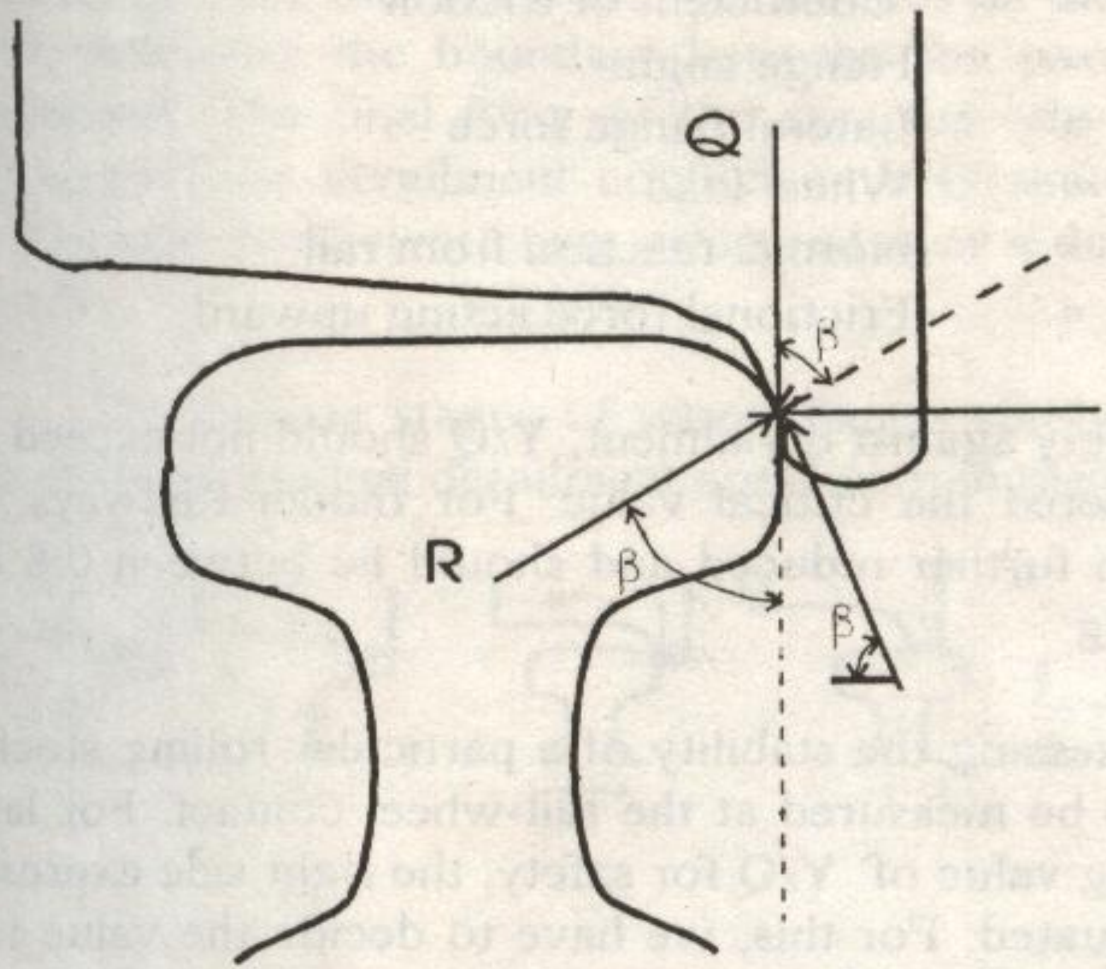
Positive Angularity is Most Critical

- In the case of positive angularity, the wheel flange rubs against the rail in a down ward arcing motion resulting in frictional forces acting upwards.
- In the case of negative angularity, the frictional forces will be directed downwards.
- In the case of zero angularity, the frictional force acts horizontally.

Derailment Reasons

- Unless cause is obvious e.g. Axle Breakage, Cattle run over etc , thorough investigation is necessary which find role of track and vehicle to cause:-
  - Flange force Y to increase
  - Wheel load Q to decrease
  - Angle of attack to increase
- List of defects help in analyzing and determining the most probable cause of derailment.

Derailment Mechanism



FORCES AT RAIL-WHEEL CONTACT

- $Y/Q = (\tan\beta - \mu) / 1 + \mu \tan\beta$

Where, μ = coefficient of friction

β = Flange angle

Y = Lateral flange force

Q = Wheel load

R = Normal reaction from rail

For safety Y/Q should not exceed 1.4 (considered as the critical value).

It should lie between 0.8 & 1 for safe running.

- THANKS

SITE INVESTIGATION

1. To locate the initial point of derailment
2. To identify the first derailed vehicle and wheel
3. To obtain sufficient evidence to determine the course of events up to the time derailed train came to a halt and
4. To explain why the vehicle derailed initially at that particular point on the track.

SITE INVESTIGATION

- sequence :

1. First considerations
2. Site sketch
3. Flange marks
4. Operational Defects/Failures
5. Track survey and examination
6. Vehicle examination

1. First considerations

- The sequence of events to be recorded i.e. how derailment occurred prima facie, from the beginning to the time the train came to a halt.
- The position of vehicles after derailment must be recorded. The wheel marks at the initial point of derailment are to be examined in order to establish the category of derailment i.e. sudden or gradual.
- It is important that such a survey must be completed before the restoration work commences on the track especially in the rear of point of derailment.

2. Site sketch

- A sketch of the whole site showing the position of derailed vehicles relative to both rails.
- Other evidences if any together with the track damages must be prepared.
- If this is not done, serious difficulties will be encountered later when this evidence is required for correlating the events relating to vehicle and track interaction.

3. Flange marks

- The most important thing in investigating the derailments
- To locate and examine the wheel mounting marks with the following details :

  A. Length

  B. Profile or path followed after mounting

  C. Whether marks are strong or faint

  D. Whether continuous or broken

  E. Single/multiple marks

Preferably, photographs should be taken not only of mounting marks found on the rail but also those found on the sleeper fastenings and ballast.

4. Operational Defects/Failures

- Speed
- Loading
- Wrong Marshalling
- Mismanipulation of Point
- Operating Staff Failure
- Improper Train Operation by the Driver

DERAILMENT ON CURVES

ADVERSE FACTORS ON A CURVE

- Excessive angular wear on the outer rail
- Excessive flattening of head on the inner rail
- Fracture and failure of rails
- Gauge widening
- Track distortion

Degree of Curve V/S Radius of Curve

- The degree of a curve (D) is the angle subtended by the curve at its centre by a chord of 30.5 metres.
- The relationship between radius and degree of a curve is given by the equation :

D = 1750/R

Hence for :

1 deg. curve, R = 1750 meters
2 deg. curve, R = 875 meter
4 deg. curve, R = 438 meter and so on.

Super-elevation

- centrifugal force acting away from the centre in a radial direction
- **$F = WV^2 / GR$**

Where :

F - Centrifugal force in tons

W - Weight of the vehicle in tons.

V - Speed in feet /sec

G - Acceleration due to gravity in feet / sec^2

R - Radius of the curve in feet

Super-elevation

- To counter this centrifugal force, outer rail on the curves is kept little higher than the inner rail known as **Cant** or **Superelevation**.

- The equilibrium super elevation is given by :

  e = GV2 / gR

- In metric system : **e = GV2 /127R**

  where:

  e- Equilibrium super elevation

  G- Gauge + Width of rail head in mm

  V- Velocity

  R- Radius of the curve

Note : The cant for each curve is normally indicated on the web of inside face of inner rail to the nearest 5mm.

VERSINE

- Versine is the perpendicular distance measured in mm from the centre of the chord line to the arc between two marked stations.