MAK 3101
Taşıt Titreşimleri

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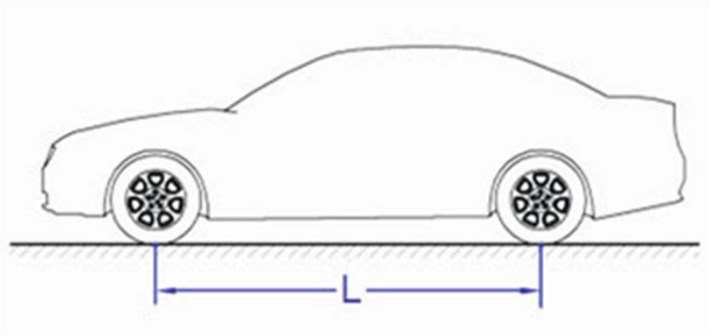
Süspansiyon Kinematiği

- Süspansiyon kinematiği, yönlendirme ve süspansiyonun sıkışması ve genişlemesi esnasında tekerin hareketlerini belirler.
- Süspansiyon kinematiğinin hesap edilebilmesi için şu bilgiler gereklidir:
  - Ağırlık merkezi pozisyonu,
  - Aks ağırlıkları,
  - Aks yükleri,
  - Fren ve tahrik kuvveti dağılımı.

Dingil mesafesi *L*

- Taşıtın xy düzlemi üzerinde, ön teker-yol temas merkezi ile arka teker-yol temas merkezi arasındaki mesafedir.



Dingil mesafesi *L*

Daha uzun dingil açıklığına sahip taşıt:

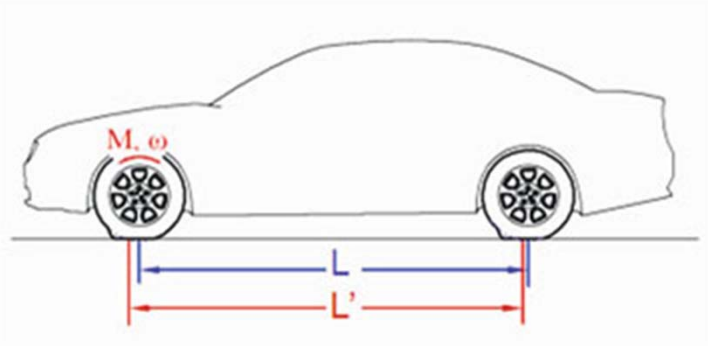
- Yolcular için daha fazla hacim sağlar,
- Daha iyi bir sürüş konforu sunar,
- Daha iyi güvenlik özellikleri sergiler.

Dingil mesafesi *L*

Daha kısa dingil açıklığına sahip taşıt:

- Daha iyi manevra kabiliyetine sahiptir,
- Daha hafiftir ve konstrüktif maliyeti düşüktür.

Dingil mesafesi değişimi



Dezavantajları:

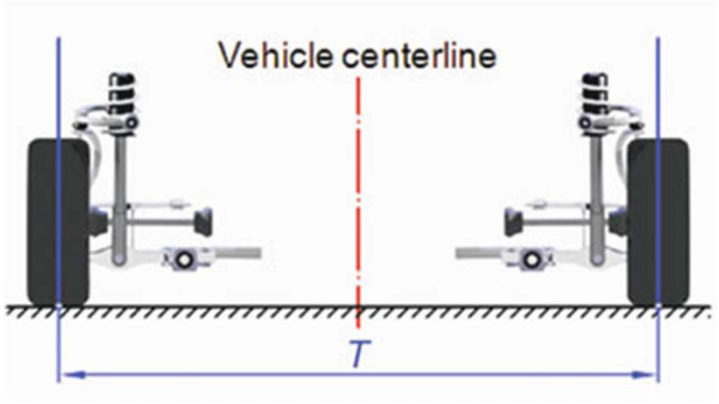
- Teker hızında dalgalanmalar,
- Tahrik sisteminde burulma titreşimleri,
- Teker hız sensöründe hata olasılığı,
- Frenleme esnasında teker zıplaması.

İz genişliği *T*

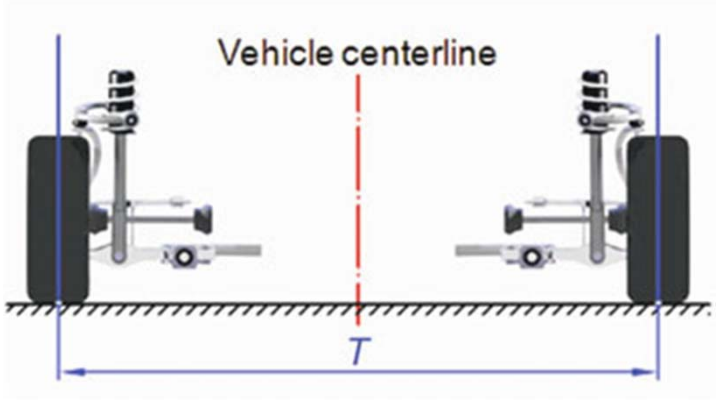
Taşıtın yz düzlemi üzerinde, teker-yol temas merkezleri arasındaki mesafedir.

Uzun iz genişliği:

- Daha iyi sürüş davranışı,
- Daha az gövde devrilmesi,
- İyileştirilmiş dizayn estetiği sağlar.



İz genişliği *T*

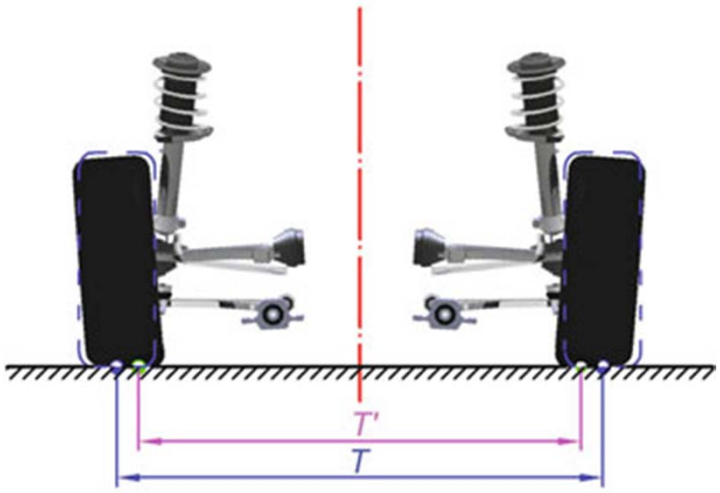


Dar iz genişliği,

- Düşük stabilite,
- Yüksek devrilme yatkınlığı,
- Yolcu ve tahrik sistemi için daha az hacim sağlar.

İz genişliği değişimi

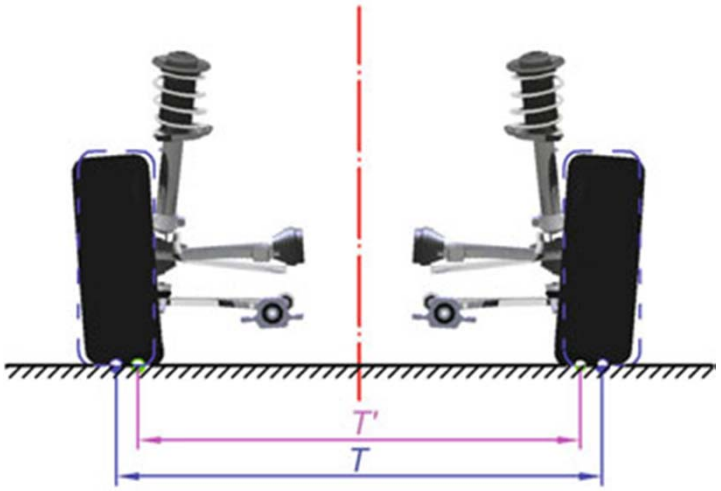
Kamber değişimi ve süspansiyonun hareketi esnasındaki kinematik etkiler tekerin izinin değişimine ve dolayısıyla iz genişliğinin değişimine yol açabilir.



İz genişliği değişimi

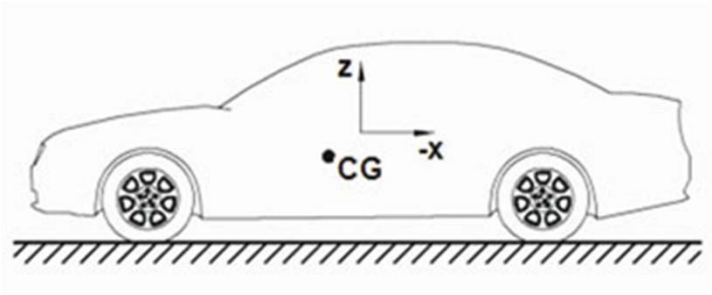
Bu durumun dezavantajları:

- Lastiğin yol yüzeyi üzerinde kayma eğilimine girmesini sonuçlar.
- Düz çizgide seyir kabiliyetini zayıflatır.
- Yanal kuvvetler oluşur.
- Yuvarlanma direnci artar.
- Yönlendirme etkilenir.



Taşıt ağırlık merkezi

Taşıtın ağırlık merkezinin alçak oluşu:

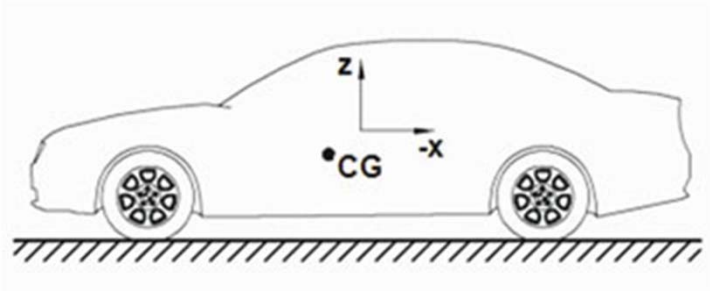


- Daha iyi yol tutuş ve güvenlik,
- Daha az devrilme ve kafa vurma etkisi,
- Eğimli yüzeylerde daha az teker yükü dalgalanmasını sonuçlar.

Taşıt ağırlık merkezi

Taşıtın ağırlık merkezinin yüksek oluşu:

- Eğimli yol şartında arka aks yükünün artışı,
- Devrilme ve kafa vurma eğiliminde artışı sonuçlar.

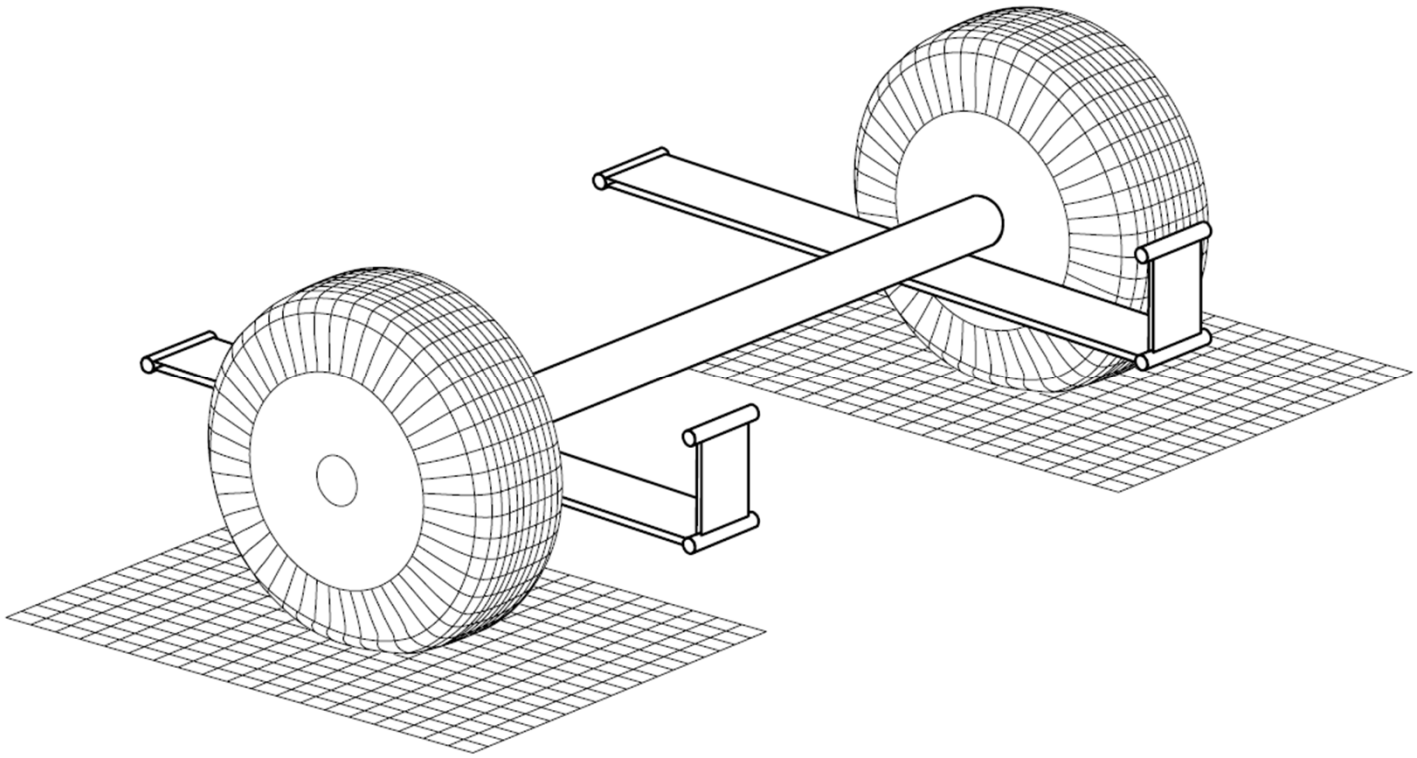


Aks yükü dağılımı

- Taşıt yüksüz pozisyondayken tipik değerleri: 44:56 to 56: 44 aralığındadır.

Bağımlı süspansiyon sistemleri

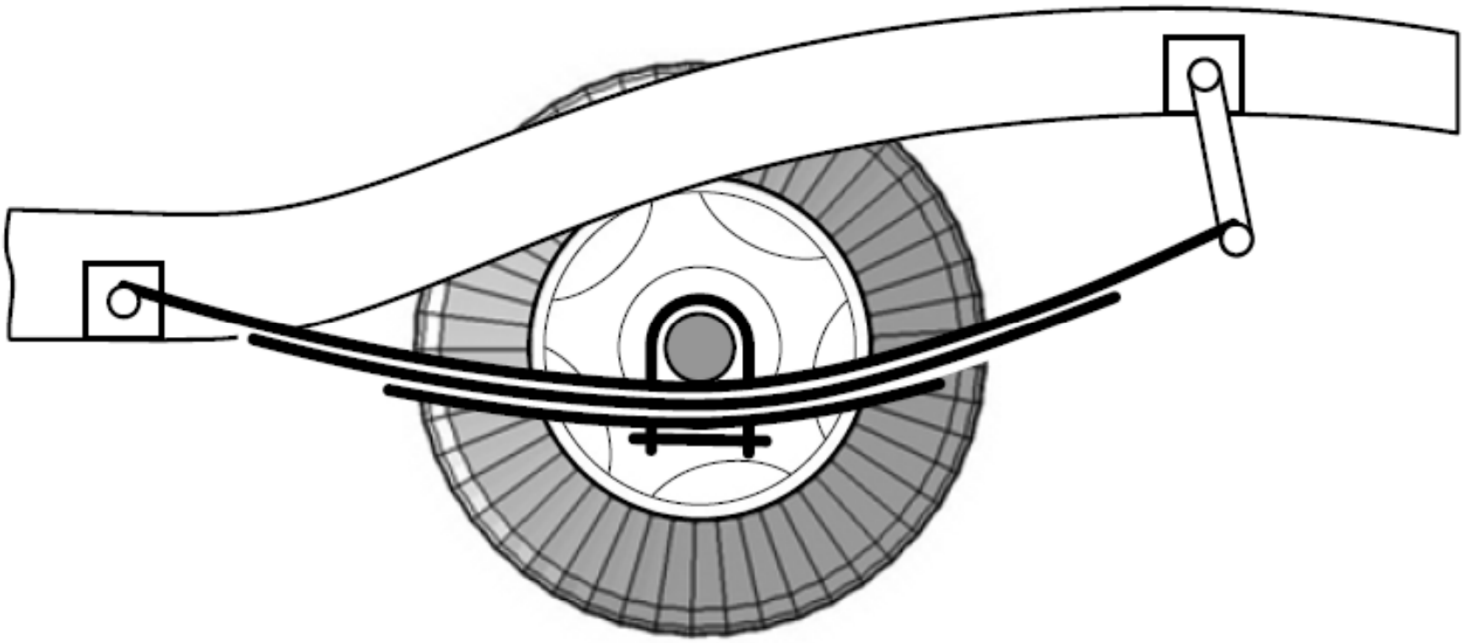
Sağ ve sol tekerler arasında katı bağlantı bulunan aks tipleri bağımlı süspansiyon olarak tanımlanır.



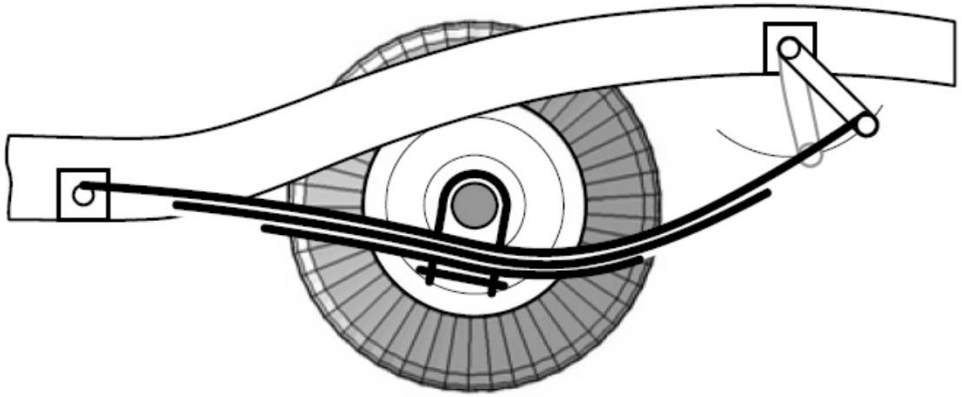
Yaprak yay muhteva eden bir katı aks bağlantısı.

Hotchkiss aks

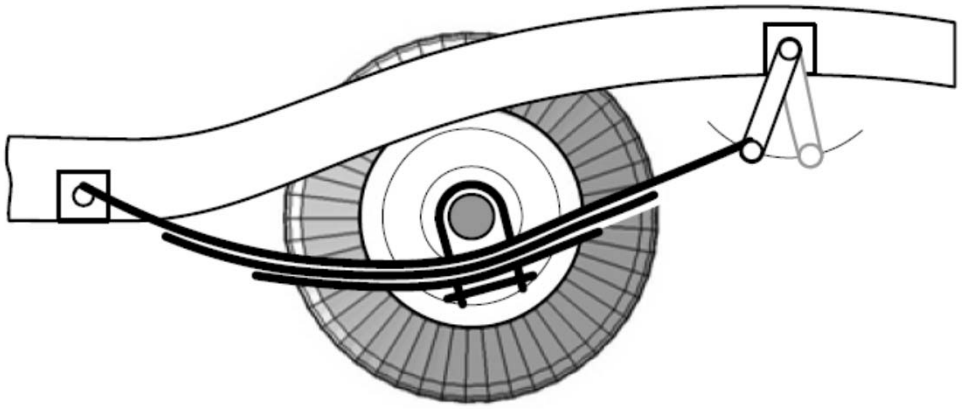
Katı aksın şasiye bağlantısı yaprak yaylar dışında herhangi bir eleman içermiyorsa bu tip aks sistemlerine Hotchkiss aks sistemi denir.



Hotchkiss aks dezavantajları

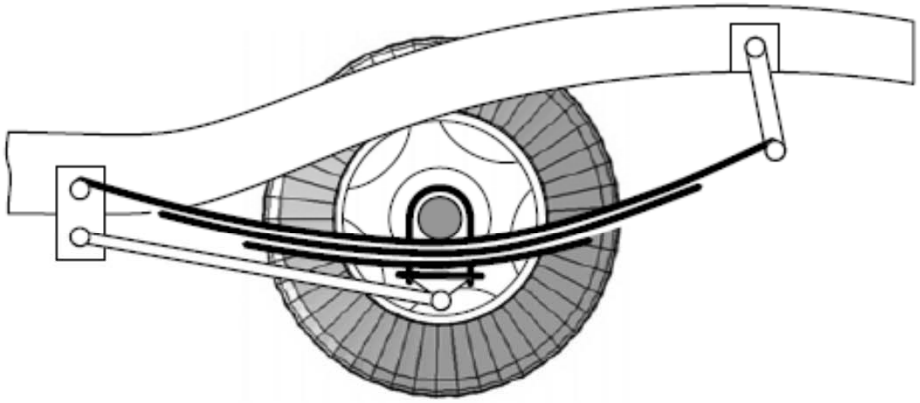


İvmelenme

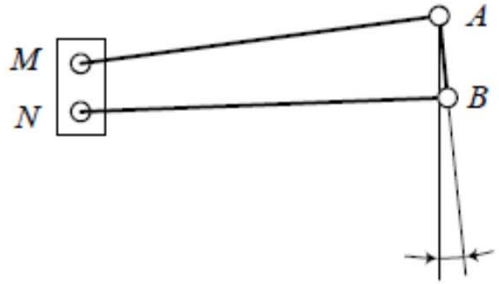


Frenleme

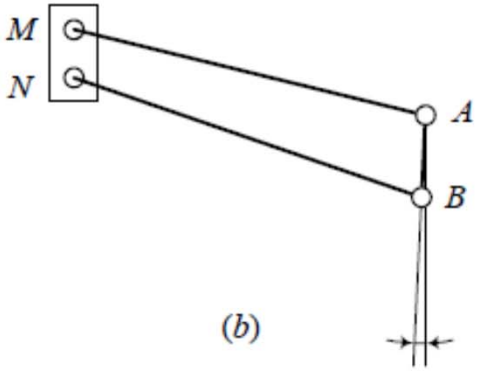
Anti-tramp bar



(a)



(a)



(b)

Hotchkiss drive drawbacks

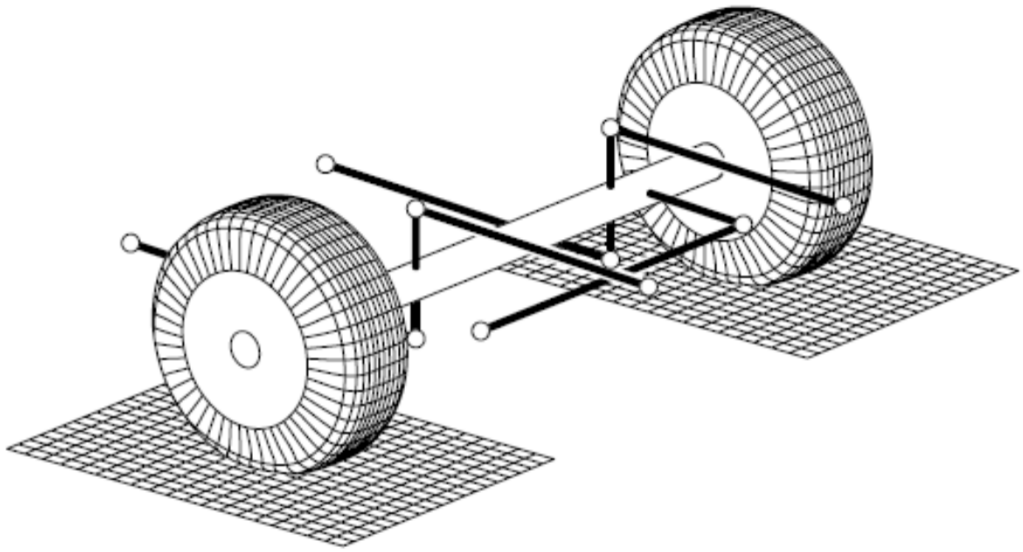
- The front wheels need room to steer left and right. Therefore, leaf springs cannot be attached close to the wheel hubs, and must be placed closer to the middle of the axle. That gives a narrow spring-base, which means that a small side force can sway or tilt the body relative to the axle through a considerable roll angle due to weight transfer. This is uncomfortable for the vehicle passengers, and may also produce unwanted steering. The solid axle positively prevents the camber change by body roll. The wheels remain upright and hence, do not roll on a side. However, a solid axle shifts laterally from its static plane and its center does not remain on the vehicle's longitudinal axis under a lateral force.

Hotchkiss drive drawbacks

- A solid axle produces bump-camber when single-wheel bump occurs. If the right wheel goes over a bump, the axle is raised at its right end, and that tilts the left wheel hub, putting the left wheel at a camber angle for the duration of deflection.

- A solid axle is counted as an unsprung member, and hence, the unsprung mass is increased where using solid axle suspension. A heavy unsprung mass ruins both, the ride and handling of a vehicle. Lightening the solid axle makes it weaker and increases the most dangerous problem in vehicles: axle breakage. The solid axle must be strong enough to make sure it will not break under any loading conditions at any age. As a rough estimate, 90% of the leaf spring mass may also be counted as unsprung mass, which makes the problem worse.
- The unsprung mass problem is worse in front, and it is the main reason that they are no longer used in street cars. However, front solid axles are still common on trucks and buses. These are heavy vehicles and solid axle suspension does not reduce the mass ratio $\varepsilon = ms/mu$ very much. When a vehicle is rear-wheel-drive and a solid axle suspension is used in the back, the suspension is called live axle. A live axle is a casing that contains a differential, and two drive shafts. The drive shafts are connected to the wheel hubs. A live axle can be three to f our times heavier than a dead I-beam axle. It is called live axle because of rotating gears and shafts inside the axle.

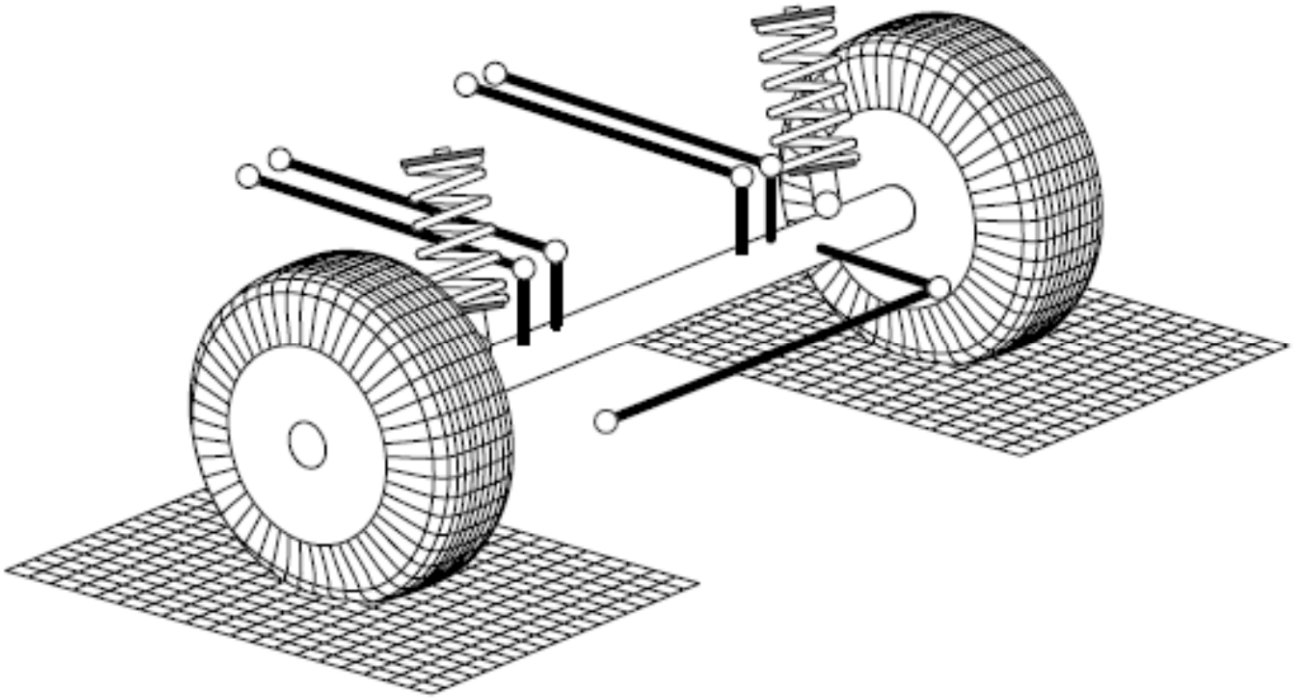
Watt bağlantısı ve Panhard kolu



- Panhard kolu, aksın taşıt koordinat sisteminde y ekseni doğrultusunda kaymasını engeller.

Watt bağlantısı ve Panhard kolu

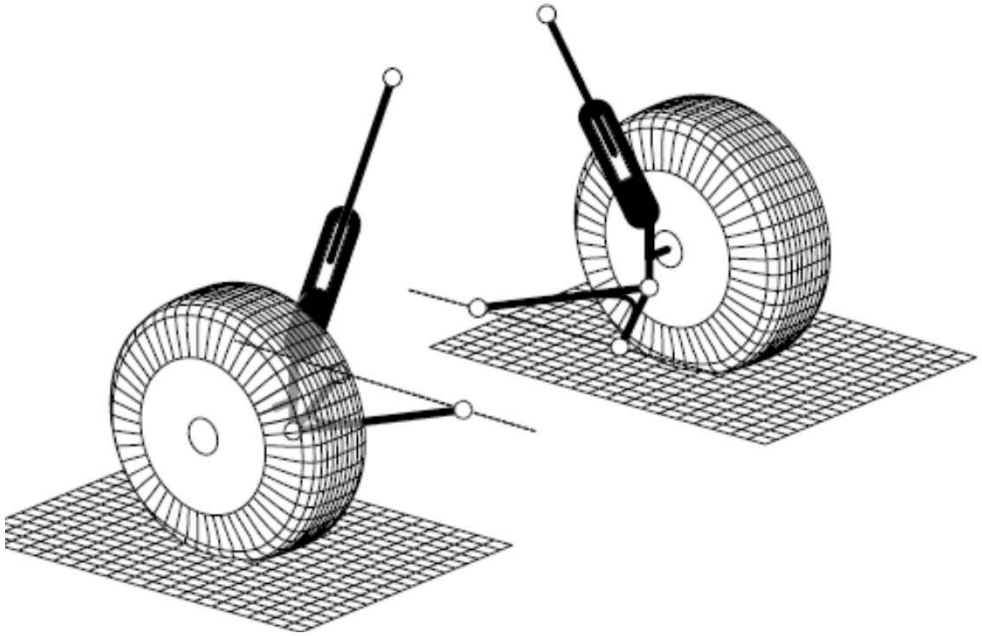
Helezon yaylı katı aks

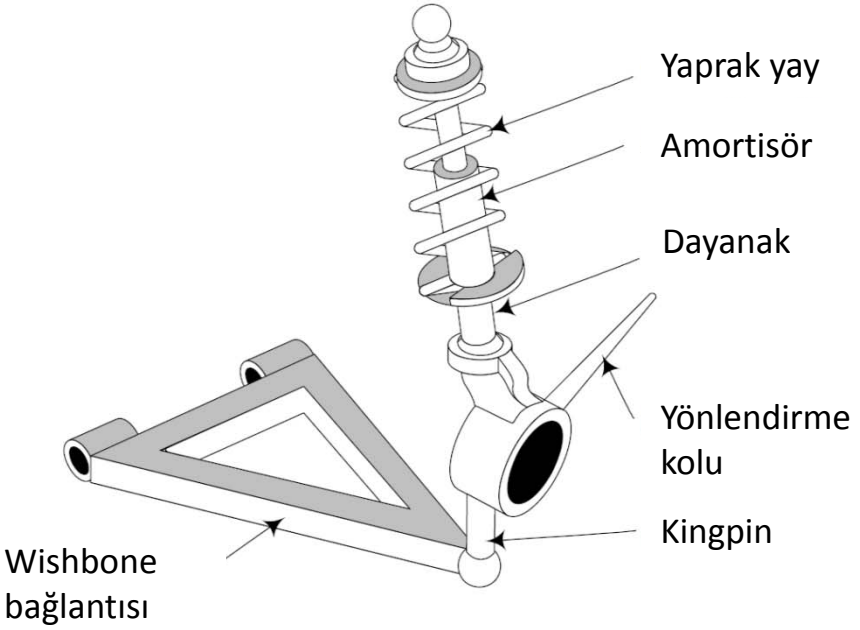


Coil spring solid axle

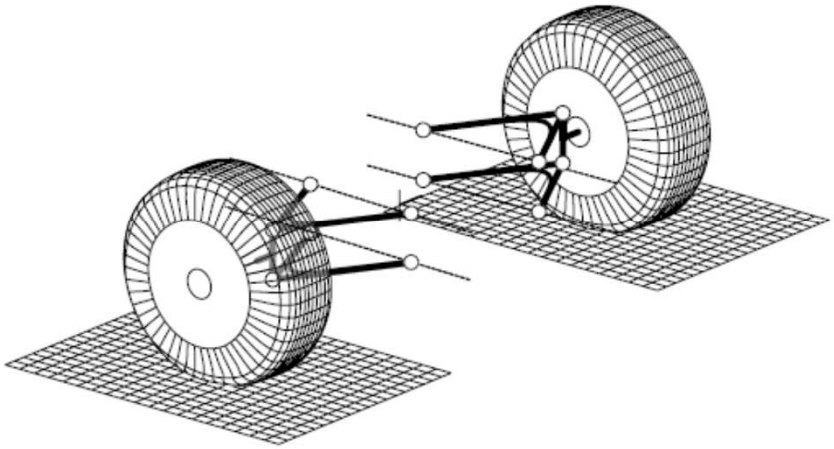
- To decrease the unsprung mass and increase vertical flexibility of solid axle suspensions, it is possible to equip them with coil springs. The suspension mechanism is made of four longitudinal bars between the axle and chassis. The springs may have some lateral or longitudinal angle to introduce some lateral or longitudinal compliance.

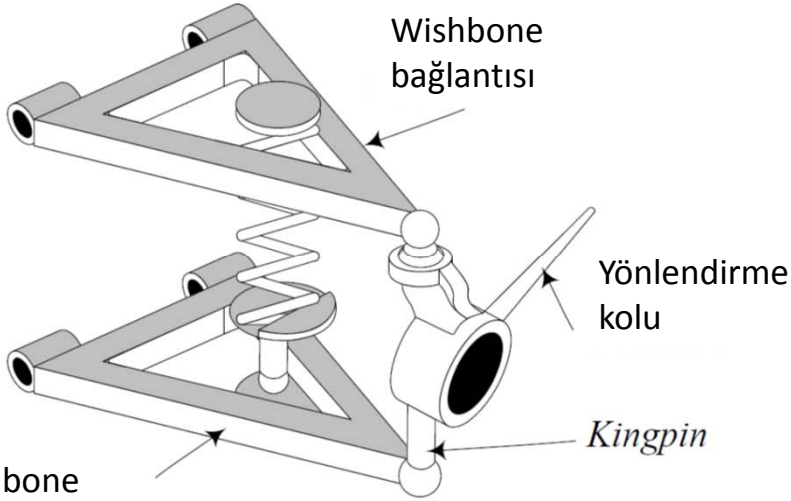
Bağımsız süspansiyon sistemleri





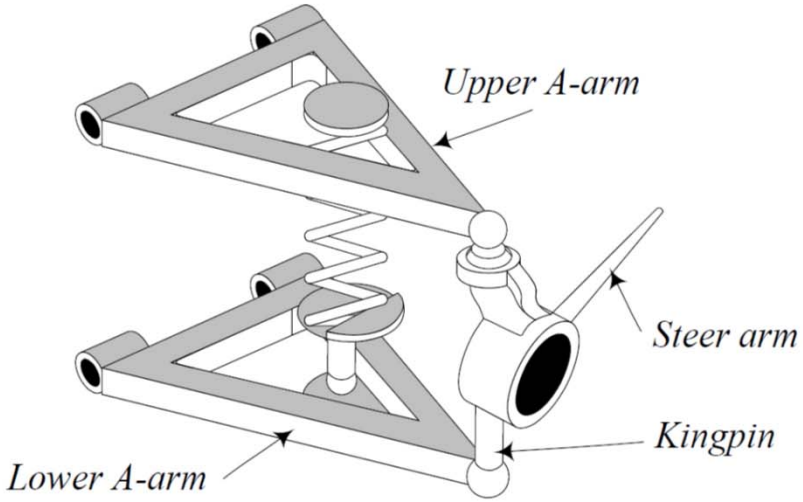
Doble A arm süspansiyon

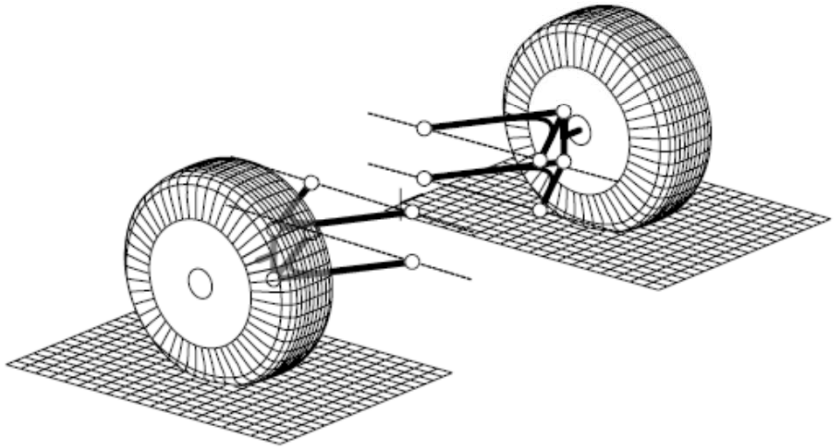




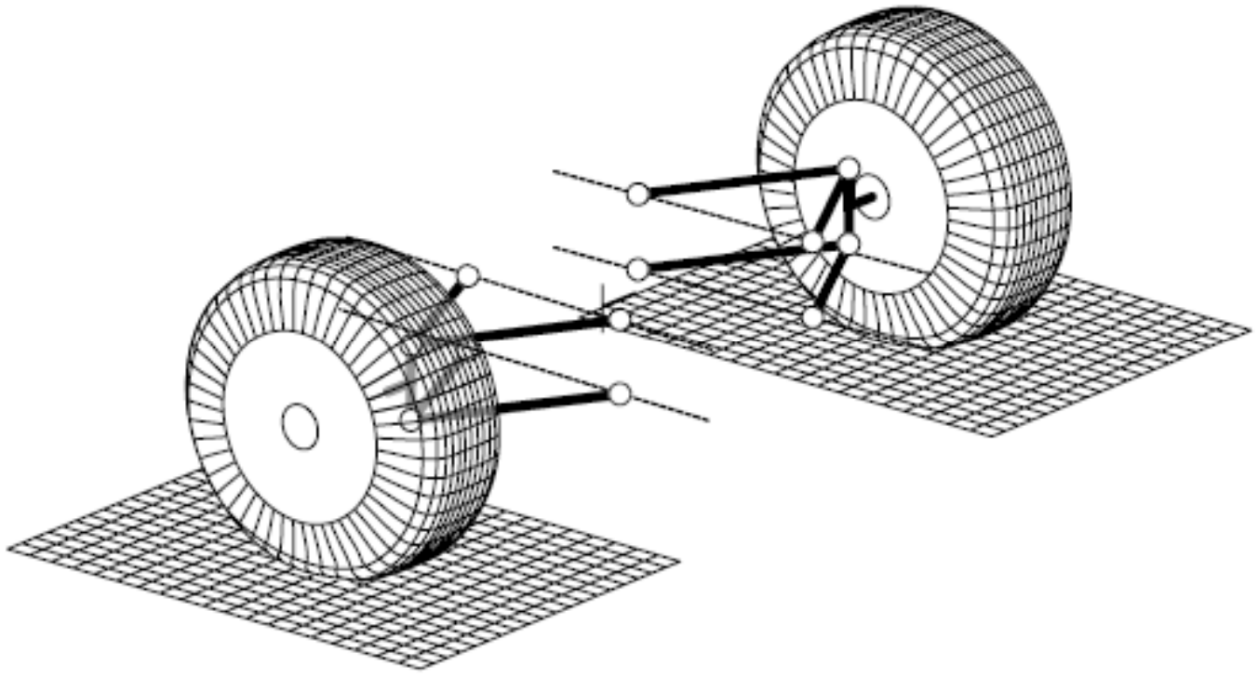
Doble A arm suspension

Consider a double A-arm suspension mechanism. The coil spring may be between the lower arm and the chassis. It is also possible to install the spring between the upper arm and the chassis. In either case, the lower or the upper arm, which supports the spring, is made stronger and the other arm acts as a connecting arm.



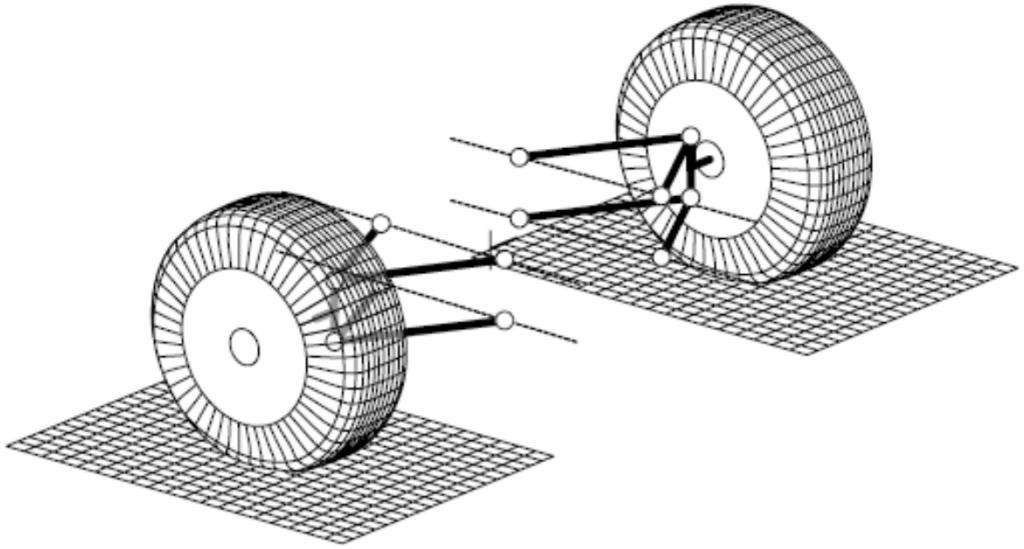


Çok bağlantı noktalı süspansiyon sistemleri

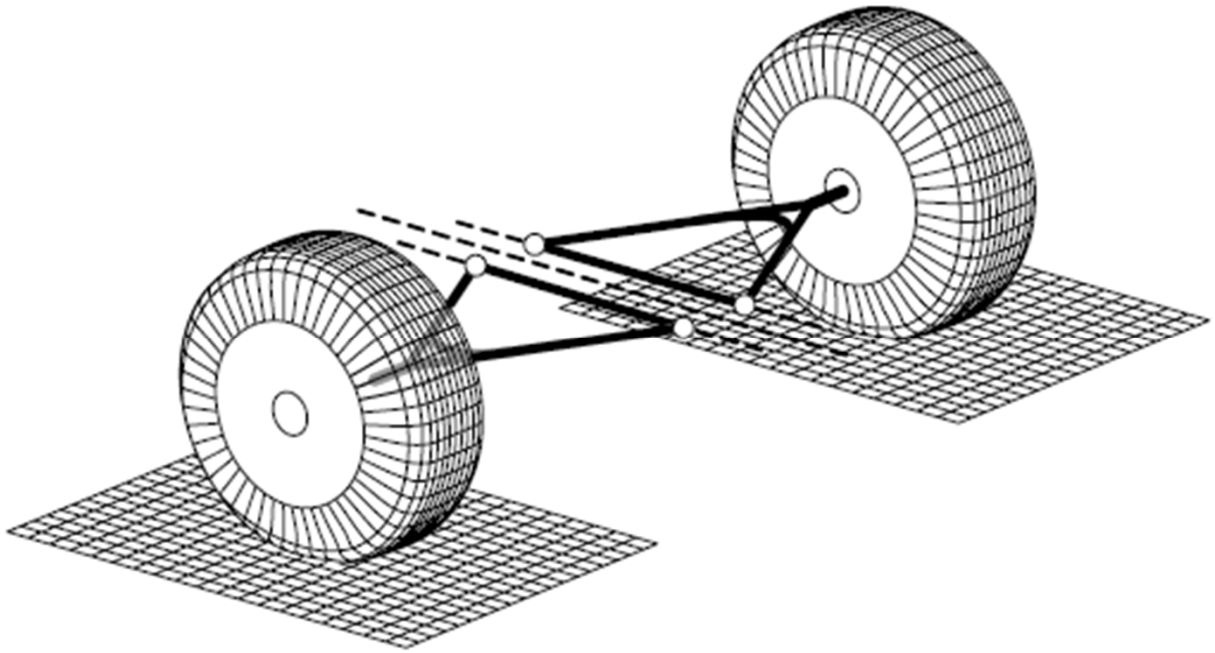


Multi-link suspension mechanism

When the two side bars of an A-arm are attached to each other with a Joint then the double A-arm is called a multi link mechanism. They are more expensive, less reliable, and more complicated compare to a double A-arm four-bar linkage.

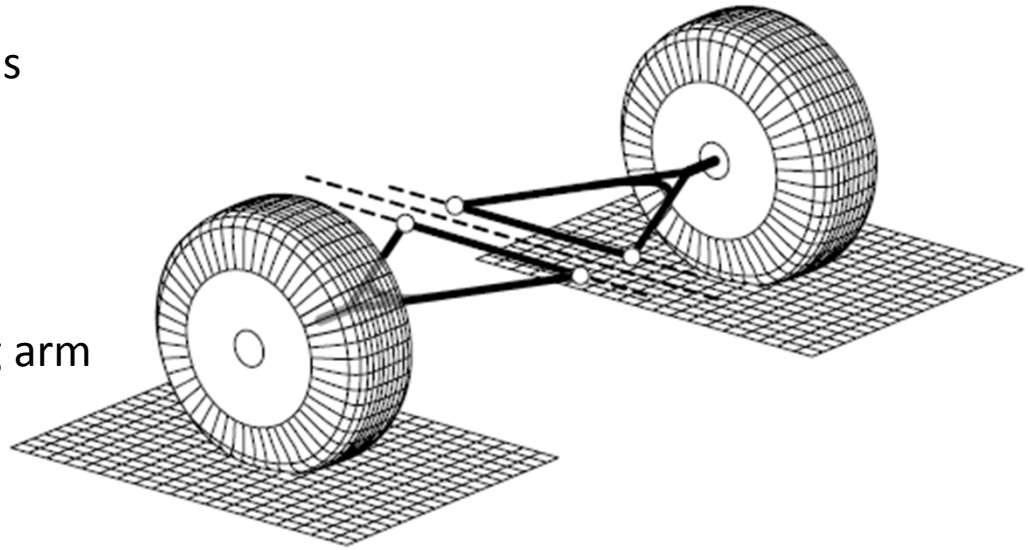


Swing-arm süspansiyon sistemi

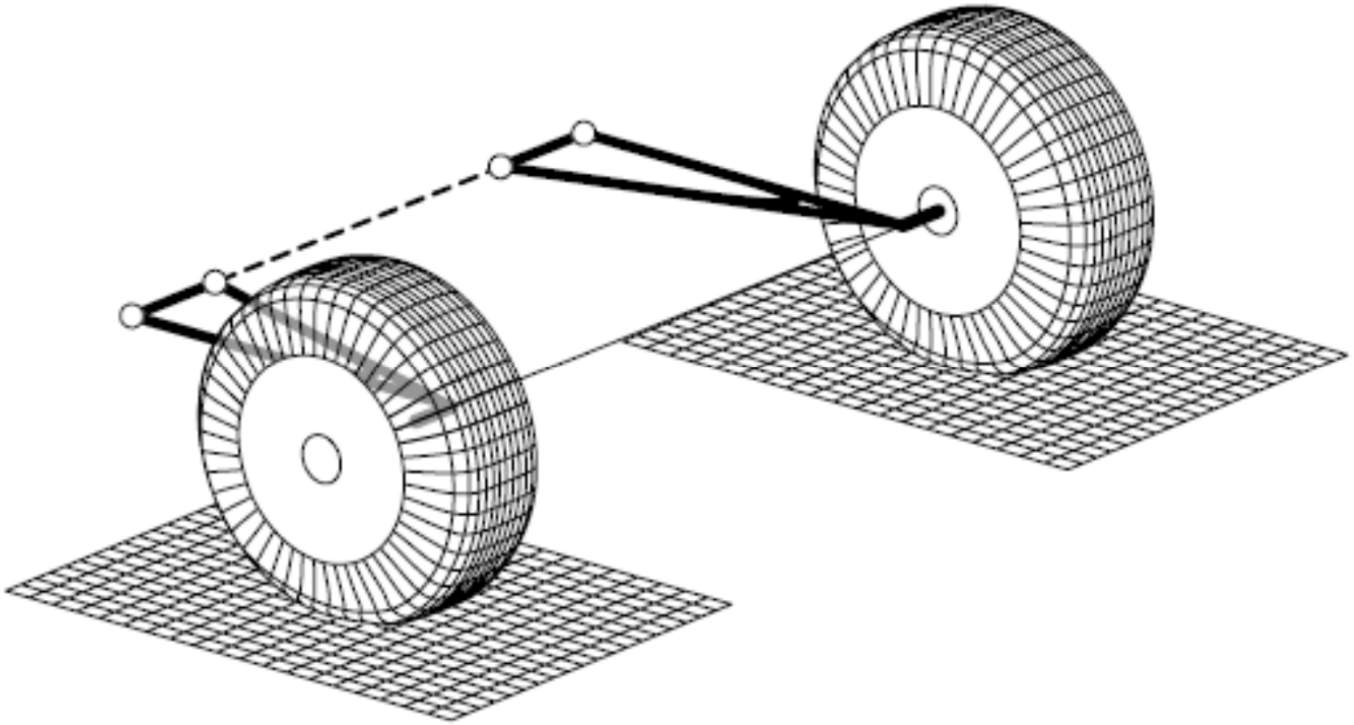


Swing arm suspension

An independent suspension may be as simple as a triangle. The base of the triangle is jointed to the chassis and the wheel to the tip point. The base of the triangle is aligned with the longitudinal axis of the vehicle. Such a suspension mechanism is called a swing axle or swing arm.
The variation in camber angle for a swing arm suspension is maximum, compared to the other suspension mechanisms.

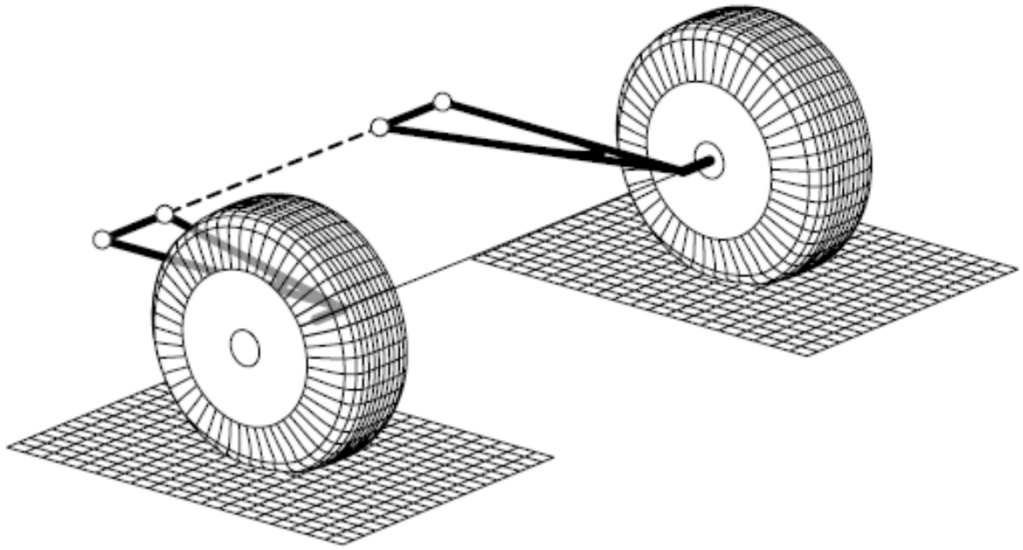


Trailing arm süspansiyon sistemi

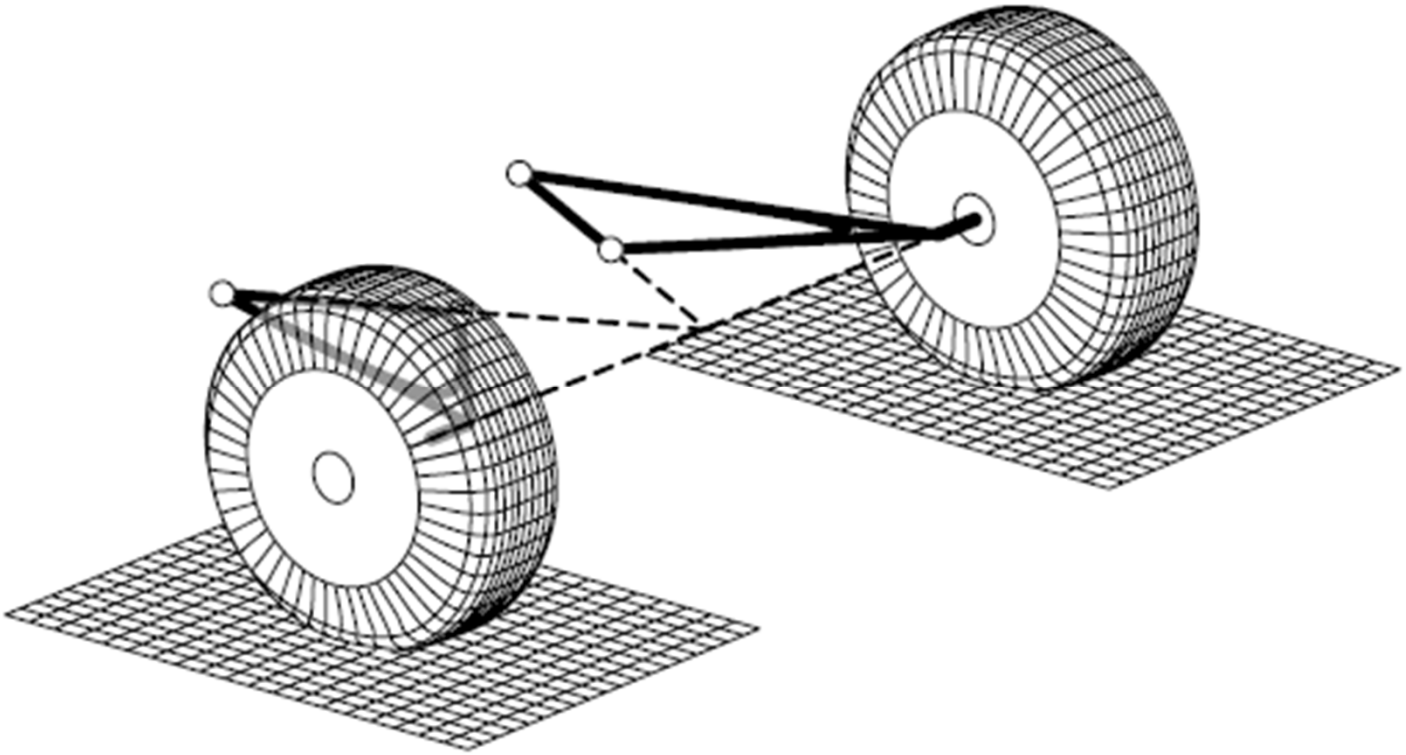


Trailing arm suspension

The camber angle of the wheel, supported by a trailing arm, will not change during the up and down motion

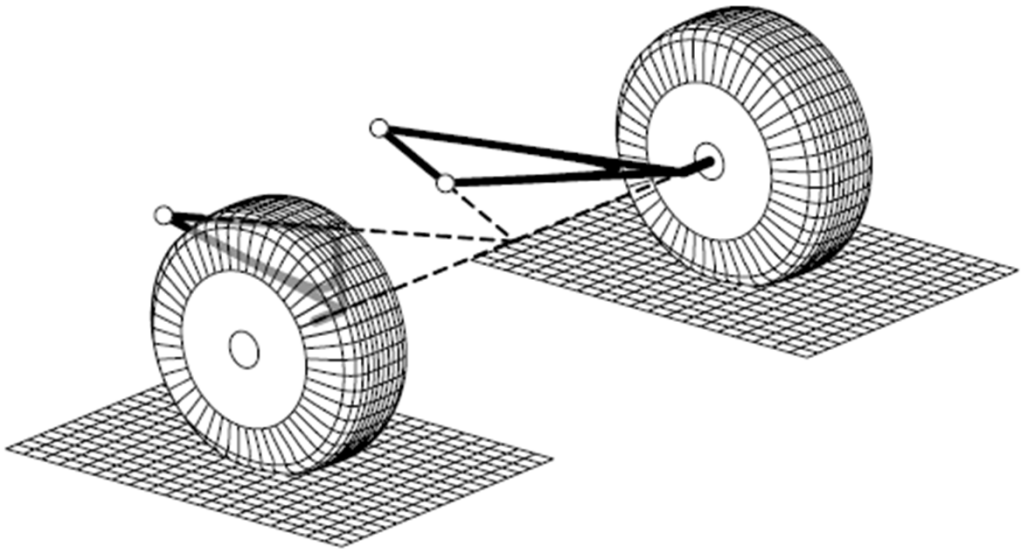


Semi-trailing arm süspansiyon sistemi

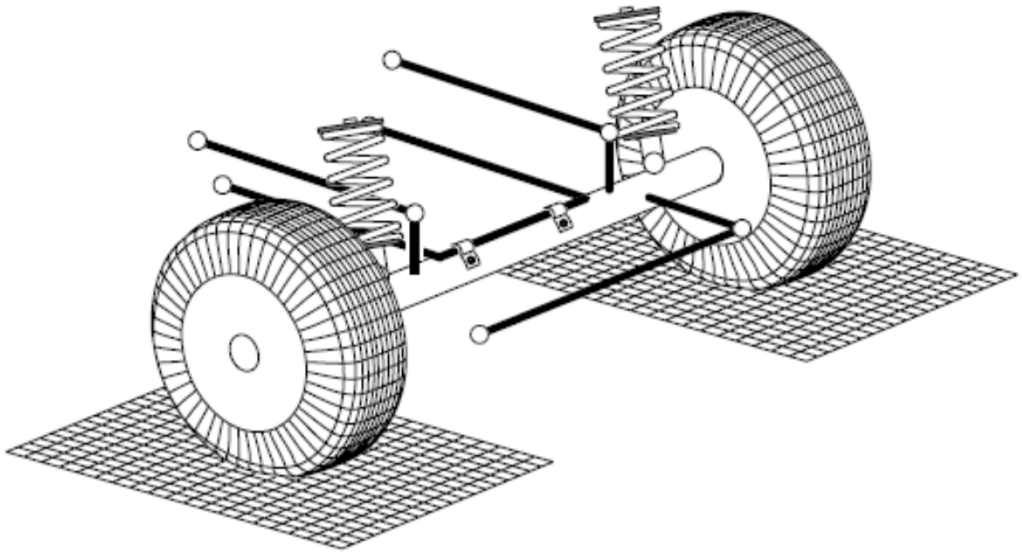


Semi-trailing arm suspension

Semi-trailing arm suspension, is a compromise
between the swing arm and trailing arm suspensions. The joint axis
may have any angle, however an angle not too far from 45 deg is more
applied. Such suspensions have acceptable camber angle change, while they
can handle both, the lateral and longitudinal forces.

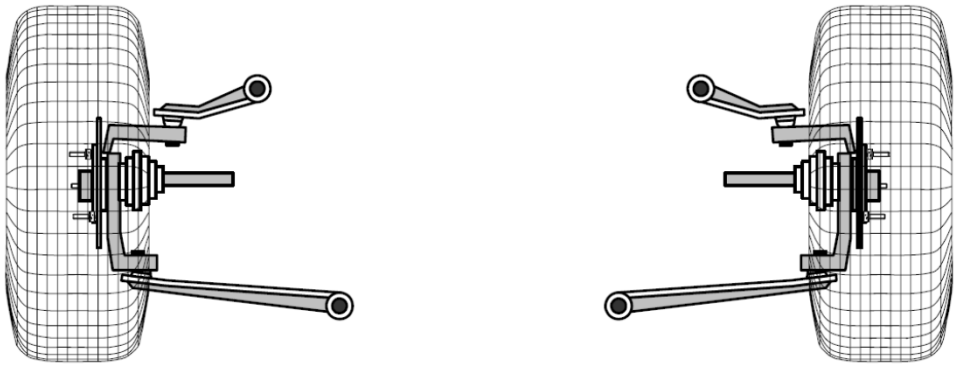


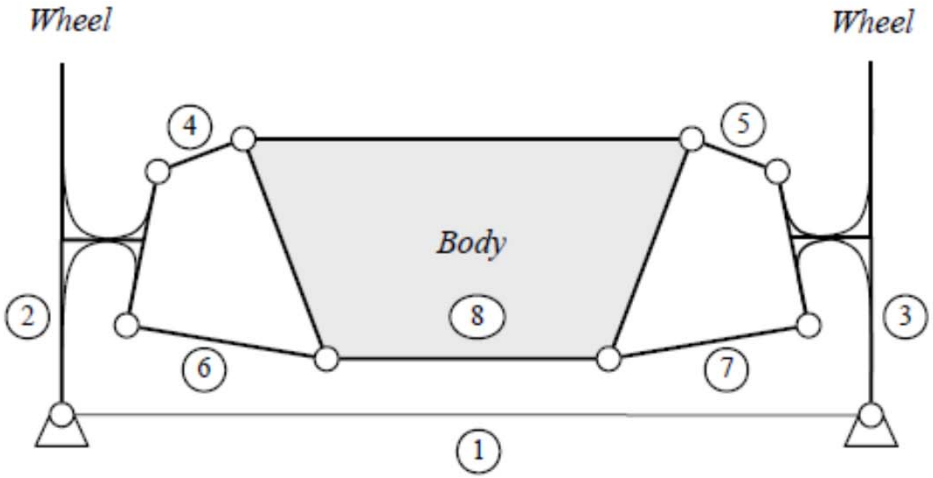
Viraj denge çubuğu



Helezon yaylar, yumuşaklıkları nedeniyle yaprak yaylara kıyasla daha iyi sürüş konforu sağlamaktadırlar. Bu nedenle, bu tip yaylar ile donatılmış taşıtların devrilme eğilimleri daha fazladır. Viraj denge çubukları taşıtın devrilme eğilimini azaltmak amacıyla kullanılmaktadır.

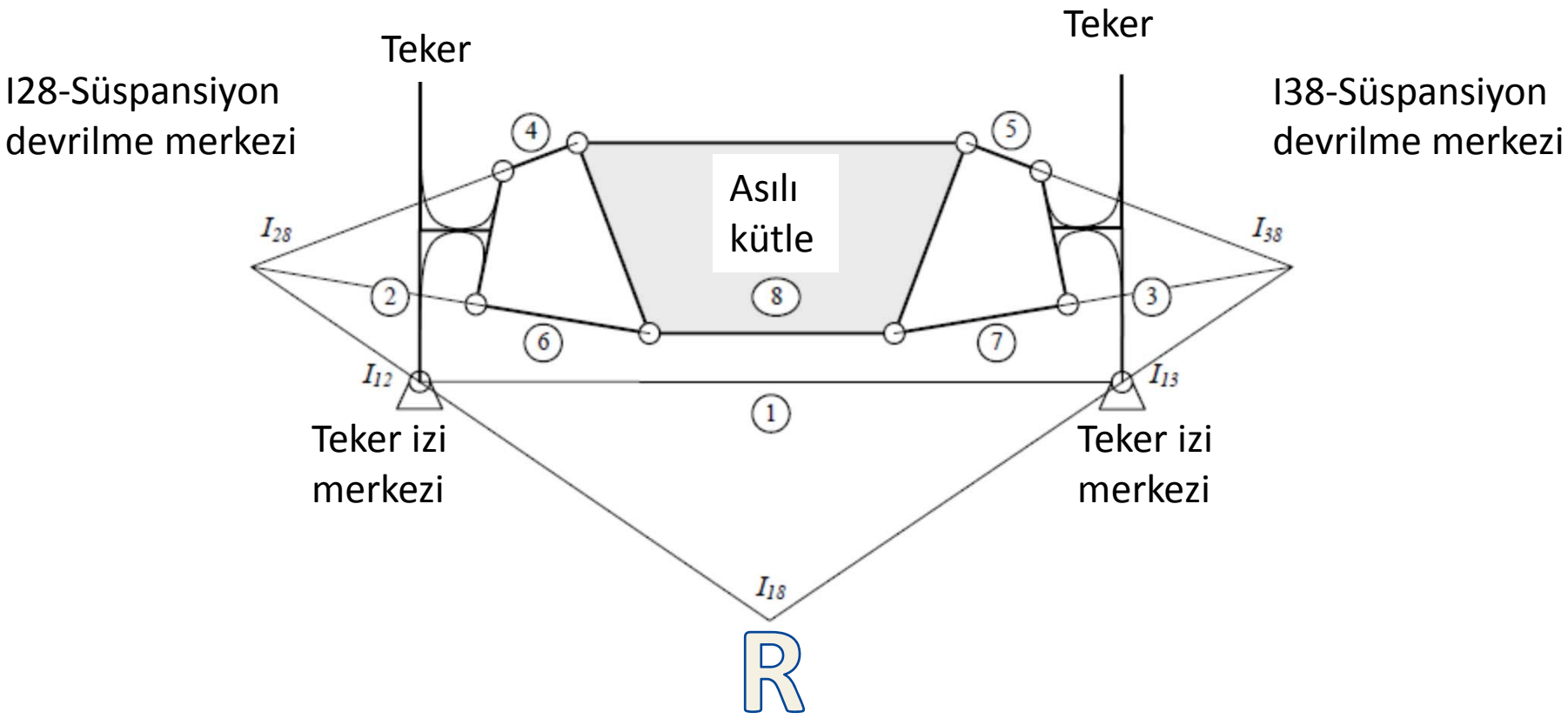
Devrilme merkezi





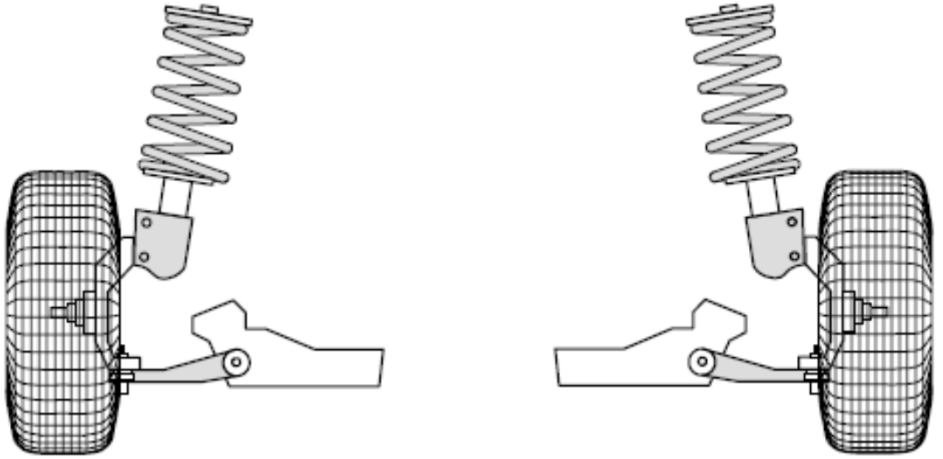
Devrilme ekseni, gövdenin devrilme hareketini gerçekleştirdiği eksendir. Devrilme ekseni, taşıtın ön ve arka süspansiyon devrilme merkezlerinin birleştirilmesi ile bulunur.

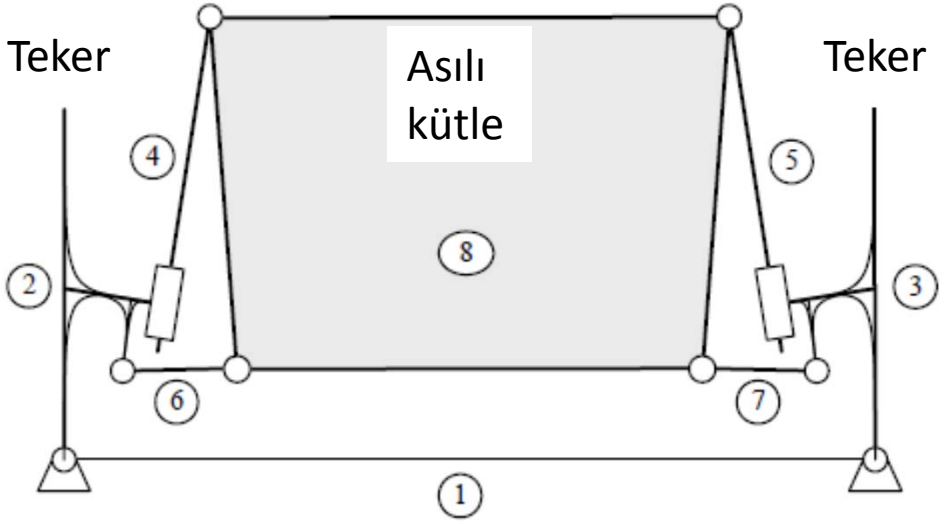
Devrilme merkezi/Kennedy teoremi
Double-wishbone süspansiyon



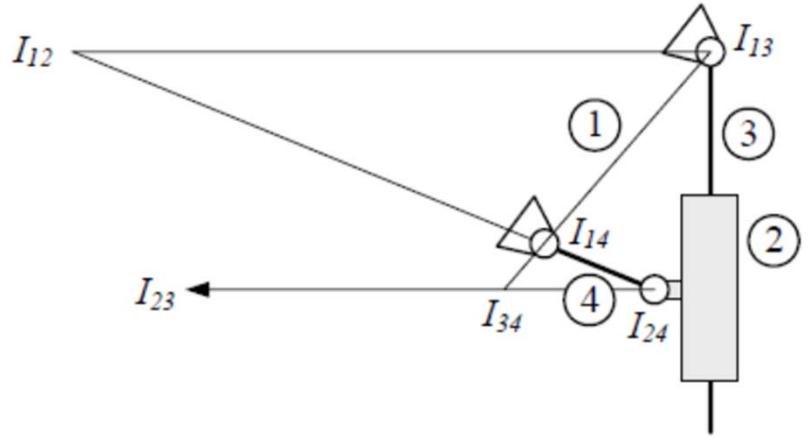
Tekerin ani dönme merkezi süspansiyon devrilme merkezi olarak adlandırılır.

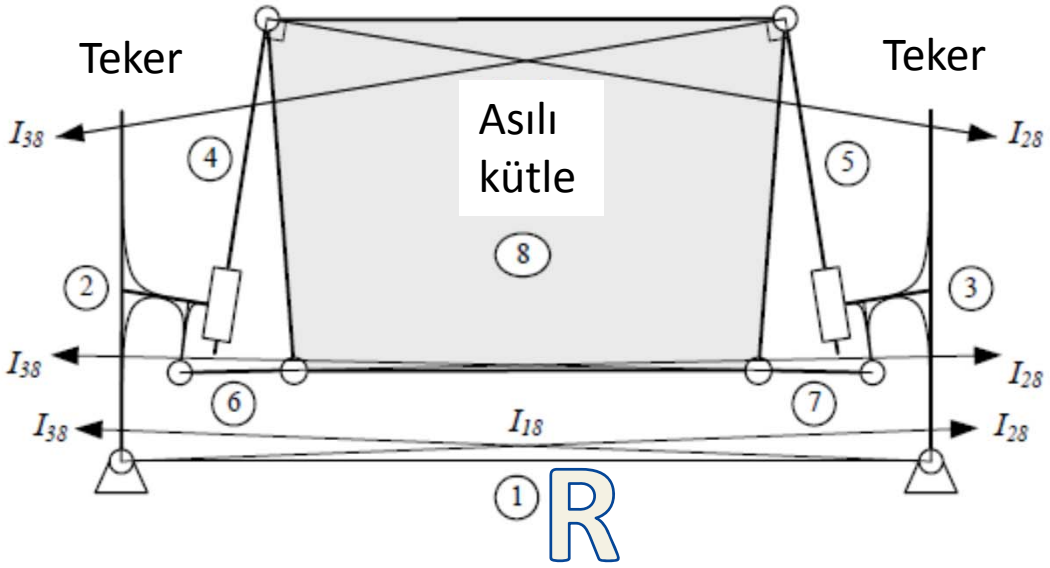
McPherson devrilme merkezi



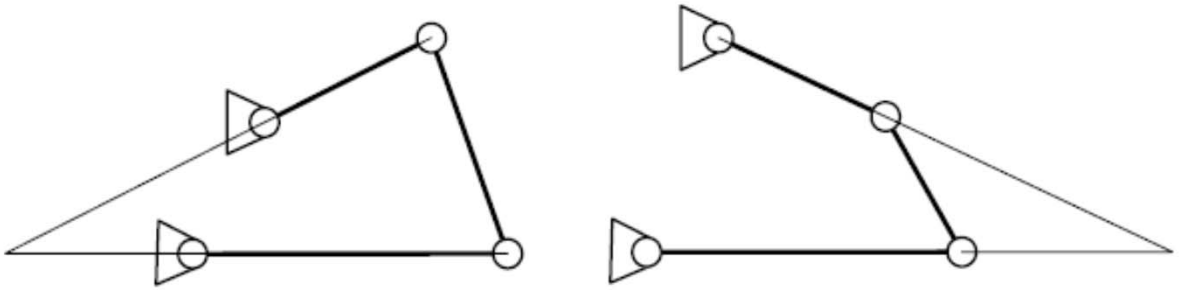


McPherson devrilme merkezi



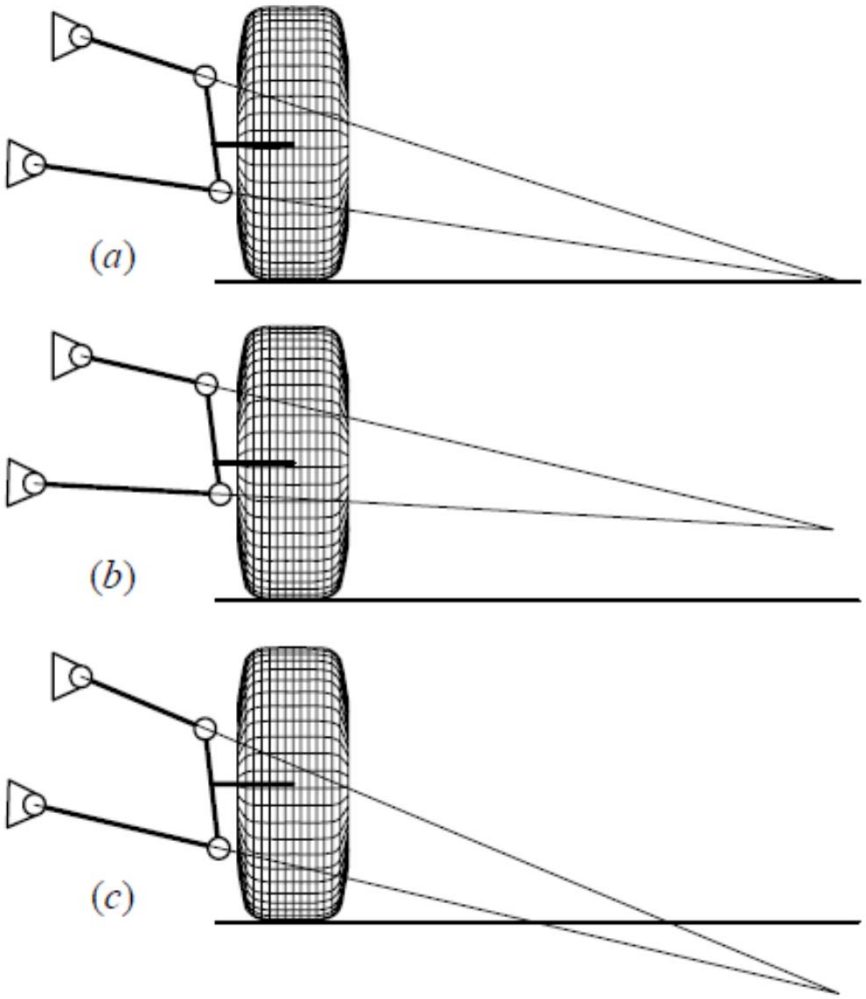


İç ve dış süspansiyon devrilme merkezleri



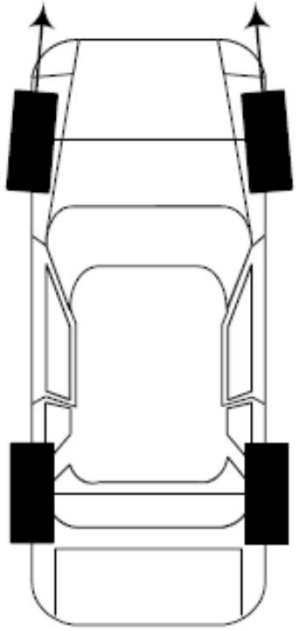
(a) (b)

Süspansiyon devrilme merkezi yüksekliği

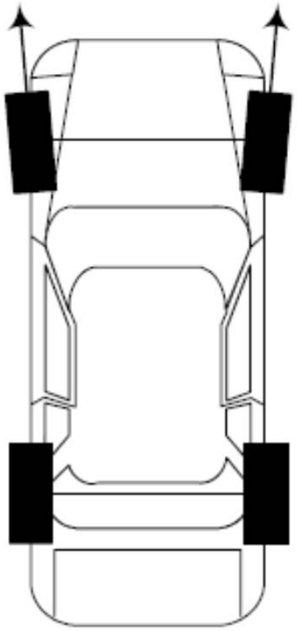


Teker açıları

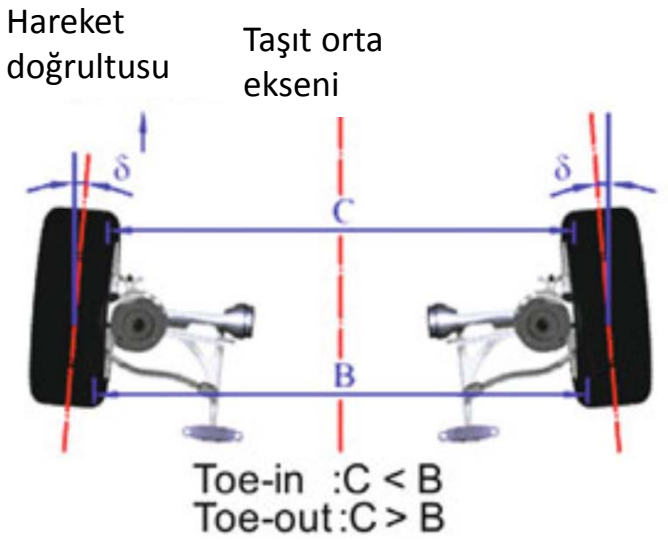
Toe-in ve Toe-out



Toe-in



Toe-out



Toe ayarı üç ana unsuru etkiler bunlar: lastik aşınması, doğrultu stabilitesi ve viraj girişindeki yönlendirme açısıdır.

Toe

- Excessive toe-in causes accelerated wear at the outboard edges of the tires,
- while too much toe-out causes wear at the inboard edges.
- Toe-in increases the directional stability of the vehicle, and toe-out increases the steering response. Hence, a toe-in setting makes the steering function lazy, while a toe-out makes the vehicle unstable.

Toe-in and directional stability

- Toe settings have an impact on directional stability. When the steering wheel is centered, toe-in causes the wheels to tent to move along paths that intersect each other in front of the vehicle. However, the wheels are in balance and no turn results. Toe-in setup can increase the directional stability caused by little steering fluctuations and keep the car moving straight.

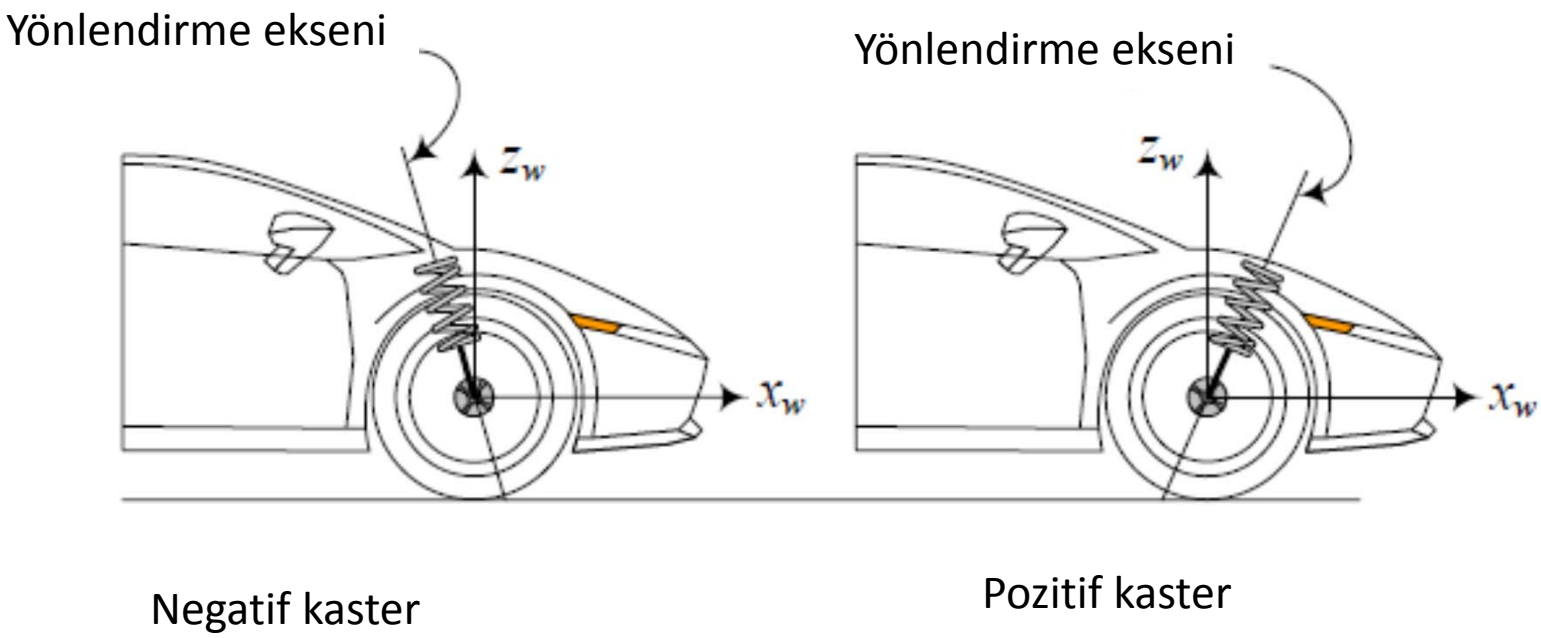
Toe-out sharper steering response

- If a car is set up with toe-out, the front wheels are aligned so that slight disturbances cause the wheel pair to assume rolling directions that approach a turn. Therefore, toe-out encourages the initiation of a turn, while toe-in discourages it. Toe-out makes the steering quicker. So, it may be used in vehicles for a faster response. The toe setting on a particular car becomes a trade-off between the straight-line stability afforded by toe-in and the quick steering response by toe-out. Toe-out is not desirable for street cars, however, race car drivers are willing to drive a car with a little directional instability, for sharper turn-in to the corners. So street cars are generally set up with toe-in, while race cars are often set up with toe-out.

Toe effect

- Front toe-in: slower steering response, more straight-line stability, greater wear at the outboard edges of the tires.
- Front toe-in: slower steering response, more straight-line stability, greater wear at the outboard edges of the tires.
- Front toe-zero: medium steering response, minimum power loss, minimum tire wear.
- Front toe-out: quicker steering response, less straight-line stability, greater wear at the inboard edges of the tires.

Kaster açısı



Negatif kaster

Pozitif kaster

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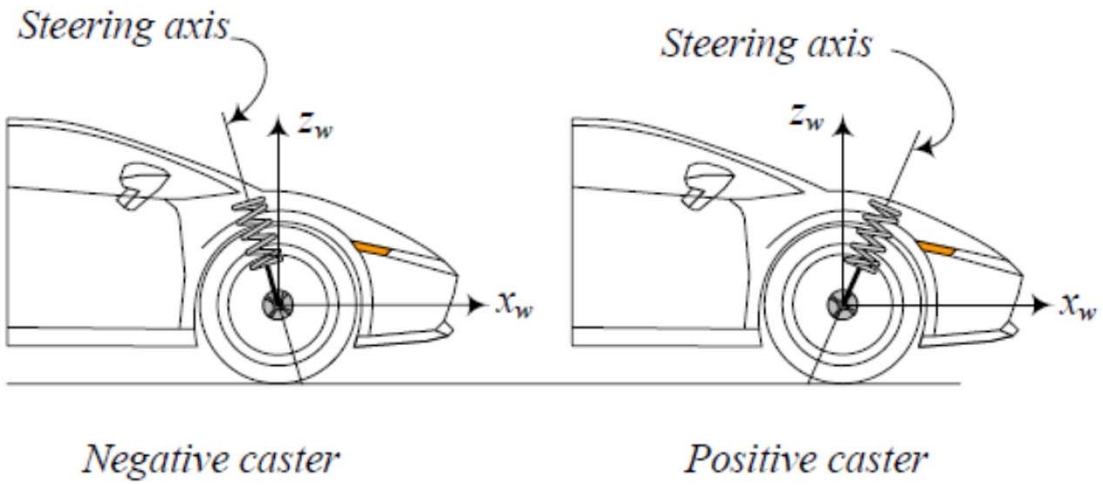
Caster angle



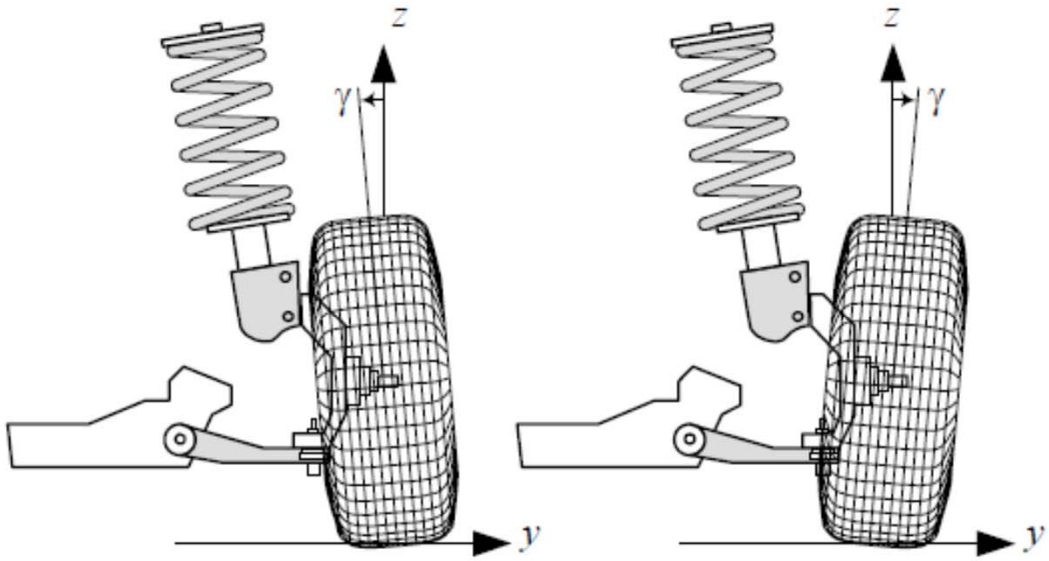
Caster is the angle to which the steering pivot axis is tilted forward or rearward from vertical, as viewed from the side. Negative caster aids in centering the steering wheel after a turn and makes the front tires straighten quicker. Most street cars are made with 4−6deg negative caster. Negative caster tends to straighten the wheel when the vehicle is traveling forward, and thus is used to enhance straight-line stability. While greater caster angles improves straight-line stability, they also cause an increase in steering effort.

Characteristics of caster in front axle

- Zero caster provides: easy steering into the corner, low steering out of the corner, low straight-line stability.
- Negative caster provides: low steering into the corner, easy steering out of the corner, more straight-line stability, high tireprint area during turn, good turn-in response, good directional stability, good steering feel.

Kamber

Kamber açısı, taşıtın önünden ya da arkasından bakıldığında teker ekseninin yol normali ile yaptığı açıdır.



Pozitif kamber Negatif kamber

–2° to +2° @ Yüksüz pozisyonda

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Trust