Some thoughts on motorcycle drum brakes

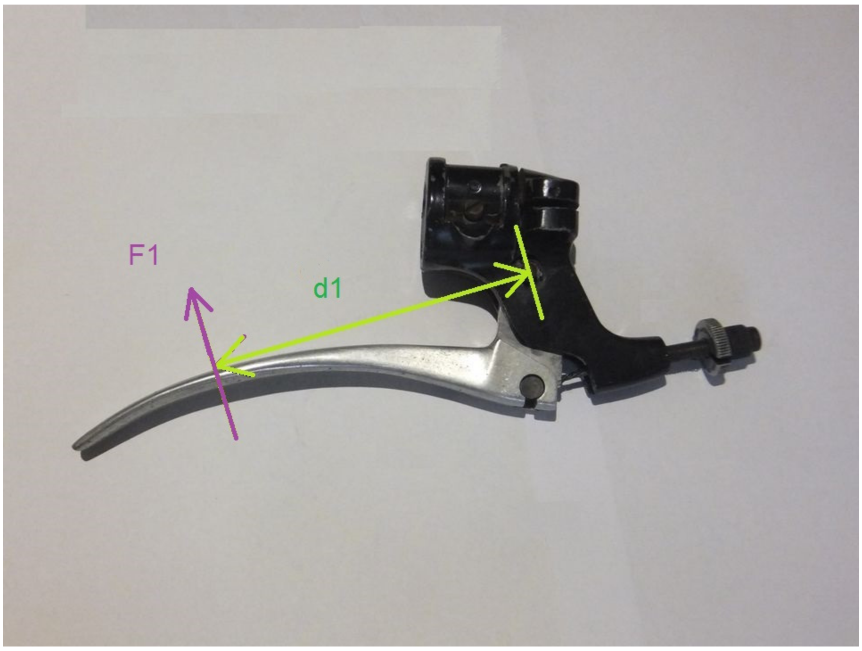
normal leading/trailing shoe drum brakes

easily identified by the presence of just one brake arm on the backing plate:

Handlebar

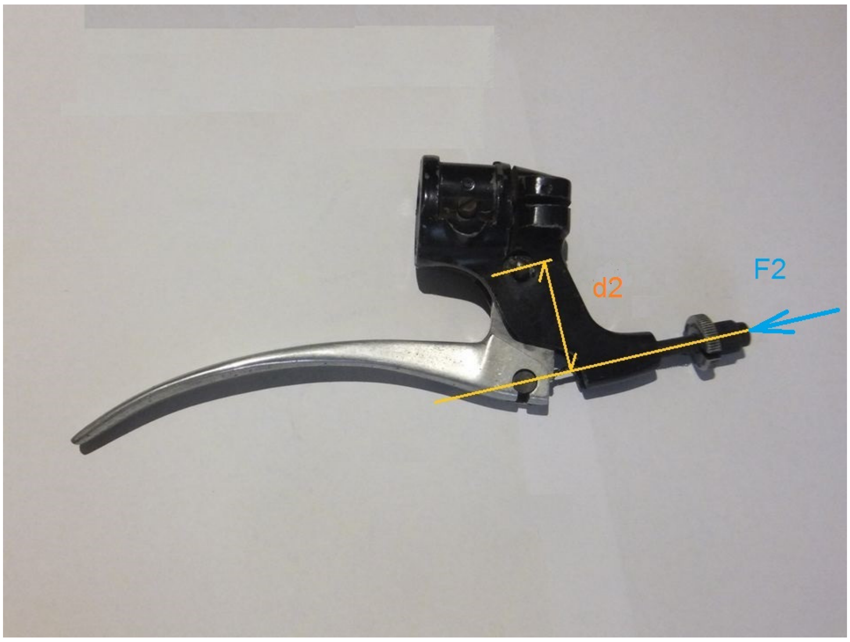
When a rider squeezes the front brake lever, the force (F1) that he applies

to the lever may be considered as centred at a point near the middle finger.



The brake lever pivots around the screw in the lever perch, over the distance d1.

The pull on the brake cable (F2) is equal to F1 multiplied by the ratio of d1 to d2.



So to take real life values, the illustrated lever assembly has d1 = 33mm

and d2 = approx 100mm. The ratio is therefore 3 to 1.

Therefore, a typical squeeze of 8 kg will become 8kg x 3 = 24 kg along the cable.

Cable

We cannot assume the cable is 100% efficient

The efficiency depends primarily on the sum of the angles through which the cable twists.

The formula states that you should divide the number 1000 by the addition of 1000 plus the sum of the cable angles.

To take an example, if the cable bends through 60 degrees at the front forks

and 90 degrees at the steering head, for a total of 150 degrees of bend,

the efficiency of the cable would be 1000 /1150, or 87% efficient.

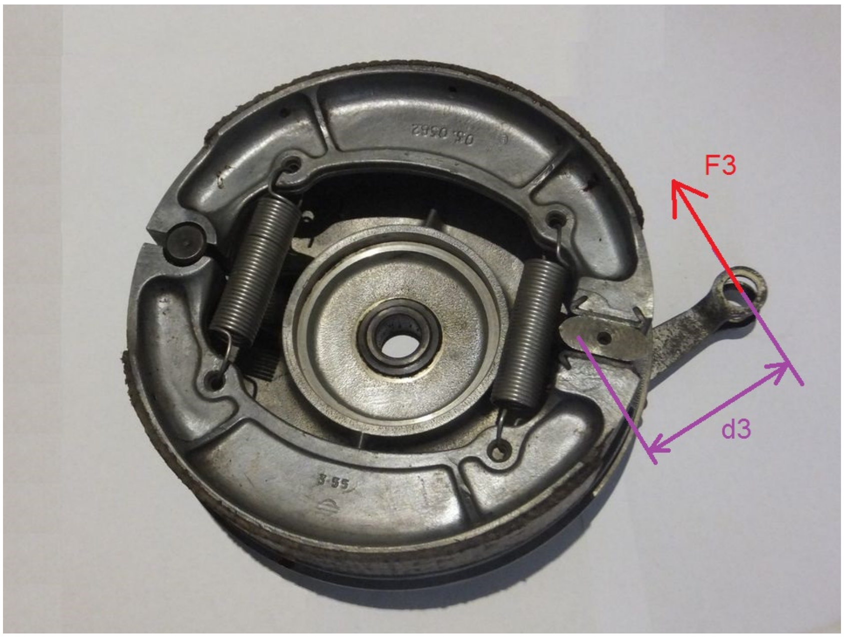
In our example, the input to the cable, F2 = 24kg while the output, F3 = 87% of 24kg, or 20.9kg

Front brake drum

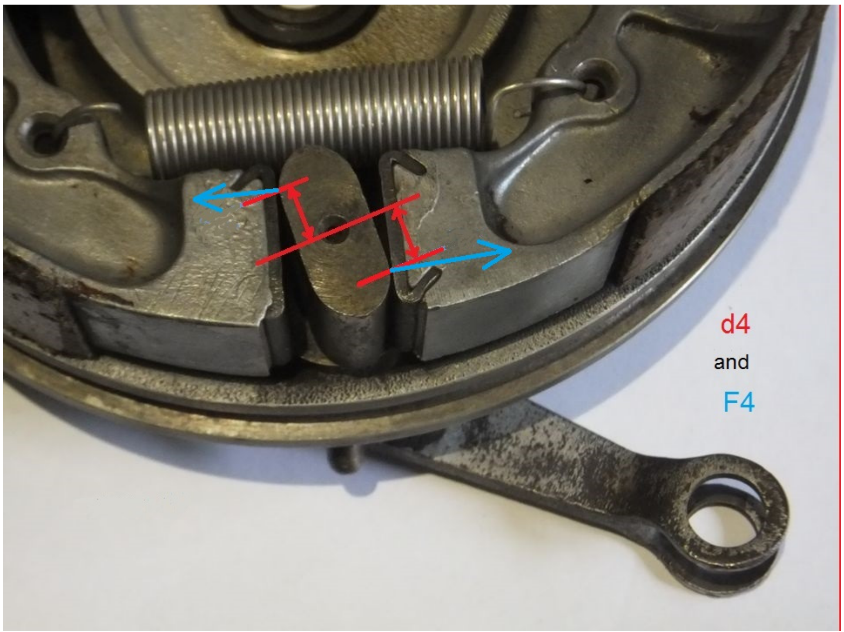
When the cable pulls the backing plate mounted arm, the cam spindle lobes

press against the ends of the brake shoes, pushing the shoes against the drum.

The distance d3 is the length of the brake arm from the centre of the cable end to the centre of the cam spindle.



The cable force (F3) is multiplied by the ratio of d3 to d4.



Distance d4 is the distance from cam spindle centre to where the cam face touches the shoe.

Once again, using the dimensions of the illustrated drum, d3 = 72mm and d4 = 12mm.

The multiplication ratio is 72mm divided by 12mm = 6 to 1.

Therefore the cable force in our example becomes 20.9kg x 6 = 125 kg at either shoe.

A substantial force you will agree.

If the brake drum arm is not perpendicular to the cable then its effective length is reduced by the factor sin ø.

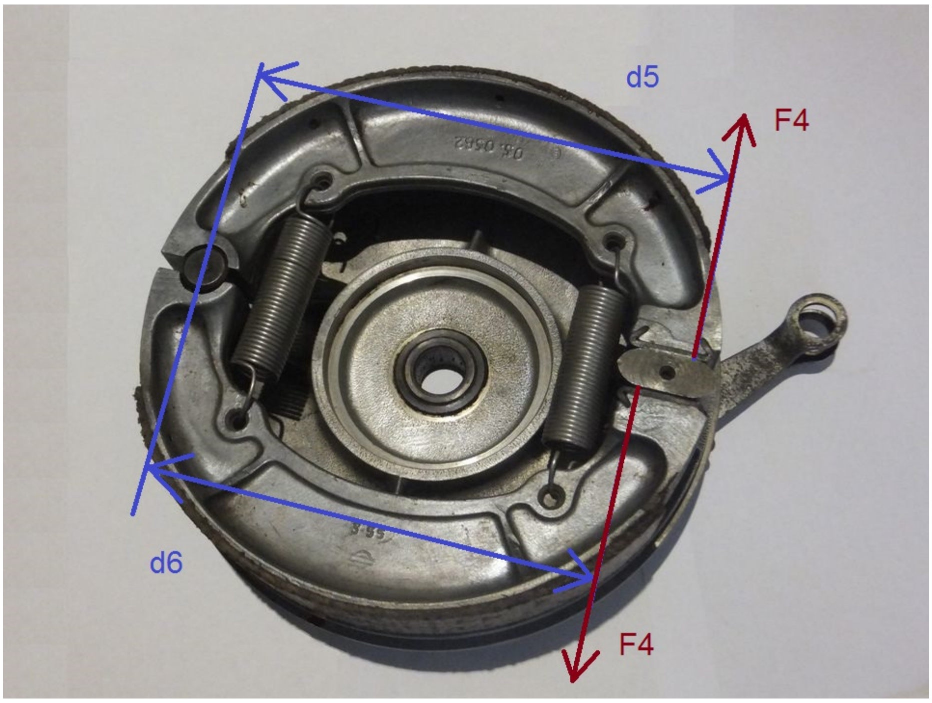
For example, for a 45 degree angle, sin ø = 0.7, therefore the effective distance d3 becomes 70% of d3 or 51mm in our example, and the ratio would be 4.25 to 1.

In our example, the overall ratio is 3 x 6 = 18 to 1. Ratios much below 20 can feel heavy, wooden

and lack feel while above 28 to 1 can feel too soft. The same ratios hold true for hydraulic brakes.

The friction applied by the brake shoe to the drum is a function of many factors including the

distance between shoe fulcrum and the spindle cam contact point. This distance differs for the 2 shoes.



In our illustrated example, d6 = 137mm and d5 = 152mm - a ratio of 90 to 100.

Therefore, the mechanical advantage over one shoe will be 90% that of the other.

<u>The question is: which shoe should get the greater pressure - leading or trailing?</u>

Most bike makers choose to advantage the leading shoe at the front of the bike, and the trailing shoe at the rear.

Front brakes with the cable running beneath the axle (a down-pointing brake arm)

apply the greater pressure to the leading shoe regardless of which side of the bike the backing plate is on.

Rear brakes with the cable or rod running beneath the axle (a down-pointing brake arm)

apply the greater pressure to the trailing shoe regardless of which side of the bike the backing plate is on.

Cables running above the axle (upward-pointing brake arms) reverse the situations described above.

By reversing the brake arm, you would be swapping the applied pressures between the two shoes.

The braking effect of the leading/trailing drum is the same going forwards, or rolling backwards down a slope.

"servo-assisted" leading shoe

Empirically, the leading shoe gives about 28% more friction than the trailing shoe , all other things being equal.

This is because in the case of the leading shoe, friction tends to rotate the shoe about the fulcrum stud

in such a direction so as to aid the cam force.

On the other hand, the trailing shoe tends to rotate in such a direction so as to oppose the force applied by the cam.

Also,

In a theoretically perfect setup, the cam would push perpendicularly on the ends of the shoes.

However, in the real world, the shoe cam travels through a significant angle before the linings contact the drum.

This angle conveys a component of friction to the end of the shoe which either pushes the edge

of the brake lining into contact with the drum, or tends to lift it from the drum.

With each cam lobe working in opposition to its mate, this effect will either add to or deduct

from the performance differential between leading and trailing shoes.

conclusion

To achieve the most powerful brakes, the leading shoe should be operated by the spindle cam

turning in the opposite direction to the wheel.

twin leading shoe drum brakes

easily identified by the presence of two brake arms on the backing plate:

Since the leading shoe gives about 28% more friction than the trailing shoe , then twin leading shoe brakes (TLS)

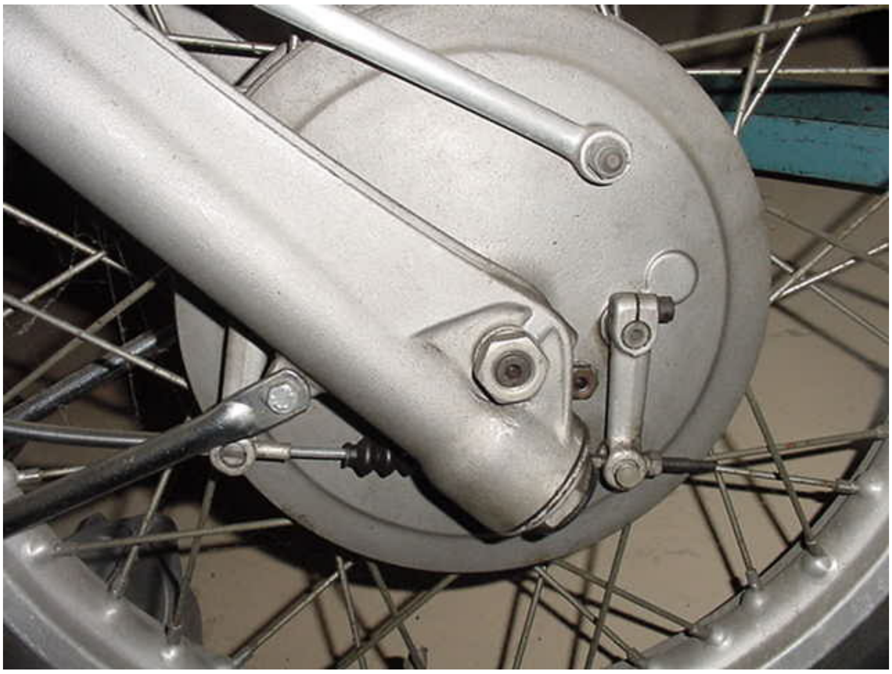
result in 14% better brakes (only one shoe is reversed from the leading/trailing situation).

Adjusting the resting position of the shoes becomes a bigger problem for TLS.

In 1955, BMW found the best solution for this was to terminate the brake cable outer at one brake arm

and the inner cable at the other brake arm.

The brakes then, were virtually self adjusting in that they were self centreing.

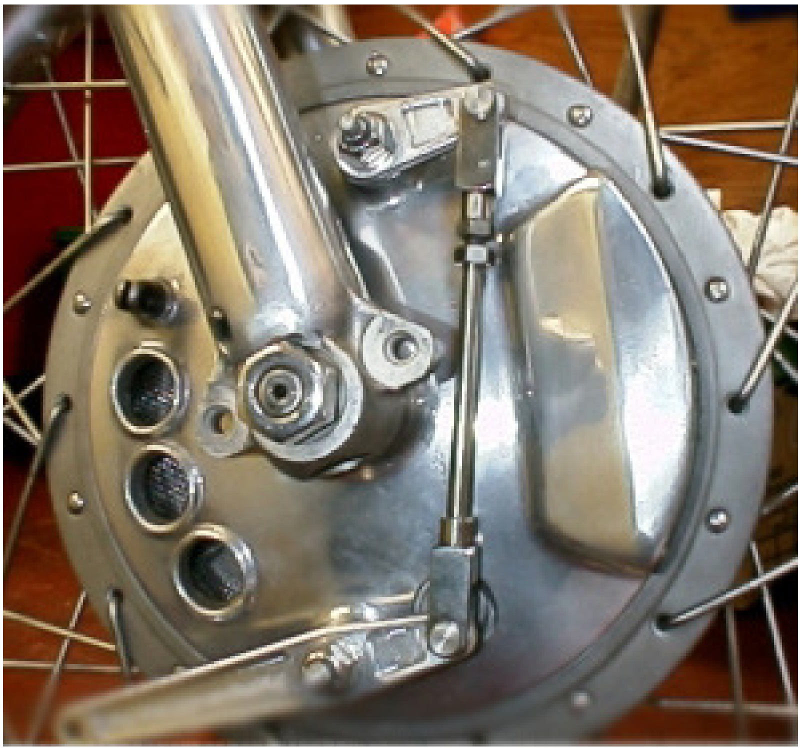


However, this BMW solution results in one leading shoe exerting a greater frictional force than the other .

The British and Japanese solution has an external brake arm linkage.

This ensures that both spindle cams rotate in the same direction.

This arrangement requires additional adjustment of the shoe balance for wear.



For good brake feel, the handlebar lever to brake shoe mechanical advantage should have a ratio lower than the leading/trailing example.

Ratios of 12 to 1 through 18 to 1 have been suggested for best feel.

The braking effect of the twin leading shoe brake is good going forwards but when rolling backwards down a slope, braking is poor.

Riders should concentrate on using the rear brake for such situations.

compensating for wear

There are many tricks, but keeping everything clean and lubricated is most important.

When worn, parts should be replaced or re-machined to reduce play and slop.

One of the ways to help the shoes become self-adjusting is to make them "floating".

The rear brakes on later model cars are just so.

The way to achieve this on old bikes is to elongate the shoe fulcrum cut out.

Caution should be exercised here because there is little to stop the shoes flopping about.

Ever noticed that car shoes have a small spring or clip pressing against the side of the shoe body? That is why.

Ariel and the BSA Competition department designed a backing plate with a floating cam spindle bearing to solve this problem.

cooling

Drum brakes fade when hot.

Gathering a little extra air with a scoop helps but only if there is also provision for the air to escape from the drum cavity.

............with thanks to Dave Dettmar, Paul Reed, Alan Donovan and Mr Google for contributions to this article. RR