Function and history

Some basic definitions

Before getting into much detail we need to consider some definitions of terms that are often banded about loosely and misunderstood as a consequence.

Handling

By this, we mean the ease, style and feel with which the motorcycle does our bidding. It depends mainly on overall geometry, chassis stiffness, weight and its distribution, tyre type and size. It may come as a surprise to some people to learn that the rider has a major influence on the handling characteristics of a motorcycle. Rider responses have a large effect on the overall interaction of the dynamic forces that control the motion of the machine.

Roadholding

This means the ability of the machine, through its tyres, to maintain contact with the road. It depends mainly on tyre type and size, suspension characteristics, weight and its distribution, and stiffness between the wheels to maintain their correct relationship to one another. In the days of relatively narrow tyres, roadholding and handling generally went hand-in-hand, indeed, the terms were used interchangeably. However, nowadays the requirements are sometimes contradictory and a compromise must be struck, depending on the intended use of the machine.

Stability

There are many types of stability or instability that can influence a motorcycle. There's balance stability, aerodynamic stability etc. Formal definitions of stability in control systems exist but they are too involved for a book of this nature, although we'll look at these aspects a bit closer in a later chapter. For our present purposes we mean:

- The ability to maintain the intended manoeuvre (i.e. continue in a straight line or round a corner) without an inherent tendency to deviate from our chosen path. This implicitly includes the absence of wobbles and weaves.
- The ability to revert to the intended manoeuvre when temporarily disturbed by external forces (e.g. bumps, cross winds and so on).

Handling, roadholding and stability are affected by many parameters and the interaction between them. The subject is complex but not magic, and – judging from some chassis designs – has not always been well understood. However, relatively simple laws of physics are always obeyed. In this book I'll try to remove the mystic and consider the main parameters involved and study their various effects. It must be emphasized that there is much cross-coupling between these effects – there is no 'correct' combination, no 'perfect' design. Any motorcycle embodies several essential compromises.

Linear and angular motions

If we are to study the behaviour of any type of vehicle we first need to consider just how it can move. The linear motions are easy to visualize, firstly the machine can move in a forward direction and the engine and brakes are responsible for controlling this. Road undulations and hills cause motion in a vertical direction and sidewinds can result in sideways movement. It is the angular motions that are somewhat less familiar to most people. The overall angular movements can be completely described by considering the motions about three separate axis. These axis are at right angles to one another and are known as roll, pitch and yaw.

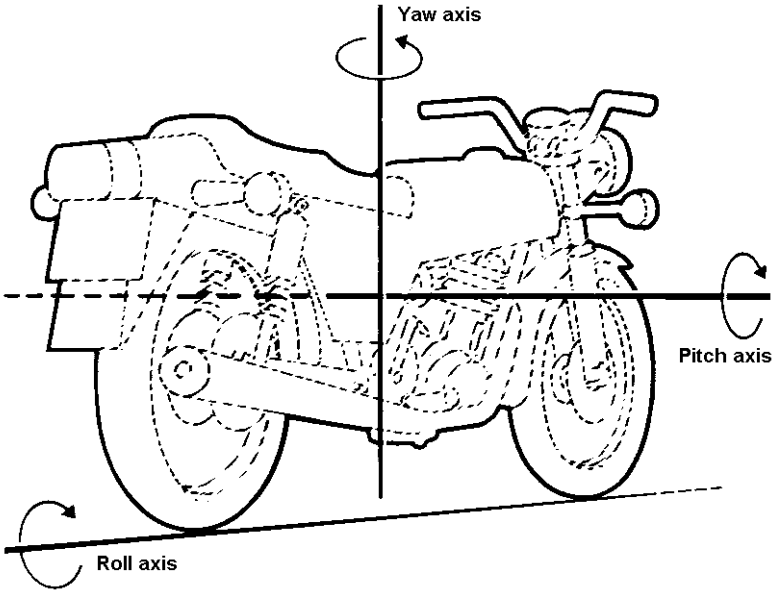

Fig. 1.1 **Showing the three principal axis of rotation.**
Yaw is the angular motion about a vertical axis.
The pitch axis is horizontal and passes sideways through the bike.
The roll axis is also horizontal and is orientated fore and aft.

Roll is probably the most familiar of the three and is the most obvious motion that occurs when we lean the bike over for cornering. Fig. 1.1 shows the roll axis as connecting the front and rear tyre contact patches. However, as we shall see later the location of this axis depends on our frame of reference and as such can be anywhere we want it to be.

Yaw is the movement about a vertical axis and occurs as we steer around a bend, it can also be caused by various disturbances such as sidewinds.

Pitch is the motion about an horizontal axis that passes sideways through the machine, we get this under braking and acceleration, as well as from road irregularities.

Due to the large roll angles involved with cornering, the pitch and yaw axis of the machine move relative to the global vertical and horizontal coordinates. For this reason it is important to be careful when specifying the axis system that we are using. There are several such systems that are used in vehicle analysis but for our purposes the two most important will be the machine coordinates and earth coordinates, initially defined in terms of the original direction of travel, before performing some manoeuvre.