Conceptual questions

Friction

1 Most bikes have normal tires: some have 'fats'.

a Suppose the wheels on both a normal bike (not shown) and the bikes above have outside diameters of 67 cm. By using your own estimate of the width of a 'normal' tire, and taking measurements on the image above, *or otherwise*, write down the ratio of skid distance for normal tires over fats, when the bikes both begin to slide on dry asphalt at 12 m/s.

Coefficients of friction for rubber on roads are listed in the table.

μ (Rubber on concrete road)	**μ (Rubber on asphalt road)**
Dry road 0.68	Dry road 0.67
Wet road 0.58	Wet road 0.53

b Why do wet conditions increase the frequency of accidents, and why might concrete roads be slightly less dangerous than asphalt when wet?

2 A motorbike cowboy stopped, but in doing so has left a 45 m skid mark on a dry asphalt road.

a The skid distance D is given by the expression … $f.D = {}^{1}/_{2}\, mu^2$ … where the symbols have their usual meanings. Argue for the correctness of the expression from physical principles without mathematics.

b Use the coefficient of friction in the table in example 2 to find the speed of the bike just before the slide began.

c Why is the rider referred to as a "cowboy"?

4, It rains a lot in the South Island of New Zealand and frosts are common in winter. Roads and bridges occasionally become covered in places with a layer of ice. Driving becomes unpredictable because the coefficient of friction between rubber and ice is 0.15, an extremely low value when compared to the coefficient for rubber on dry road, which is 0.67.

a Interpret the symbols in the equation …

$$\frac{1}{2} \not{m}\, u^2 = \mu_k \not{m}\, g D$$

... and write down the ratio of skid distance for a truck on dry road over the skid distance on ice.

Being cautious and a little afraid, a local farmer decided not to take a truck loaded with pigs to town on one such morning, but to go to town in the car with his wife instead, believing that to be less dangerous.

b How would you use the loaded toy truck and several toy cars of similar scale and construction to show him that he was mistaken? [Give details].

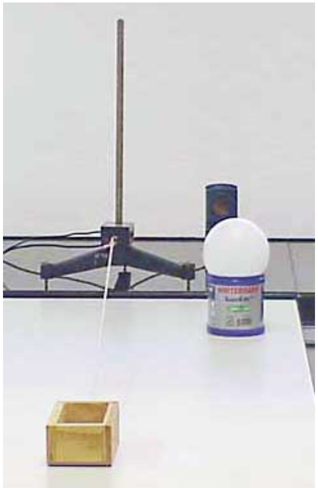
5 Part I

A student measures the static coefficient of friction by attaching a string to a box with added weights and pulling it across a table with a hand-held force probe and plotting a force-time graph.

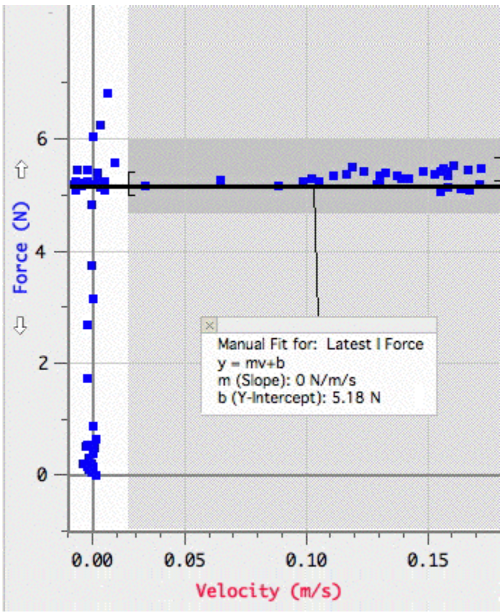
a What is meant by the *static* coefficient of friction?

b The force measured rises to a peak just before sliding begins and then drops back a little to a steady value. Why might the static coefficient of friction found in this way be inaccurate?

In an effort to get more reliable values for both the static and dynamic coefficients of friction the experiment is redesigned so that the box and the force probe remain stationary at all times.



In the new design the force probe is attached to a clamp stand on a fixed bench behind the table. The table is on castors *wheels" and is pulled away from the bench. A motion detector on the bench records the position of a ball, fixed to the table, as a function of time to make a force-velocity plot.



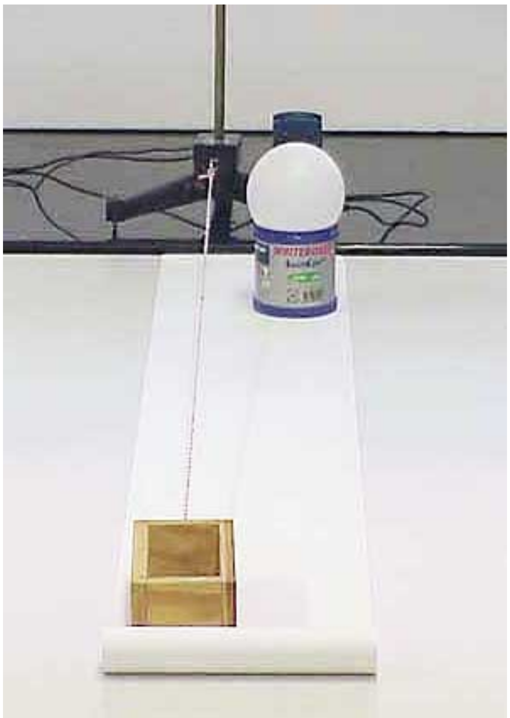
c What is the main advantage of the new arrangement?

d If the mass of the box and weights was (0.20 + 0.60) kg find both the static and dynamic coefficients of friction.

e Within what limits does the dynamic coefficient of friction constant.

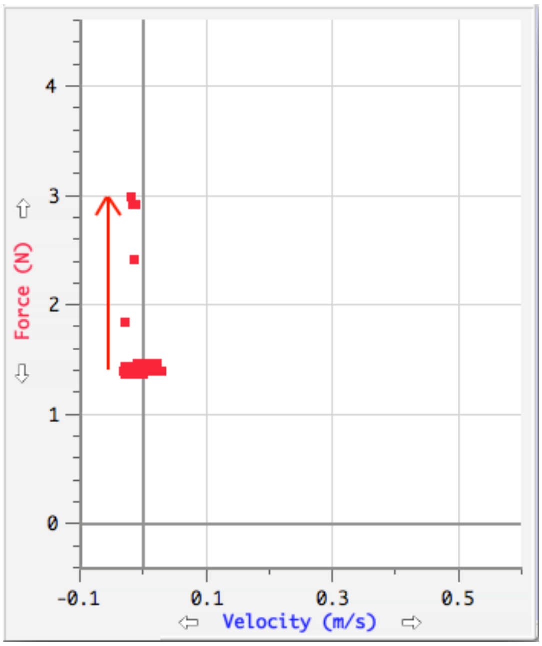
5 Part II

The moving table arrangement is modified slightly to measure the coefficients of friction between the box and fax copy paper.

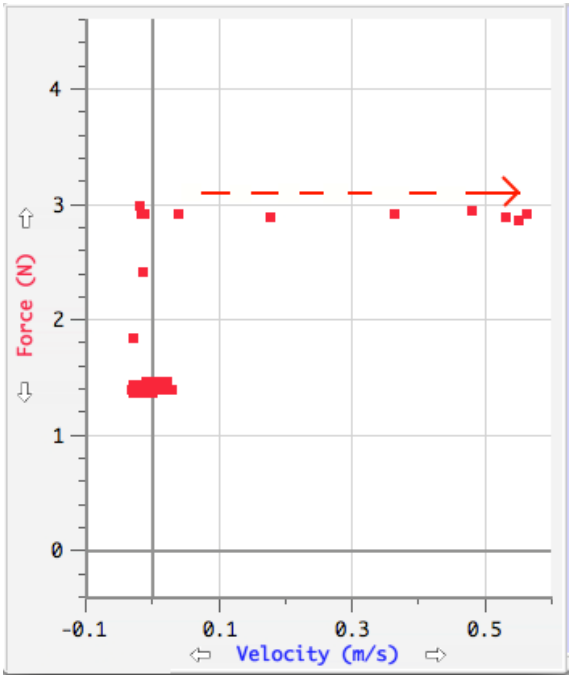


The force probe was zeroed and the paper was pulled away from the bench. Force-velocity plots are shown at three times.

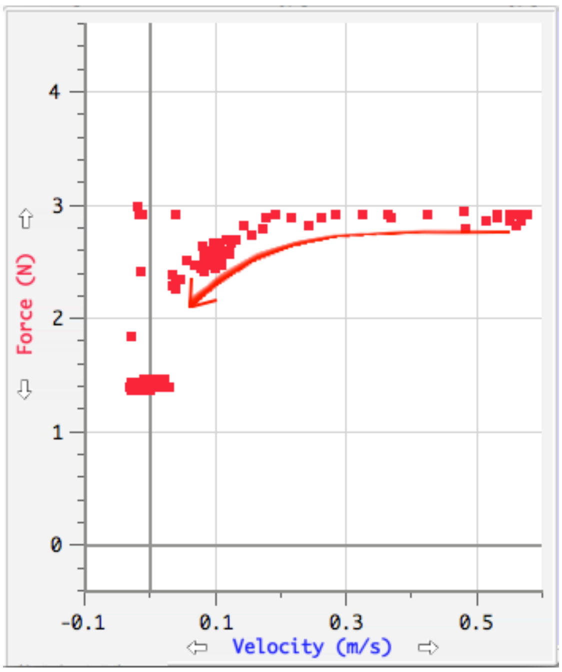
1 …



2 …



3 …



a Interpret the graphs (explain what is happening during each process).

b Find the coefficient of dynamic friction at 0.10, 0.30, and 0.5 m/s if the mass of the box was reduced in this case to (0.2+ 0.3) kg.