7

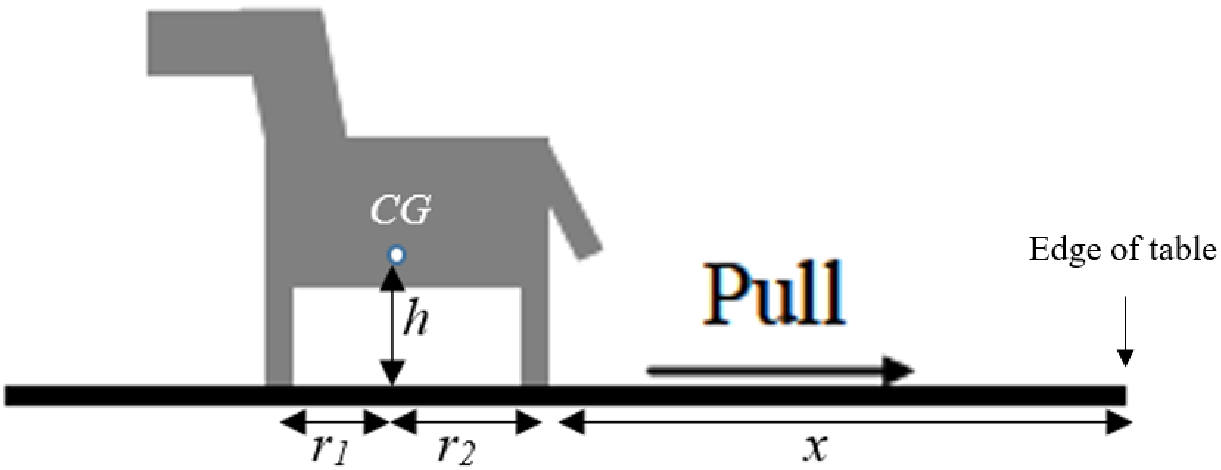

Fig. 7.1

A wooden toy horse rests on a tablecloth on a smooth table, with its back legs located at a distance $x = 0.300$ m from the edge of the table. It has a mass $m = 100$ g and its center of gravity (CG) is at distances $r_1 = 0.0500$ m from the front legs and $h = 0.0500$ m above ground. The distance between the front and back legs is 0.150 m. The coefficient of friction between the cloth and the horse is 0.750. The tablecloth is pulled horizontally.

(a) Describe a situation in which friction opposes motion and another in which it causes motion.

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(b) The cloth is pulled such that the horse is on the verge of slipping. The coefficient of friction μ is a dimensionless number defined as the ratio of frictional force to normal force exerted by one surface on another. Show that the frictional force f between the cloth and the horse is approximately 0.736 N.

[2]

(c) Determine

(i) the acceleration of the horse relative to the table assuming the horse does not slip relative to the cloth.

Acceleration = …………………….. m s^{-2} [2]

(ii) the velocity of the horse when the back legs reach the edge of the table.

Velocity = ………………….. m s^{-1} [2]

(d) The table exerts a force N_1 and N_2 on the front and back legs of the horse respectively.

(i) Draw in and label all the forces acting on the horse in **Fig 7.1** as it is being pulled horizontally. Pay attention to the relative magnitudes of the vertical forces. [2]

(ii) Write down an expression to show

1. the vertical equilibrium of the horse

……………………………………………………………… [1]

2. rotational equilibrium of the horse about its centre of mass while it is being pulled.

……………………………………………………………… [1]

(iii) From your answers in **(ii)**, show that

$$N_2 = mg\frac{r_1 - \mu h}{r_1 + r_2}$$

[2]

(iv) Hence determine a value for N_2 and N_1.

N_2 = …………………….. N [1]

N_1 = …………………….. N [1]

(v) If the height of the center of gravity could be adjusted, determine the value above which the back legs of the horse would lose contact with the table.

Maximum height = …………………. m [2]

(vi) Apart from a low centre of gravity, suggest another two features which will make it less likely for the back legs of the horse to lose contact with the table.

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(CLT – cancelled)