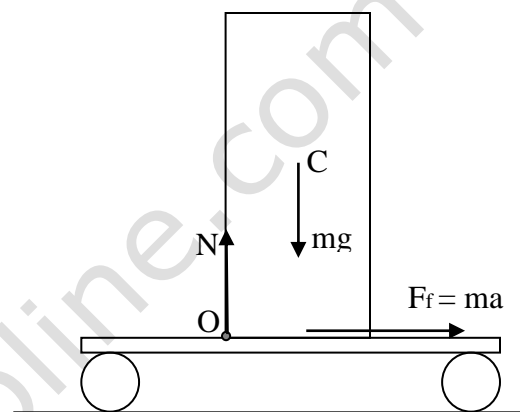


Q- A 2 m tall cylindrical compressor of mass 100 kg and 50 cm in diameter (base) is placed on a large cart. If there is sufficient friction to avoid any slipping, what is the maximum acceleration of the cart on level road for which the compressor will not topple.

As the compressor is mounted in the center and if the cart is moving with constant velocity there is no chance of tipping over of the compressor. The problem will arise only when the cart is accelerating. At the time of accelerating of the cart the compressor is to be accelerated with it, this is done by the force of friction between the surface of the cart and the compressor. This force is also creating a torque which is trying to rotate the compressor anticlockwise about its center of mass and due to which the line of action of the normal reaction of the surface on the compressor ($N = mg$) is shifting to left, providing a torque to balance the torque due to the friction. As the acceleration increases the normal reaction shifts and finally having a shift = $d/2$. A further increase in the acceleration will cause the tipping about point O.



If the acceleration a of the cart is such that the compressor is just not tipping i.e. at the verge of tipping the torques due to the normal reaction and due to friction about the center of mass of the compressor are just balancing. Gives us

$$ma(h/2) = mg(d/2)$$

$$\text{or } a = (d/h)g = (20/72)9.8 = 2.72 \text{ m/s}^2$$

Therefore, to avoid the toppling of compressor the acceleration of the cart should be less than 2.72 m/s^2 .

Note:

[For this analysis the friction between the surface of the cart and the compressor is considered sufficient to avoid any sliding, otherwise before toppling it will be slid backward. For this also we can say that coefficient of static friction must be greater than (a/g) .]