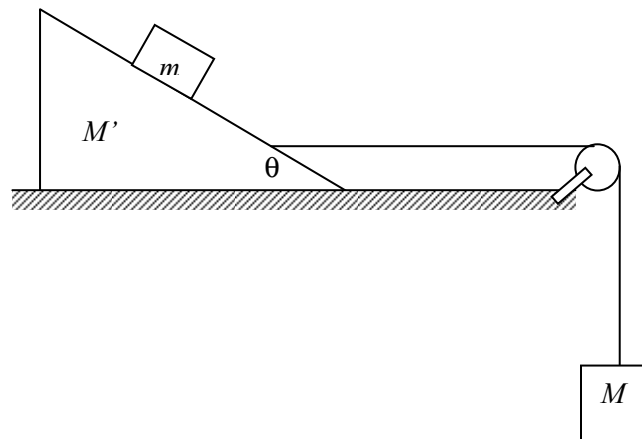


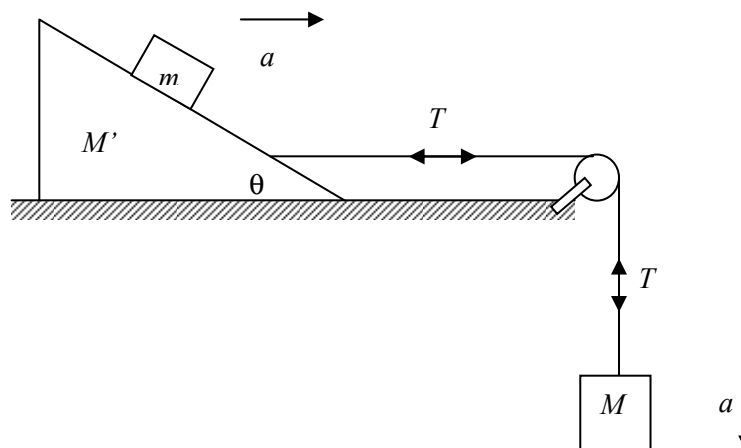
This problem has been asked by a registered student of Vidya Drishti. ([www.vidyadrishti.com](http://www.vidyadrishti.com))

**Question: Find the mass  $M$  of the hanging block in figure which will prevent the smaller block from slipping over the triangular block. All surfaces are frictionless and the strings and the pulleys are light.**



**Solution:**

Mass  $m$  has zero relative acceleration with respect to triangular block  $M'$  because it is not slipping over triangular block.



Therefore triangular block  $M'$  and smaller block  $m$  moves with same horizontal acceleration  $a$  towards right with respect to grand frame.

As both the string and pulley are light, tension in every part of the string will be same i.e.  $T$ .

(Why tension  $T$  is shown in both directions here? Go for Vidya Drishti Physics package at

<http://www.vidyadrishti.com/phyppackage.php>)

Clearly, hanging mass  $M$  also moves with acceleration  $a$  (downwards).

**F. B. D. of hanging block  $M$  w. r. t. ground:**

Mass  $M$  moves with acceleration (downwards).

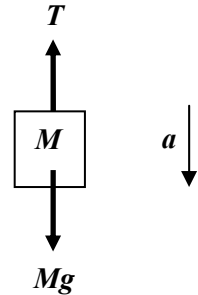
Forces are:

Weight  $Mg$  (downward)

Tension  $T$  (upward)

Newton's second law along vertical direction becomes

$$Mg - T = Ma \quad \dots (i)$$



**F. B. D. of triangular block  $M'$  w. r. t. ground:**

Block  $M'$  moves with acceleration  $a$  (rightwards).

Forces are:

Weight  $M'g$  (downward)

Tension  $T$  (rightward)

Normal  $N$  from ground (upward)

Normal  $N'$  from smaller block  $m$  (perpendicular to slope as shown)

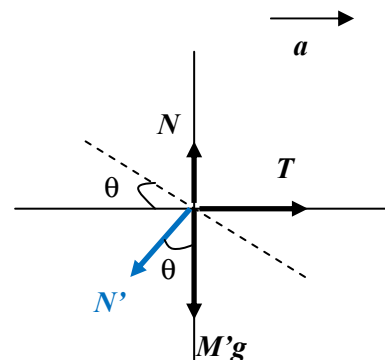
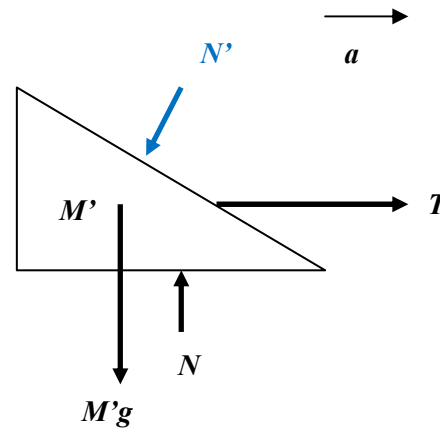
We will use Newton's second law along horizontal as well as in vertical direction.

Along horizontal:

$$T - N' \sin \theta = M'a \quad \dots (ii)$$

Along vertical:

$$N - M'g - N' \cos \theta = 0 \quad \dots (iii)$$



**F. B. D. of smaller block  $m$  w. r. t. ground:**

Block  $m$  moves with acceleration  $a$  (rightwards) w.r.t. ground.

Forces are:

Weight  $mg$  (downward)

Normal  $N'$  from triangular block  $M'$  (perpendicular to slope as shown)

We will use Newton's second law along horizontal as well as in vertical direction.

Along horizontal:

$$N' \sin \theta = ma \quad \dots (iv)$$

Along vertical:

$$N' \cos \theta - mg = 0 \quad \dots (v)$$

From equation (v), we get  $N'$ , which is

$$N' = \frac{mg}{\cos \theta}$$

Putting this value of  $N'$  in equation (iv), we get acceleration  $a$ , which is

$$a = \frac{N' \sin \theta}{m}$$

$$\Rightarrow a = g \tan \theta$$

Putting values of  $N'$  and  $a$  in equation (ii), we get  $T$ , which is

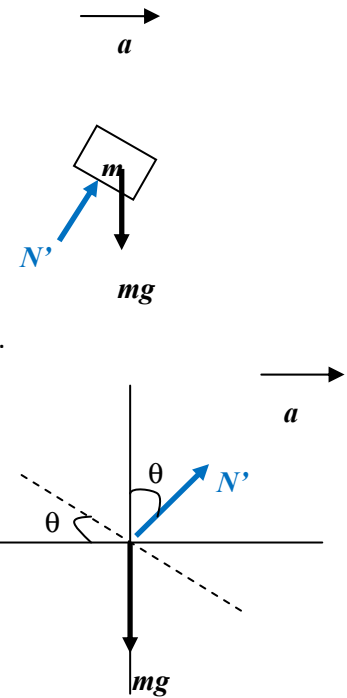
$$T - N' \sin \theta = M'a$$

$$\Rightarrow T = M'a + N' \sin \theta = M'g \tan \theta + \left( \frac{mg}{\cos \theta} \right) \sin \theta$$

$$\Rightarrow T = (m + M')g \tan \theta$$

Putting values of  $a$  and  $T$  in equation (i), we get  $M$ , which is

$$Mg - T = Ma$$



$$\Rightarrow M = \frac{T}{g-a} = \frac{(m+M')g \tan \theta}{g-g \tan \theta} = \frac{(m+M')g \tan \theta}{(\cot \theta - 1)g \tan \theta}$$

$$\Rightarrow M = \frac{m+M'}{\cot \theta - 1}$$

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