For Chapter 13

Credits

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Similar to Problem 30 on page 133 of the Halliday Resnick and Walker textbook

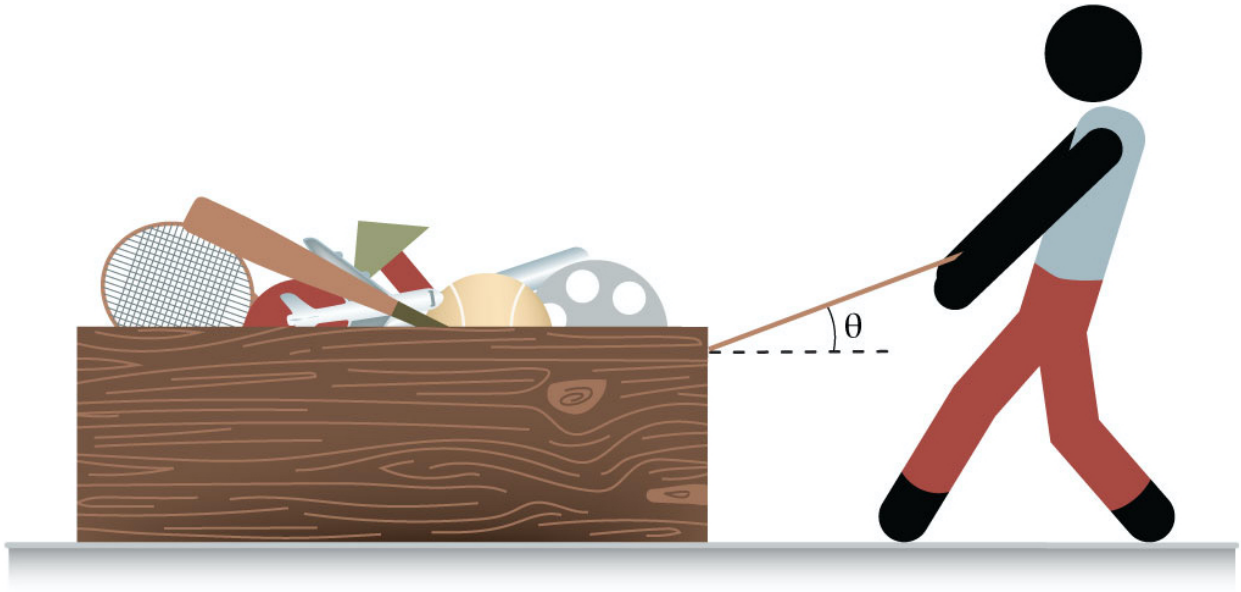
Question - Frictional Forces and Motion – with answers

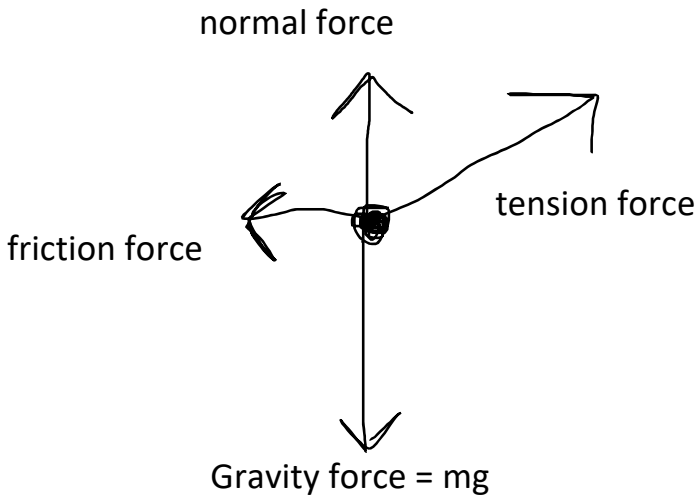
A child pulls on a rope as shown and the chest accelerates across the horizontal floor at 0.456 metres per second squared.

The toy chest and its contents have a mass of 18.4 kilograms and the coefficient of kinetic friction between the chest and the floor is 0.420. The angle $\theta = 42.0^{o}$.

What is the magnitude of the tension force that the child must exert on the rope to cause this acceleration?

Ignore the dimensions of the box. Treat it like a particle.





Answers

net force = ma = 18.4 kg x 0.456 m/s^2 = 8.3904 newtons to the right (1 mark)

weight = mg = 18.4 x 9.81 = 180.504 N down

Take "T" to be the tension force

Friction force = μ x normal force = 0.420 x normal force

Assume up is positive and to the right is positive

Vertical direction T sinθ + normal force = mg = 180.504 N
Horizontal direction T cosθ - friction force = ma = 8.3904 N

So there are two simultaneous equations with two unknowns

T sinθ + normal force = 180.504 N
T cosθ - 0.420 normal force = 8.3904 N

Solving gives T= Tension force = 82.3777=82.4 N
Normal force = 125.5 N

Marking notes: 3/6=9 marks if assumed the normal force = mg so T=113N
1/9 if assumed normal force = m g cos θ. Not an incline

Details for the solution. I use substitution
T sinθ + normal force = 180.504 N
T x 0.6991306 + normal = 180.504
So normal force = 180.504 – (T x 0.6991306)

T cosθ - 0.420 normal force = 8.3904 N
T x0.743144 - 0.420 normal force = 8.3904 N

So using substitution

{T x0.74314} - {0.420 x (180.504 – (T x 0.6991306)} = 8.3904 N
{T x0.74314} - {75.826 – Tx0.28103} = 8.3904
Tx1.0241 =+ 84.216 N
T = 82.234 = 82.2 N

Not needed, but normal force = 125.5 N
0/6 marks if assumed the normal force = mg