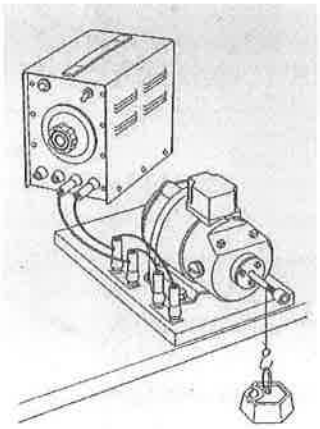
Work and Efficiency

Efficiency: The ratio of the amount of useful work done to the amount of total work done.

Formula: $\%\ \text{efficiency} = \frac{\text{useful output}}{\text{total input}} \times 100$

1. An electric motor has an input power of 160 W. In raising a load, 120 W of power are dissipated. What is the efficiency of the motor?



(input) 160 W → [ ] → 40W (output)

120W (lost)

$\frac{40W}{160W} \times 100 = 25\%$ efficient

2. A student does 400. J of work using a pulley to raise a 72 N box to a height of 5.0 meters. at constant speed

a) How much work does the student do against gravity?

$W_g = F_g \cdot d \cdot \cos\theta \qquad \theta = 180°$

$W_g\ (72N)(5.0m)(\cos 180°) = -360J$

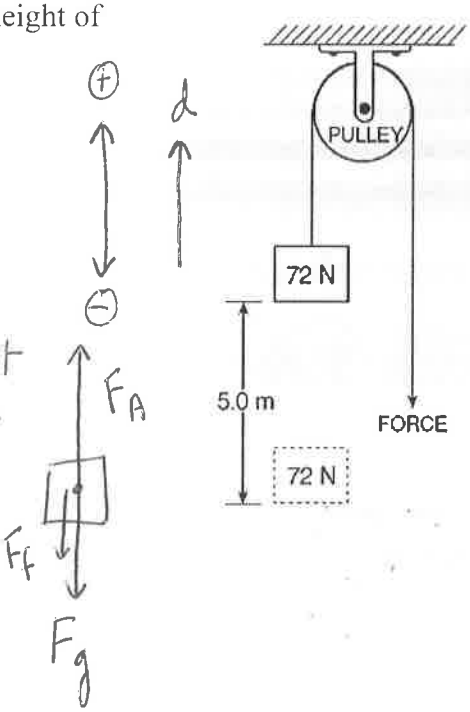
$W_A = 360J$ against gravity

b) How much work does the student do against friction?

$W_{TOTAL} = W_g + W_f + W_{A\,TOTAL} = 0J$

$-360J + W_f + 400J = 0J$

$W_f = -40J \qquad W_A \text{ against friction} = 40J$



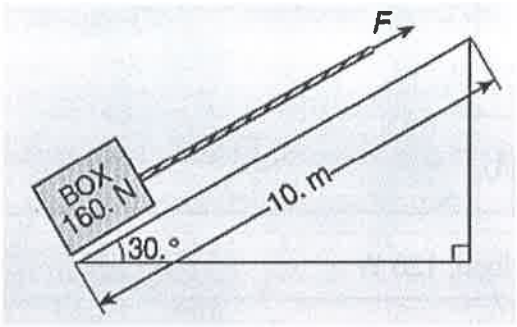
c) How efficient is this pulley?

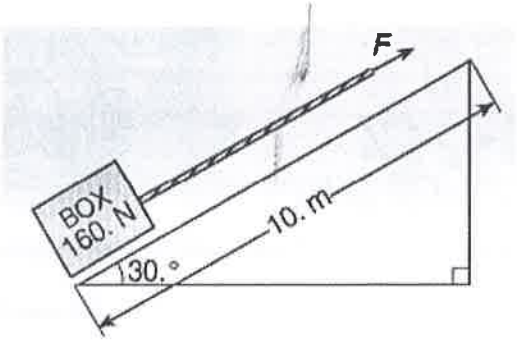
$\frac{360J}{400J} \times 100\% = 90\%$ efficient

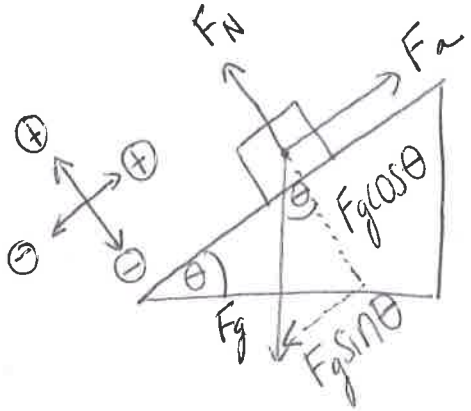
3. A 160.-newton box is pulled to the top of a frictionless ramp at constant speed as shown in the diagram. Calculate the amount of work done.

$F_g = 160.\ N \quad d = 10.\ m$

Find $F_A \parallel d$

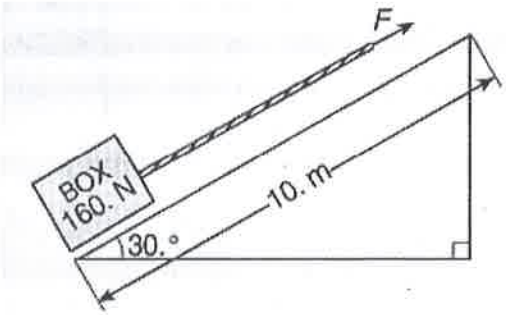






$W_{g\parallel} = F_g \sin\theta\, d = 8.0 \times 10^2\ J$ or $800\ J$

↑ in parallel direction



$W_A = 800J$

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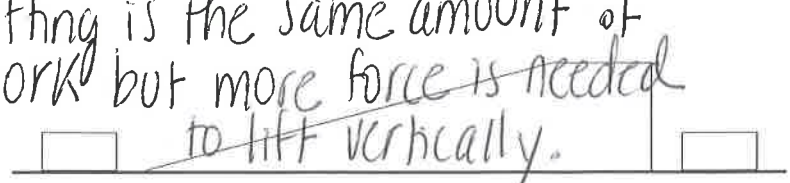
4. Compare the amount of work needed to get this box to the top of the hill by either lifting it or dragging it up the incline if:

Lifting is the same amount of work but more force is needed to lift vertically.



a) the incline is frictionless

b) the incline is not frictionless

Same amount of work done

Dragging against friction is more work overall than just work by gravity because more force is required.

lifting & dragging

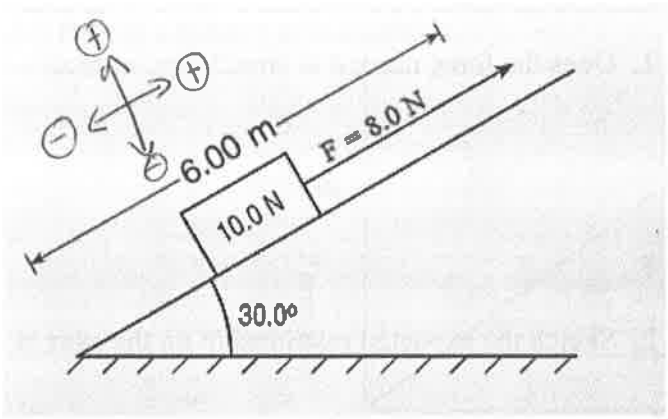
$W_1 = Fd$ (lifting) or $W_2 = fD$ (dragging) $\quad W_1 = W_2$

$W_1 < W_2$

Path Independent:

Work done against gravity is independent of the path.

5. An 8.0 newton force is used to pull a 10.0 newton box 6.00 meters up a rough hill at constant speed as shown in the diagram.



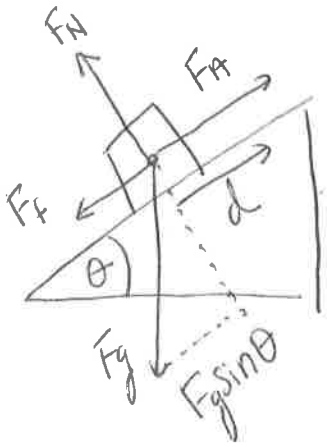
a) How much work was done pulling the box up the hill?

$W_A = F_A \cdot d \cdot \cos\theta \qquad \theta = 0°$

$W_A = (8.0\,N)(6.00\,m)(\cos 0°)$

$W_A = 48\,J$

b) How much work was done overcoming gravity?



$W_g = (F_g \sin\theta)(d)$

$W_g = (10.0\,N)(\sin 30°)(6.00\,m) = -30\,J$

c) How much work was done overcoming friction?

$W_{NET} = \emptyset\,J \qquad W_{NET} = W_A + W_f + W_g$

$\emptyset J = 48J + -(?) + -30J$

$W_f = -18J$

d) How efficient is this process?

$\frac{30J}{48J} \times 100 = 63\%$ efficient