The 15 N force pulls the 2 kg block up the 30° rough incline as shown. The block’s initial velocity is 1 m/s, and after traveling 5 m along the incline, its velocity is 3 m/s. Answer the following questions, showing all your work. \[ W_{\text{net}} = \Delta K \quad |W_g| = mg\Delta y \]
\[ W_f = -fd \quad K = \frac{1}{2} mv^2 \quad f_k = \mu kN \]

1. What is the work done by the 15 N force?
   a) 38.2 J           b) 42.7 J           c) 59.3 J           d) 61.5 J           e) 75.0 J

2. What is the work done by gravity?
   a) –32.7 J           b) –49.1 J           c) 0 J           d) 28.4 J           e) 61.3 J

3. What is the total work done by all the forces?
   a) 8.0 J           b) 14 J           c) 0 J           d) –23 J           e) –50 J

By the work-energy theorem, \( W_{\text{net}} = \Delta K \), so just calculate the change in kinetic energy.

4. What is \( \mu_k \), the coefficient of kinetic friction between the block and the incline?
   a) 0.08           b) 0.17           c) 0.21           d) 0.33           e) 0.40

\[ W_{\text{net}} = \Delta K, \text{ so we have } W_{15} + W_g + W_f = 8J. \text{ Solve this for } W_f \text{ and set that equal to } -\mu mg \cos(\theta)d. \]

5. Suppose the statement of the problem remained the same EXCEPT that the direction of the 15 N force was now tilted UP by an additional 2°. Circle how your answers would have to change.

Answer to #1 would go: UP \underline{Down} \quad \text{Stay the same}

Since the component of the 15 N force in the direction of the motion is now smaller, the work it does goes down.

Answer to #2 would go: UP \quad \underline{Down} \quad \text{Stay the same}

Gravity doesn’t care about other forces, only about the vertical displacement of the object.
Answer to #3 would go:          UP  Down  Stay the same

Since the change in kinetic energy doesn’t change, the net work can’t change.

Answer to #4 would go:          UP  Down  Stay the same

This one is tougher. Since the (positive) work done by the 15 N force goes down, the work done by gravity doesn’t change, and the change in kinetic energy is the same, the (negative) work done by friction has to become smaller in magnitude. Two factors enter into this change. Since the 15 N force now has a small component perpendicular to the incline, the normal force changes. The new normal force is

\[ N_{\text{new}} = mg \cos \theta - 15 \sin(2^\circ) \]

So if we keep \( \mu_k = 0.21 \), the work done by friction goes from \(-17.84 \text{ J}\) to \(-17.29 \text{ J}\).

However, the work done by the 15 N force went from 75 J down to \(15 \cos(2^\circ)5 = 74.95\), a decrease of 0.05 J. So keeping \( \mu_k = 0.21 \) means the change in the work done by friction is too large compared to the change in the work done by the mis-directed 15 N force. So we have to RAISE \( \mu_k \) so that the decrease in the work done by friction isn’t so large.