5. A 1.8 kg block is moved at constant speed over a surface for which coefficient of friction $\mu = \frac{1}{4}$. It is pulled by a force *F* acting at 45° with horizontal as shown in Fig. 9.9. The block is displaced by 2 m. Find the work done on the block by (a) the force *F* (b) friction (c) gravity.

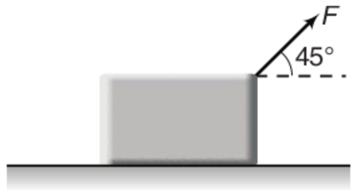

Fig. 9.9

Since the speed is constant, the net force is zero, ΣF=0.
∴The horizontal force(s) and the vertical force(s) are equal.

- The question involves frictional force so that must be taken into account during calculations.

The maximum amount of friction force that a surface can apply upon an object can be easily calculated with the use of the given formula:

$$\boxed{F_{fric} = \mu \cdot F_{norm}}$$

F_{norm} is the normal or perpendicular force pushing the objects together, whereas 'μ' is the coefficient of friction, which is given in the question as $\mu = \frac{1}{4}$

The first thing to do is to resolve the applied force into it's x and y components.

$$F_x = F(\cos\theta) = F\cos(45) = \frac{F}{\sqrt{2}}$$

$$F_y = F\sin(\theta) = F\sin(45) = \frac{F}{\sqrt{2}}$$

Next, since we are given the mass of the block, we need to find it's weight:
W = mg = (1.8)(10) = 18 N

$$\Sigma F_y = F_{norm} + F_y + (-W)$$

$$\Sigma F_y = F_{norm} + \frac{F}{\sqrt{2}} + (-18)$$

Since $\Sigma F_y = 0$:

$$\boxed{F_{norm} = 18 - \frac{F}{\sqrt{2}}}$$

$$\Sigma F_x = F_x + (-F_{fric})$$

$$\Sigma F_x = \frac{F}{\sqrt{2}} + (-\mu \cdot F_{norm})$$

$$\Sigma F_x = \frac{F}{\sqrt{2}} + (\frac{-1}{4} \cdot 18 - \frac{F}{\sqrt{2}})$$

Since $\Sigma F_x = 0$:

$$\frac{1}{4}(18-\frac{F}{\sqrt{2}})=\frac{F}{\sqrt{2}}$$
$$\frac{4F}{\sqrt{2}}=18-\frac{F}{\sqrt{2}}$$

$$\therefore \quad \boxed{F=\frac{18\cdot\sqrt{2}}{5}N}$$

(a) $W_F = FS\cos 45^\circ$

$$= \left(\frac{18\sqrt{2}}{5}\right)(2)\left(\frac{1}{\sqrt{2}}\right) = 7.2J$$

(b) $W_f = (\mu N)(S)\cos 180^\circ$

$$= \left(\frac{1}{4}\right)\left(18 - \frac{F}{\sqrt{2}}\right)(2)(-2)$$

(c) $W_{mg} = (mg)(s)\cos 90^\circ = 0.$

NOTE: In the frictional force formula, F_{norm} is found by applying net force, i.e. Newton’s Third Law, whereby gravity (mg), the normal force and the y-component of the diagonal force F, all act in the y-direction.
This is only applied to this question and it’s scenario, that is, object being dragged on a horizontal surface, in the x-direction. The surface is not inclined.