IN ONE DIMENSION:

Work Done:

Work Done By Friction:

Total Work Done By a motor force, moving distance d against friction:

Note: F­Motor – FFriction because force due to friction is negative. Subtraction makes the result additive.

If the forces are in opposite directions then the total work done is the work done by friction plus the work done moving the object.

If the forces are in the same direction (i.e. the motor force is a braking force) then the work done by friction is subtracted and we are left with the work done by the motor force only.

With external force:

If Fext is in the same direction as Fmotor then they have the same sign, subtracting Fext removes the work done by the external force leaving just the work done by the motor force against friction.

If Fext is in the opposite direction to Fmotor then they have different signs. Subtracting the opposite sign causes the work done against Fext to be added to the total work done by Fmotor.

IN THREE DIMENSIONS:

Calculate the work done in each axis separately.

Work done by the motor force should always be positive; also if the motor force does not have a non-zero component in a particular direction it has done no work.

This is solved by taking a unit vector of the motor force (preserving the signs) and multiplying the work done by this unit vector. This zeros the components of the work done where the motor force had zero value components in x,y,z.

This also has the effect of correcting for the sign of the force and giving us positive or zero components of the work done in each direction.

Work done is a scalar so we add the components in x,y,z axes and get the total work done by the motor force.

The only special case here is in the z direction where gravity is always acting in negative direction. The Z-axis calculations can be corrected to account for this.