Work & Energy – Q4 [16 marks](19/6/21)

Exam Boards

OCR : Mechanics (Year 1)

MEI: Mechanics a

AQA: Mechanics (Year 1)

Edx: Mechanics 1 (Year 1)

A block of mass $5kg$ is initially ascending a slope at a speed of $2ms^{-1}$. The slope has a gradient of 0.75, and the only resistance to motion is a frictional force of $20N$.

(i) How far up the slope does the block travel? [6 marks]

(ii) What is the total time taken for the block to travel up the slope and return to its starting point? [10 marks]

Solution

(i) By conservation of energy,

Work done against friction = loss of KE – gain in PE

So $20d = \frac{1}{2}(5)(2^2) - (5)(9.8)dsin\theta$, [3 marks]

where d is the distance moved, and $tan\theta = 0.75 = \frac{3}{4}$,

so that $sin\theta = \frac{3}{5}$ (from the Pythagorean triple 3,4,5) [1 mark]

Thus $20d = 10 - \frac{147d}{5}$,

$\Rightarrow 100d = 50 - 147d \Rightarrow d = \frac{50}{247} = 0.202m$ or $20.2cm$ (3sf)

[2 marks]

(ii) Up the slope, by N2L:

$-5gsin\theta - 20 = 5a$, where a is the acceleration up the slope

So $a = -(9.8)\left(\frac{3}{5}\right) - 4 = -\frac{247}{25} = -9.88\, ms^{-2}$ [3 marks]

If t is the time taken to go up the slope,

$'v = u + at' \Rightarrow 0 = 2 + \left(-\frac{247}{25}\right)t$

$\Rightarrow t = \frac{50}{247} = 0.20243s$ [2 marks]

Down the slope, by N2L:

$5gsin\theta - 20 = 5a'$, where a' is the acceleration down the slope

So $a' = (9.8)\left(\frac{3}{5}\right) - 4 = \frac{47}{25} = 1.88\, ms^{-2}$ [2 marks]

From (i), $d = \frac{50}{247}$

If t' is the time taken to go down the slope,

$'s = ut + \frac{1}{2}a(t')^{2'} \Rightarrow \frac{50}{247} = 0 + \frac{1}{2}(\frac{47}{25})(t')^2$

$\Rightarrow (t')^2 = \frac{2500}{11609} \Rightarrow t' = 0.46406$

So total time is $0.20243 + 0.46406 = 0.66649 = 0.666s$ (3sf)

[3 marks]