# 3.6 Further Mechanics: Work, Energy and Elastic Strings Depth: 10-minute Pack

EDEXCEL 9FM0 · Calculator allowed · about 10 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

**Answer ALL questions. Show all your working.**

## Key results: work-energy principle, elastic strings/springs and circular motion

*Original content written for Revision Library.*

Unless a question states otherwise, take g = 9.8 m/s^2, model each object as a particle, and treat every string or spring as light; strings are inextensible while rods are light and rigid. This worksheet is a depth paper combining three areas of Further Mechanics, momentum, impulse and collisions are assumed known from elsewhere and are not the focus here: the work-energy principle, elastic strings and springs, and circular motion, and several questions require you to combine two of these ideas within a single question. Kinetic energy is KE = (1/2)*m*v^2 and gravitational potential energy relative to a reference level is GPE = m*g*h; the work-energy principle states that the total work done by all the forces acting on a particle (including work done against resistances such as friction) equals its change in kinetic energy. Hooke's law states that the tension (or thrust) in an elastic string or spring of natural length l and modulus of elasticity lambda, when extended (or compressed) by x, has magnitude T = lambda*x/l, and the elastic potential energy stored is EPE = lambda*x^2/(2*l); an elastic string can only pull, and goes slack once its length is less than l, whereas a spring can both pull and push. For a particle moving on a circle of radius r with angular speed omega, the linear speed is v = r*omega and the centripetal acceleration, directed towards the centre, has magnitude a = v^2/r = r*omega^2; for a conical pendulum, or a vehicle on a banked track, resolve forces vertically and horizontally to link the tension or normal reaction to the speed. For vertical circular motion, combine Newton's second law in the radial direction with energy conservation; for a particle on a string, or on the inside of a smooth track, the critical condition is that the tension or normal reaction is zero, whereas a particle threaded on a rigid rod can maintain circular motion even when this condition would otherwise be violated, in which case the rod is in thrust (compression) rather than tension.

**1** A block of mass 5 kg is pulled from rest along a rough horizontal floor by a constant horizontal force of 30 N. The coefficient of friction between the block and the floor is 0.25. The block travels a distance of 4 m. Take g = 9.8 m/s$^2$.

**(a)** Find the work done against friction as the block travels the 4 m. **(2)**

**(b)** Use the work-energy principle to find the speed of the block after it has travelled the 4 m, giving your answer to 3 significant figures. **(4)**

**(Total for Question 1 is 6 marks)**


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# Mark scheme · 3.6 Further Mechanics: Work, Energy and Elastic Strings Depth: 10-minute Pack

## Question 1

(a) finds the normal reaction R = mg = 49 N and the friction force F = μ*R = 0.25*49 = 12.25 N **M1**

(a) work done against friction = 12.25*4 = 49 J, cao **A1**

**(a) Answer: 49 J**

(b) finds the work done by the applied force: 30*4 = 120 J **M1**

(b) sets up the work-energy equation: $(1/2)*m*v^2$ = work by force - work against friction, ft (a) **M1**

(b) substitutes to get $(1/2)(5)v^2 = 120 - 49 = 71$ **M1**

(b) v = awrt 5.33 m/s, cao **A1**

**(b) Answer: v = awrt 5.33 m/s**


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