

QQQ – Further Mechanics 1 – Chapter 3 – Elastic Strings, Springs & Hooke's Law (Version 1)

Total Marks: 23

(23 = Platinum, 21 = Gold, 18 = Silver, 16 = Bronze)

1. A light elastic string of natural length 0.4 m has one end A attached to a fixed point. The other end of the string is attached to a particle P of mass 2 kg. When P hangs in equilibrium vertically below A , the length of the string is 0.56 m.

(a) Find the modulus of elasticity of the string. (3)

A horizontal force is applied to P so that it is held in equilibrium with the string making an angle θ with the downward vertical. The length of the string is now 0.72 m.

(b) Find the angle θ . (3)

(Total 6 marks)

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2.

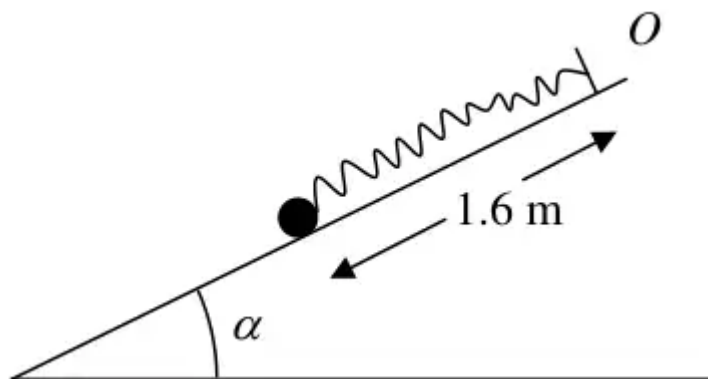


Figure 1

A particle of mass 0.8 kg is attached to one end of a light elastic spring, of natural length 2 m and modulus of elasticity 20 N. The other end of the spring is attached to a fixed point O on a smooth plane which is inclined at an angle α to the horizontal, where $\tan \alpha = \frac{3}{4}$. The particle is held on the plane at a point which is 1.6 m down a line of greatest slope of the plane from O , as shown in Figure 1. The particle is then released from rest.

Find the initial acceleration of the particle. (6)

(Total 6 marks)

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3. A light elastic string with natural length l and modulus of elasticity kmg has one end attached to a fixed point A on a rough inclined plane. The other end of the string is attached to a package of mass m .

The plane is inclined at an angle θ to the horizontal, where $\tan \theta = \frac{5}{12}$

The package is initially held at A . The package is then projected with speed $\sqrt{6gl}$ up a line of greatest slope of the plane and first comes to rest at the point B , where $AB = 3l$.

The coefficient of friction between the package and the plane is $\frac{1}{4}$

By modelling the package as a particle,

(a) show that $k = \frac{15}{26}$ **(6)**

(b) find the acceleration of the package at the instant it starts to move back down the plane from the point B . **(5)**

(Total 11 marks)

Solutions

1.

Mark scheme (a)

Scheme	Marks
T or $\frac{\lambda \times e}{l} = mg$ (even $T = m$ is M1, A0, A0 sp case)	M1
$\frac{\lambda \times 0.16}{0.4} = 2g$	A1
$\Rightarrow \lambda = \underline{49 \text{ N}}$ or 5g	A1
	(3)

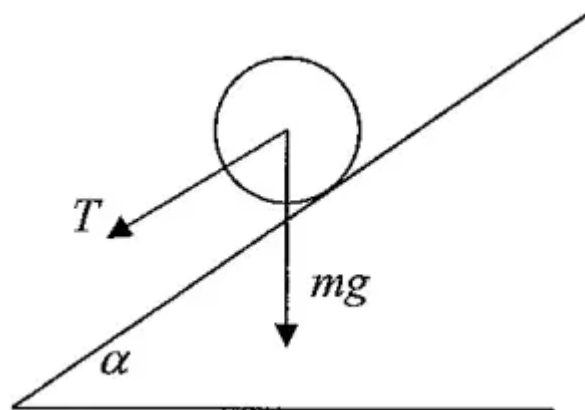
Mark scheme (b)

Scheme	Marks
R(↑) $T \cos \theta = mg$ or $\cos \theta = \frac{mg}{T}$	M1
$49 \cdot \frac{0.32}{0.4} \cdot \cos \theta = 19.6$ or $4g \cdot \cos \theta = 2g$ or $2mg \cdot \cos \theta = mg$ (ft on their λ)	A1ft
$\Rightarrow \cos \theta = \frac{1}{2} \Rightarrow \theta = 60^\circ$ (or $\frac{\pi}{3}$ radians)	A1
	(3)
	(6 marks)

Notes

Special case $T \sin \theta = mg$ giving $\theta = 30$ is M1 A0 A0 unless there is evidence that they think θ is with horizontal – then M1 A1 A0

2.



Scheme	Marks
HL $T = \frac{20 \times 0.4}{2} (= 4)$ accept -4	M1 A1
$mg \sin \alpha + T = ma$	M1 A1
$0.8g \times 0.6 + 4 = 0.8a$	M1
$a = 10.88 \approx 10.9 \text{ (m s}^{-2}\text{)}$ accept 11	A1
	(6 marks)

Notes

The scheme brackets the last two M1 marks: the M1 for $0.8g \times 0.6 + 4 = 0.8a$ depends on the previous M1.

3.

Mark scheme (a)

Scheme	Marks	AO
Work done against friction $= 3l \times \mu mg \cos \theta \left(= \frac{9mgl}{13} \right)$	B1	3.4
	B1	3.4
Gain in EPE $= \frac{kmg \times 4l^2}{2l} (= 2kmg l)$	B1	3.4
Gain in GPE $= mg \times 3l \sin \theta \left(= \frac{15mgl}{13} \right)$		
Work energy equation:	M1	2.1
$\frac{1}{2}m \times 6gl = \frac{9mgl}{13} + 2kmg l + \frac{15mgl}{13}$	A1	1.1b

$2k = 3 - \frac{24}{13} = \frac{15}{13}, k = \frac{15}{26} *$	A1*	2.2a
	(6)	

Notes

B1 B1 B1: Use model to obtain one correct term

Use model to obtain two correct terms

Use model to obtain three correct terms

M1: Work-energy equation. Need all terms and no extras. Dimensionally correct. Condone sign errors and sin/cos confusion.

A1: Correct unsimplified equation

A1*: Obtain given result from correct working

NB: The use of *suvat* equations is not a valid alternative method because the acceleration is not constant

Mark scheme (b)

Scheme	Marks	AO
Tension in the string at B : $\frac{\frac{15}{26}mg \times 2l}{l} \left(= \frac{15mg}{13} \right)$	B1	3.1a
Equation of motion: tension + component of weight – friction $= ma$	M1	3.3
$\frac{15mg}{13} + mg \sin \theta - \frac{1}{4}mg \cos \theta = ma$ $\left(mg \left(\frac{15}{13} + \frac{5}{13} - \frac{3}{13} \right) = ma \right)$	A1 A1	1.1b 1.1b
$a = \frac{17g}{13}$	A1	1.1b
	(5)	
	(11 marks)	

Notes

B1: Correct unsimplified expression for the tension in the string

M1: Equation of motion. Need all terms and no extras. Condone sign errors and sin/cos confusion Allow with T or their T

A1 A1: Unsimplified equation with at most one error

Correct unsimplified equation

A1: Exact answer or accept 12.8 or 13 (m s^{-2})