FM1 – Mechanics Chapter 3
Exam Questions: Hooke's Law

Q1.

A particle P of mass m is attached to one end of a light elastic string of natural length a and modulus of elasticity $3mg$.

The other end of the string is attached to a fixed point O on a ceiling.

The particle hangs freely in equilibrium at a distance d vertically below O.

Show that $d = \frac{4}{3}a$.

(3)
(Total 3 marks)

$T = mg$

$\lambda = 3mg$

$L = a$

$$T = \frac{\lambda x}{L}$$

$$mg = \frac{3mg\,x}{a}$$

$$amg = 3mg\,x$$

$$x = \frac{a}{3}$$

$$d = a + \frac{a}{3} = \frac{4}{3}a$$

Q2.

A particle P of mass 0.5 kg is attached to one end of a light elastic spring, of natural length 1.2 m and modulus of elasticity λ newtons. The other end of the spring is attached to a fixed point A on a ceiling. The particle is hanging freely in equilibrium at a distance 1.5 m vertically below A.

Find the value of λ.

(3)
(Total 3 marks)

$L = 1.2$

$x = 1.5 - 1.2 = 0.3$

$T = 0.5g$

$$T = \frac{\lambda x}{L}$$

$$0.5g = \frac{\lambda (0.3)}{1.2}$$

$$\lambda = 19.6$$

Q3.

A particle P of mass m is attached to one end of a light elastic string of natural length l and modulus of elasticity $3mg$.

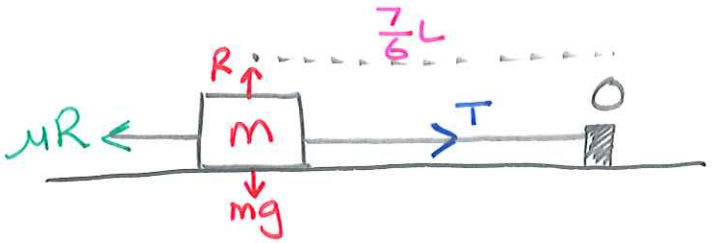
The other end of the string is attached to a fixed point O on a rough horizontal table.

The particle lies at rest at the point A on the table, where $OA = \frac{7}{6}l$.

The coefficient of friction between P and the table is μ.

Show that $\mu \geq \frac{3}{2}$

(Total 4 marks)



$\lambda = 3mg$

$x = \frac{7}{6}L - L = \frac{1}{6}L$

$T = \frac{\lambda x}{L}$

$T = \frac{3mg\left(\frac{1}{6}L\right)}{L}$

$T = \frac{1}{2}mg$

$\mu R = T$

$\mu mg = \frac{1}{2}mg$

$\mu = \frac{1}{2}$ max

$\therefore \mu \leq \frac{1}{2}$

Q4.

A light elastic string has natural length $2a$ and modulus of elasticity $4mg$.
One end of the elastic string is attached to a fixed point O. A particle P of mass m is attached to the other end of the elastic string.
The particle P hangs freely in equilibrium at the point E, which is vertically below O

Find the length OE.

(Total 4 marks)

$\lambda = 4mg$

$l = 2a$

$T = mg$

$T = \frac{\lambda x}{l}$

$mg = \frac{4mg\,x}{2a}$

$2amg = 4mg\,x$

$2a = 4x$

$x = \frac{2a}{4} = \frac{a}{2}$

$OE = 2a + \frac{a}{2} = \frac{5}{2}a$

Q5.

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)

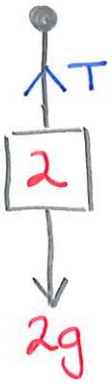
A horizontal force is applied to P so that it is held in equilibrium with the string making an angle θ with the downward vertical. The length of the string is now 0.72 m.

(b) Find the angle θ.

(3)

(Total 6 marks)

(a)



$2g = T$

$L = 0.56$

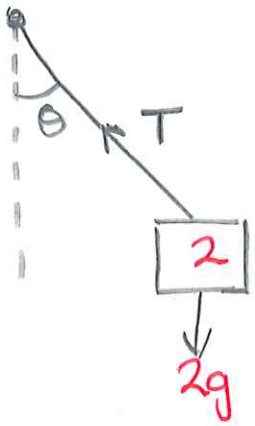
$x = 0.56 - 0.4 = 0.16$

$T = \frac{\lambda x}{L}$

$2g = \frac{\lambda (0.16)}{0.4}$

$\lambda = 49 N$

(b)



$T = \frac{\lambda x}{L}$

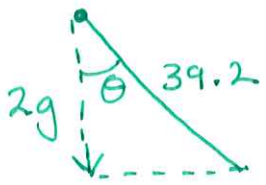
$T = \frac{49(0.32)}{0.4}$

$T = 39.2$

$L = 0.4$

$x = 0.72 - 0.4$

$= 0.32$



$\cos^{-1}\left(\frac{2g}{39.2}\right) = 60°$