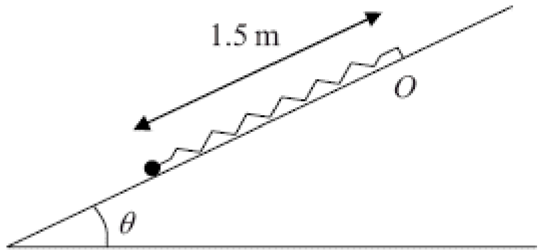
**1.**




A particle of mass 0.5 kg is attached to one end of a light elastic spring of natural length 0.9 m and modulus of elasticity $\lambda$ newtons. The other end of the spring is attached to a fixed point $O$ on a rough plane which is inclined at an angle $\theta$ to the horizontal, where $\sin\theta = \frac{3}{5}$. The coefficient of friction between the particle and the plane is 0.15. The particle is held on the plane at a point which is 1.5 m down the line of greatest slope from $O$, as shown in the diagram above. The particle is released from rest and first comes to rest again after moving 0.7 m up the plane.

Find the value of $\lambda$.

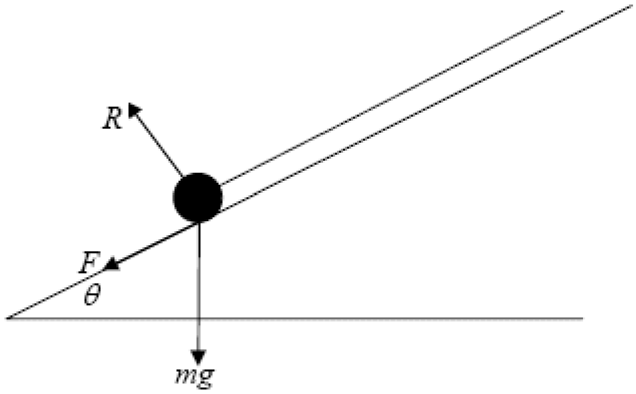
**(Total 9 marks)**

**2.** A particle $P$ of mass $m$ is held at a point $A$ on a rough horizontal plane. The coefficient of friction between $P$ and the plane is $\frac{2}{3}$. The particle is attached to one end of a light elastic string, of natural length $a$ and modulus of elasticity $4mg$. The other end of the string is attached to a fixed point $O$ on the plane, where $OA = \frac{3}{2}a$. The particle $P$ is released from rest and comes to rest at a point $B$, where $OB < a$.

Using the work-energy principle, or otherwise, calculate the distance $AB$.

**(Total 6 marks)**

**1.**




EPE lost $= \frac{\lambda \times 0.6^2}{2 \times 0.9} - \frac{\lambda \times 0.1^2}{2 \times 0.9} \left(= \frac{7}{36}\lambda\right)$ M1 A1

R$(\uparrow)$ $R = mg\cos\theta$ M1

$= 0.5g \times \frac{4}{5} = 0.4g$

$F = \mu R = 0.15 \times 0.4g$ M1 A1

P.E. gained = E.P.E. lost − work done against friction

$0.5\text{g} \times 0.7\sin\theta = \frac{\lambda \times 0.6^2}{2 \times 0.9} - \frac{\lambda \times 0.1^2}{2 \times 0.9} - 0.15 \times 0.4g \times 0.7$ M1 A1 A1

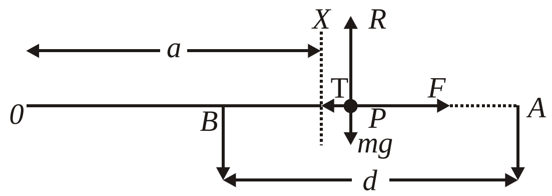
$0.1944\lambda = 0.5 \times 9.8 \times 0.7 \times \frac{3}{5} + 0.15 \times 0.4 \times 9.8 \times 0.7$

$\lambda = 12.70......$

$\lambda = 13$ N or 12.7 A1

**[9]**

**2.**




$F = \mu R = \mu mg$ B1 B1

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

Attempt to relate $Fd$ to EPE M1

$\frac{2}{3}\ mg\ d = \frac{4mg(\frac{a}{2})^2}{2a}$ M1 A1 ft

*[A1 ft only on omission of g in F]*

Final answer: $d = \frac{3}{4}a$ A1 6

**[6]**

**1.** This was probably the least well done of all the questions and correct solutions were relatively rare. The most common mistake was the assumption that there was no final EPE but this was often combined with other errors to give a huge variety of different wrong answers. A surprisingly large proportion of candidates treated this as an equilibrium question, either starting with $T = \mu R + mg \sin \theta$ or slipping an EPE term in as well for good measure. Others realised that it was an energy question but forgot to include the work done against friction; these attempts either used only the frictional force in their equation or ignored it completely, offering as their solution "Initial EPE = *mgh*". Another common error was to include the GPE term twice, once as energy and again as part of the "Work done" expression, showing a lack of understanding of the origin of the *mgh* formula. Very many candidates scored only the 3 marks for finding friction, while those who thought that this was a simple conversion of EPE into GPE had no need to find the friction and so didn't even earn these. Some candidates who included all necessary terms fell at the accuracy hurdle. Inexplicably, a final extension/ compression of 0.2 was not uncommon and other errors arose from inappropriate use of the various lengths mentioned, 1.5, 0.9 and 0.7. There were also all the usual sign errors generated by mistakes in identifying gains and losses. A few candidates produced a perfect solution but lost the final mark by giving their answer as 12.7008.

**2.** Good candidates found this straightforward, finding *AB* immediately from a single application of the work-energy equation. However, a large number of candidates did not have a clear strategy for the problem and marks of 1, 2 or 3 were common.

Common errors were: using $\frac{3a}{2}$, not the *extension*, in the energy term; omitting the frictional force, or equating it to the tension, or including the tension when considering the work done, e.g. $(T - F)x = \dfrac{4mg\left(\frac{a}{2}\right)^2}{2a}$ ; and not realising that the string was slack at *B*, so introducing an extra " elastic energy" term.

Candidates who used a two-stage approach, first finding the velocity at the instance the string became slack, were rarely successful.