Motion in a circle – 2022 GCE Mechanics Further Math A Y543

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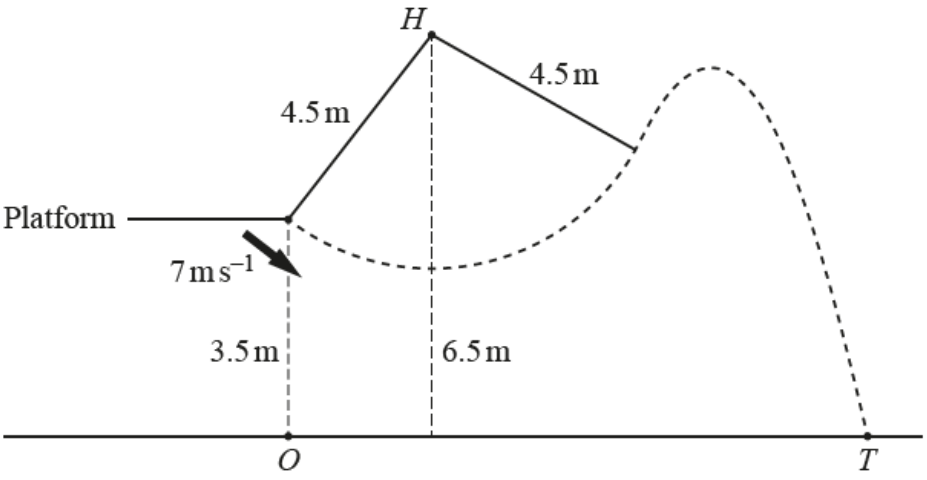
The training rig for a parachutist comprises a fixed platform and a fixed hook, H. The platform is 3.5 m above horizontal ground level. The hook, which is not directly above the platform, is 6.5 m above the ground.

One end of a light inextensible cord of length 4.5 m is attached to H and the other is attached to a trainee parachutist of mass 90 kg standing on the edge of the platform with the cord straight and taut.

The trainee is then projected off the platform with a velocity of $7\,\text{m s}^{-1}$ perpendicular to the cord in a downward direction. The motion of the trainee all takes place in a single vertical plane and while the cord is attached to H it remains straight and taut.

When the speed of the trainee reaches $5.5\,\text{m s}^{-1}$ the cord is detached from H and the trainee then moves under the influence of gravity alone until landing on the ground (see diagram).



The trainee is modelled as a particle and air resistance is modelled as being negligible.

(a) Show that at the instant before the cord is detached from H, the tension in the cord has a magnitude of 1005.5 N. **[6]**

The point on the ground vertically below the edge of the platform is denoted by O. The point on the ground where the trainee lands is denoted by T.

(b) Determine the distance OT. **[5]**

The ground around T is in fact an elastic mat of thickness 0.5 m which is angled so that it is perpendicular to the direction of motion of the trainee on landing. The mat, which is very rough, is modelled as an elastic spring of natural length 0.5 m. It is assumed that the trainee strikes the mat at ground level and is brought to rest once the mat has been compressed by 0.3 m.

(c) Determine the modulus of elasticity of the mat. Give your answer to the nearest integer. **[4]**