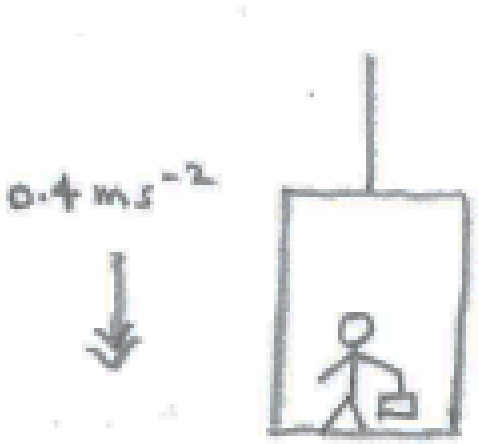
Mechanics Exercises - Misc (4 pages; 8/3/19)

(1) Forces

A man is in a lift, which is moving downwards with an acceleration of $0.4ms^{-1}$. The lift is suspended by a cable, and the man is holding a parcel by a light string, as in the diagram. The masses of the lift, man and parcel are 300kg, 80kg and 5kg, respectively.



(i) Find :

(a) the tension in the cable

(b) the reaction between the man and the floor of the lift

(c) the tension in the string

(ii) Does the man feel heavier or lighter than he would if the lift were stationary and he were no longer carrying the parcel?

(2) Friction

A sledge with a child onboard is being pulled along on level ground, at a constant speed, by means of a rope inclined at 30° to the horizontal. The sledge and child together have a mass of $100kg$. The coefficient of friction between the sledge and the ground is $\frac{1}{10}$. Assuming that $g = 10$, find the tension in the rope.

(3) Energy

A car of mass 1 tonne starts to climb a hill at $20ms^{-1}$. The slope of the hill is a constant θ, where $sin\theta = \frac{1}{10}$. If the car is not accelerating (or braking) and there is a constant resistance to motion of $1000N$, find the speed of the car when it has gained a height of $5m$. Assume that $g = 10$.

(4) Oscillations

A lift has an elastic string suspended from its ceiling, with a mass of 10 grams at the end of the string. The string has natural length 80 cm, and modulus of elasticity $20N$. Initially, when the lift is stationary, the mass is hanging in equilibrium. The lift then starts to ascend with an acceleration of 0.2 ms^{-2}. Show that the extension of the string after $t\ secs$ is $0.4 - 0.008\cos(50t)\ cm$.

[Assume that $g = 9.8ms^{-2}$]

(5) Oscillations

A flexible bar is embedded horizontally in a wall. A particle rests on the free end of the bar, and the bar (with the particle) is pulled down 2cm below the horizontal, and then released. Given that the bar and particle start to perform simple harmonic motion about the horizontal position, with 5 cycles per second, how long is it before the particle loses contact with the bar, and what speed does it have at that point? [Note: The particle will not be in contact with the bar long enough to complete a cycle of the simple harmonic motion.]

(6) Equilibrium

A uniform solid hemisphere rests in equilibrium on a rough slope, with its curved surface in contact with the slope, which is inclined at an angle α to the horizontal, in such a way that the plane face of the hemisphere is vertical. Find α.

(7) Equilibrium

A stepladder is made up of two sides, which have weights 80N and 8N. Both sides are of length 2m. There is a platform resting on the top, which together with a person standing on it weighs 700N. The two sides are also joined together by a horizontal light rope of length 1m, which starts at a distance of 0.6m along each side, from the base. See Fig. 1. There is no friction between the ladder and the ground, or between the platform and the ladder. Find the tension in the rope.

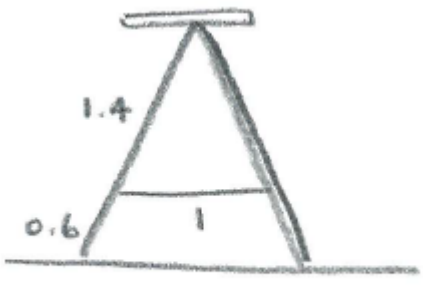


Fig. 1

(8) Oscillations

A 0.2 kg mass is held between two elastic strings, as shown in the diagram. The upper string has original length 8m and modulus of elasticity 2N, and is initially extended by 4m. The lower string has original length 6m and modulus of elasticity 1N, and is initially extended by 2m. When the mass is released, determine its subsequent motion (assume $g = 10$, and ignore any resistance to motion).