Problem 1.

A projectile is launched with initial velocity = 30 m/s at an angle of 70° above the horizontal. Ignore air resistance.

a) How long will it take to reach its maximum height above the ground?

b) How far has it travelled horizontally by the time it reaches its maximum height?

c) When it reaches its maximum height, it undergoes a chemical explosion, and it separates into two equal-mass fragments. Just after the explosion, one of the fragments is observed to be moving at 25 m/s directly downward. What is the velocity vector, at this instant, of the other fragment?

Problem 2.

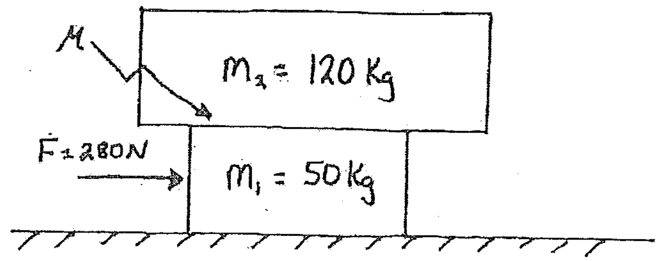
A 5 kg object is released, from rest, at a height of $h = 2R_m$ above the surface of the Moon, where $R_m = 1740$ km is the radius of the Moon. The mass of the Moon is 7.3×10^{22} kg.

a) What is its speed when it hits the surface of the Moon? Ignore the gravitational effects of the Earth, the Sun, and the other planets.

b) How much work did the Moon do on the object as it fell?

Problem 3.

A 50 kg block slides underneath a 120 kg block with an acceleration $a = 2$ m/s^2 when an external horizontal force of 280 N is applied. The 50 kg block is on a horizontal frictionless surface, but there is friction between the two blocks.

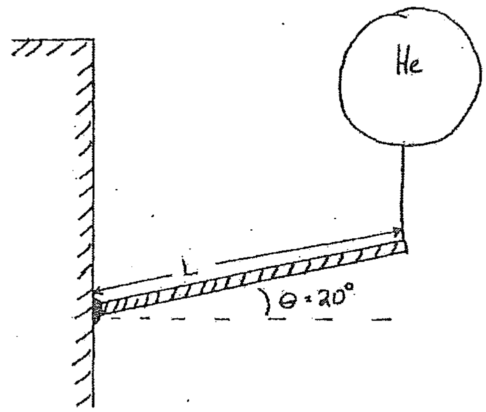


a) Find the coefficient of kinetic friction between the two blocks.

b) Find the acceleration (magnitude and direction) of the 120 kg block (when it is still in contact with the other block).

Problem 4.

A pole of mass M = 30 kg and length L = 2 m is attached to a vertical wall by a hinge at one end and is attached via a massless string to a helium-filled balloon at the other end. The pole is at an angle of 20° to the horizontal.

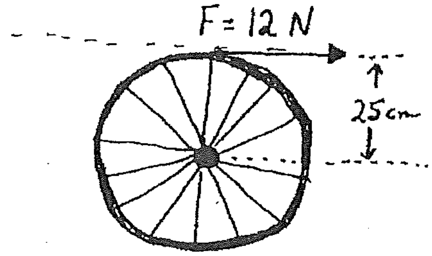


a) What is the tension in the string?

b) What are the horizontal and vertical components of the force exerted by the hinge on the pole?

c) Assume that the balloon wall is made of a thin, massless material. The density of helium is 0.18 kg/m^3 and the density of air is 1.3 kg/m^3. What is the radius of the balloon?

Problem 5.



A bicycle wheel with a moment of inertia of 30 kg$\cdot$m^2 rotates with an initial angular speed of 5.0 rad/s. A tangential force of 12.0 N is applied at a distance of 25 cm from the center of the wheel, in such a way that the rotation rate decreases.

a) How long will it take the wheel to stop?

b) How many revolutions will the wheel have made by the time it stops (from the instant the tangential force is first applied)?

c) What is the direction of the torque caused by the tangential force? Pick one of the following: i) to the left, ii) to the right, iii) out of the page, iv) into the page, v) none of the these.

Problem 6.

Earth's polar ice caps contain 2×10^{19} kg of ice. Since this ice is located at the poles, its contribution to the Earth's moment of inertia is negligible. As a weird practical joke, the Klingon empire arranges to have all of this ice moved to a single pile, located at the equator. The mass of the Earth is 6.0×10^{24} kg, its radius is 6370 km, and the moment of inertia of a sphere about an axis through its center is $\frac{2}{5}MR^2$; you can treat the Earth as a perfect sphere.

a) Would the length of the day become shorter or longer? Why?

b) By how much?

Problem 7.

A string of mass $m = 2.0 \times 10^{-3}$ kg, and length $L = 3$ m oscillates in a standing wave, at a frequency of 60 Hz. There is one and a half wavelengths between the two ends of the string.

a) What is the tension in the string?

b) If one end of the string is plucked, how long would it take until the other end of the string reacts?

Problem 8.

A 0.2 kg mass is held vertically by a spring. The mass is pulled down and released, and it then oscillates vertically, with a time dependence given by $y = (0.5)\cos(\pi t)$, where y is in meters and t is in seconds.

a) What are the amplitude, angular frequency and period of the motion?

b) What is the spring constant of the spring?

c) Write the equation for the velocity of the mass, $v(t)$.

d) Now, instead, a penny is placed on top of the mass before it is pulled down. The frequency of the oscillation the same as before, but the amplitude is larger. What is the maximum amplitude with which the mass can be released, such that the penny will not fly off the top of the mass during the oscillation?