Homework 7

(I) The wheels of a suitcase with a mass of 36 kg are broken. It is tied to a rope making a 40° angle with horizontal. The grumpy owner of the suitcase drags it on the horizontal floor by pulling on the rope with a force of 65 N. The gravitational acceleration is $10\,\mathrm{m}\cdot\mathrm{s}^{-2}$.

(a) *[5 pts.]* Find the magnitude of the normal force between the floor and the suitcase.

(b) *[5 pts.]* The coefficient of kinetic friction between the floor and the suitcase is $\mu_K = 0.13$. What is the frictional force acting on the suitcase.

(c) *[5 pts.]* Find the acceleration of the suitcase.

(d) *[5 pts.]* Starting from rest, how much time does it take for the speed of the suitcase to reach a comfortable walking speed of $0.5\,\mathrm{m}\cdot\mathrm{s}^{-1}$.

(II) *[10 pts.]* A brick of mass 1.5 kg slides on a frictionless ramp making an angle of 30° with horizontal. If the brick starts from rest, how much time does it take for it to reach the end of the ramp 3 m away? The gravitational acceleration is $10\,\mathrm{m}\cdot\mathrm{s}^{-2}$.

(III) *[10 pts.]* A brick of mass 1.5 kg is on a ramp. The coefficient of static friction between the brick and the ramp is $\mu_S = 0.2$. Find the largest possible angle between the ramp and horizontal so the brick can stay on the ramp without starting to slide down. The gravitational acceleration is $10\,\mathrm{m}\cdot\mathrm{s}^{-2}$.

(IV) *[10 pts.]* A train engine pulls out of a station along a horizontal track with five indentical freight cars behind it, each with a weight of 90 kN. The train reaches a speed of $15\,\mathrm{m}\cdot\mathrm{s}^{-1}$ within 5 min of starting out. Find the magnitude of the force pulling the tail car forward. All frictions can be neglected. The gravitational acceleration is $10\,\mathrm{m}\cdot\mathrm{s}^{-2}$.

(V) *[10 pts.]* Two masses $m_1 = 26\,\mathrm{kg}$ and $m_1 = 42\,\mathrm{kg}$ are connected by a rope that is massless and which does not stretch. The rope runs through a pulley and the masses are hanging from the rope on each side of the pulley. Find the acceleration of each mass and the tension of the rope. The gravitational acceleration is $10\,\mathrm{m}\cdot\mathrm{s}^{-2}$.

(VI) The gravitational pull of a spherical object of mass M on another object of mass m at a distance r from its center is $G\frac{Mm}{r^2}$ where $G = 6.7 \times 10^{-11}\,\mathrm{m}^3 \cdot \mathrm{kg}^{-1} \cdot \mathrm{s}^{-2}$ is the Universal Constant of gravitation. Geostationary satellites follow a circular trajectory to travel around the Earth in about 24 h. That is why they are geostationary. The radius of the Earth is $6,371\,\mathrm{km}$ and its mass is $6 \times 10^{24}\,\mathrm{kg}$.

(a) *[10 pts.]* Using the above information, find the value of the gravitational acceleration at the surface of the Earth.

(b) *[10 pts.]* Find the altitude above ground of geostationary satellites.

(c) *[10 pts.]* Knowing it takes one year for the Earth to complete a circular revolution of around the Sun at a distance of $146 \times 10^9\,\mathrm{m}$, find the mass of the Sun.

(VII) *[10 pts.]* A string of length 15 m is used to hold a disco ball of mass 3 kg above the dance floor. The ball is attached 5 m from one end of the string and the two ends are attached to two points at the same height above floor and at a distance of 12 m from each other. Find the tension of the string on both sides of the disco ball. The gravitational acceleration is $10\,\mathrm{m} \cdot \mathrm{s}^{-2}$.