Study Guide for Midterm 2 for Algebra-Based Physics-1: Mechanics (PHYS135A-01)

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October 24th, 2018

1 Equations

- Newton's First Law: $\vec{F}_{Net} = 0$ if $\vec{v}$ is constant. Newton's Second Law: $\vec{F}_{Net} = m\vec{a}$. Newton's Third Law: $\vec{F}_{AB} = -\vec{F}_{BA}$.
- Normal force: $\vec{N} = +mg\hat{y}$, if weight is $w = -mg\hat{y}$ (flat surface).
- Force of Friction: $\vec{F} = -\mu\vec{N}$ (minus sign: opposes motion).
- Static versus kinetic friction: $\mu_s \geq \mu_k$.

2 Newton's Laws

1. A drone system has a forward thrust, backwards drag, lift upwards, and weight force downwards. (a) Draw a free-body diagram of the system including these four vectors. (b) What is the acceleration if the weight is -40 N, the thrust is 55 N, the lift is 40 N, and the drag is 15 N? (The drone mass is 5 kg).

    - A: There is a net force on the frog, downwards.
    - B: There is a net force on the frog, upwards.
    - C: There is no net force on the frog, because it is moving at constant velocity.
    - D: There is a net force on the frog, in a horizontal direction.

2. A surfer on a surfboard slides along the surface of the ocean, slowing down. The water provides the normal force that balances her weight. If we call the direction in which she is moving "positive," in which direction is the net force?
    - A: In the same direction she is moving.
    - B: In the opposite direction she is moving.
    - C: In the upward direction.
    - D: In the downward direction.

3. Consider Fig. 1. Show that if the applied force $F_\perp$ and the tension T balance to 0 N, that $T = F_\perp/(2\sin\theta)$.

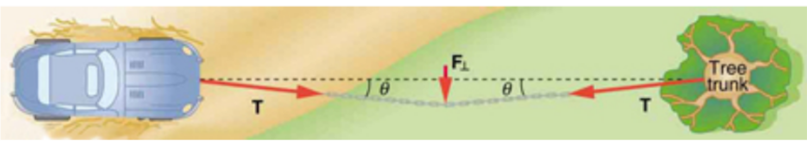

Figure 1: Diagram for exercises 3 and 4, **Newton's Laws.**

4. If a person applies $F_\perp = 1000$ N, and the angle is $\theta = 7°$, what is the tension T in the line? (Use $T = F_\perp/(2\sin\theta)$).

5. A 5.00×10^5 kg rocket is accelerating upwards with thrust 1.250×10^7 N, but there is also a downward force of 4.5×10^6 N due to air resistance (the rocket also has a weight). (a) Draw a free-body diagram including weight, thrust, and air-resistance. (b) Calculate the acceleration using Newton's second law.

6. Consider Fig. 2, in which two tugboats push a barge ($F_x = 2.7 \times 10^5$ N, and $F_y = 3.6 \times 10^5$ N). (a) What is the magnitude of the net force on the barge? (b) If the barge has a mass of 5×10^6 kg, what is the acceleration of the barge?

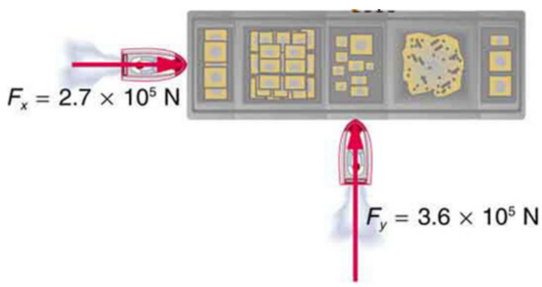

Figure 2: Diagram for exercise 6, **Newton's Laws.**

3 Friction and Drag

1. A dog who "just can't right now" is being pulled along a ceramic kitchen floor by its human. The human exerts a force of 20 N horizontally, and the dog has a mass of 20 kg. If the lazy puppy is moving at a constant velocity, what is the coefficient of kinetic friction μ_k between the dog and the floor?

2. Consult Fig. 3. (a) What is the magnitude of the force of friction on a 1000 kg vehicle on rubber tires, skidding across dry concrete? (b) What would be the new magnitude of the force of friction if the concrete was wet? (c) What is the magnitude of the force of friction on a 60 kg snowboarder sliding across wet snow on a waxed snowboard?

3. Consult Fig. 4. If $m_1 = 1000$ grams, and $m_2 = 225$ grams, (a) what is the coefficient of static friction between the upper block and the table if the system is not moving? (b) If m_1 is decreased suddenly, and the system begins to move, will it move at constant velocity, or accelerate?

Table 5.1 Coefficients of Static and Kinetic Friction

System	Static friction μ_s	Kinetic friction μ_k
Rubber on dry concrete	1.0	0.7
Rubber on wet concrete	0.7	0.5
Wood on wood	0.5	0.3
Waxed wood on wet snow	0.14	0.1
Metal on wood	0.5	0.3
Steel on steel (dry)	0.6	0.3
Steel on steel (oiled)	0.05	0.03
Teflon on steel	0.04	0.04
Bone lubricated by synovial fluid	0.016	0.015
Shoes on wood	0.9	0.7
Shoes on ice	0.1	0.05
Ice on ice	0.1	0.03
Steel on ice	0.4	0.02

Figure 3: (Left) Frictional coefficients for exercise 2, **Friction and Drag**.

4. A system of area A moves at velocity v through air with density ρ_{air}. The drag force is $\vec{F}_D = \frac{1}{2} C \rho_{air} A v^2$, where C is a measured constant. (a) When weight $\vec{w}$ balances with $\vec{F}_D$, the system reaches *terminal velocity* v_T. Show that $v_T = \sqrt{2mg/C\rho A}$. (b) What is v_T for a skydiver who has $m = 60$ kg, $A = 1$ m^2, $C \approx 0.7$, in air with $\rho = 1.225$ kg/m^3? (Use $v_T = \sqrt{2mg/C\rho A}$).

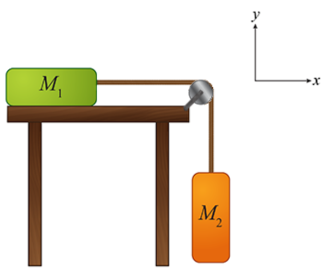

Figure 4: Diagram for exercise 3, **Friction and Drag**.