

Group Problem

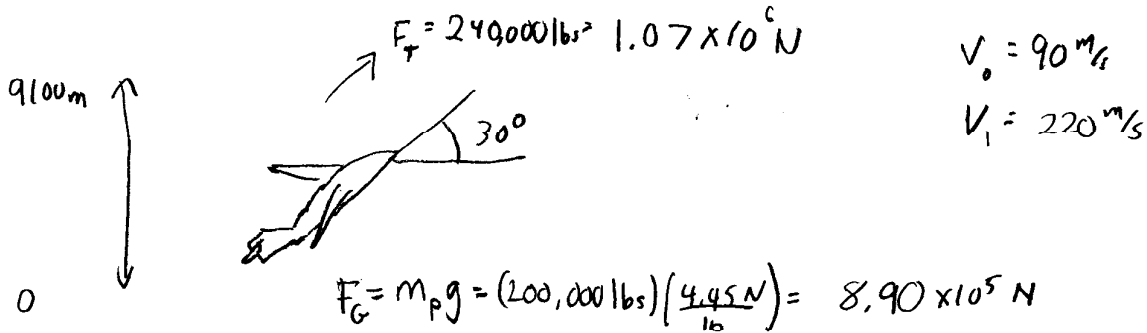
One morning while waiting for class to begin, you are reading a newspaper article about airplane safety. This article emphasizes the role of metal fatigue in some accidents. Metal fatigue results from the flexing of airframe parts in response to the forces on the plane, especially during take off and landings. As an example, the reporter uses a plane with a take off weight of 200,000 lbs (1 lb = 4.45 N), and a take off speed of 200 mph (90 m/s) which climbs at an angle of 30° above the ground, with a constant acceleration until it reaches its cruising altitude of 30,000 feet (9100 m) with a speed of 500 mph (220 m/s). The jet engines provide a forward thrust of 240,000 lbs by pushing air backwards. The article then goes on to explain that a plane can fly because the air exerts an upward force on the wings perpendicular to their surface called "lift." You know that air resistance is also a very important force on a plane and is in the direction opposite to the velocity of the plane. The article tells you this force is called "drag." Although the reporter writes that some metal fatigue is primarily caused by the lift and some by the drag, she never tells you the magnitude of the lift or drag for her example plane. Luckily, the article contains enough information to calculate them, so you do.

Group Problem

Context-Rich Problems: Solutions Outline

FOCUS the PROBLEM

Draw a picture of the situation including ALL information given in the problem.



Question(s): What is the problem asking you to find?

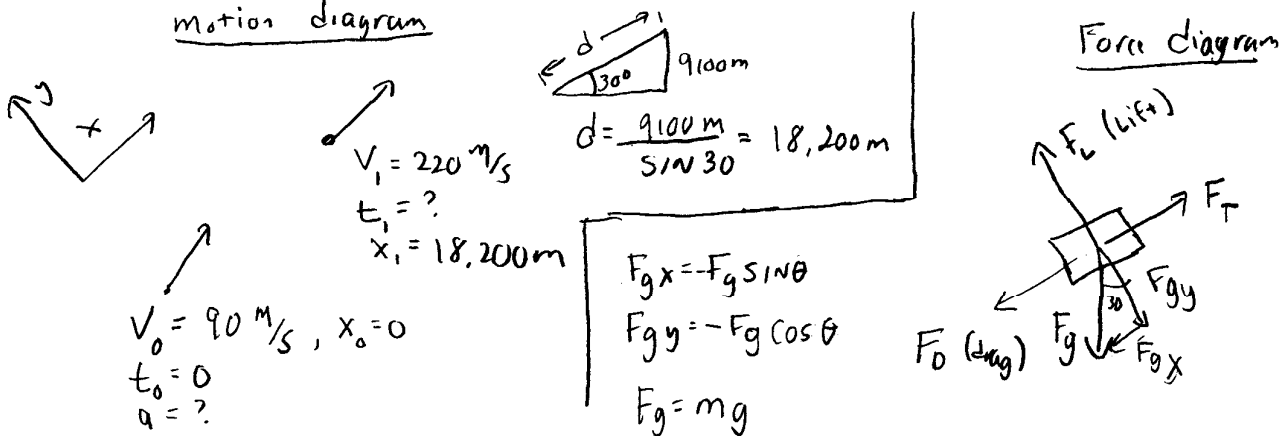
what is the drag force and lift force

Approach: Outline the approach you will use.

Use kinematic equations to find acceleration. Use Newton's Second law to find forces. Chose x axis along the direction of motion.

DESCRIBE the PHYSICS

Draw physics diagram(s) and define ALL quantities uniquely.



Write general forms of all equations you think you will use.

$$\sum \vec{F} = m \vec{a} \Rightarrow \sum F_x = m a_x, \sum F_y = m a_y$$

$$v^2 = v_0^2 + 2a(x - x_0)$$

PLAN the SOLUTION

Construct Specific Equations (Same Number as Unknowns)
Put in actual numbers as little as possible and reasonable.

Solve for F_L

$$\sum F_y = 0$$

$$F_L - F_g \cos \theta = 0$$

Ⓘ $F_L = F_g \cos \theta$

Solve for F_D

$$\sum F_x = ma$$

Ⓙ $-F_D - F_g \sin \theta + F_T = ma$

Solve for a

$$V_1^2 = V_0^2 + 2a(x_1 - x_0)$$

Ⓚ $a = \frac{V_1^2 - V_0^2}{2(x_1 - x_0)}$

Solve for m

Ⓛ $F_g = mg \Rightarrow m = F_g/g$

Plug Ⓛ and Ⓚ in Ⓙ

$$F_D = F_T - F_g \sin \theta - ma$$

$$F_D = F_T - F_g \sin \theta - \frac{F_g}{g} \frac{(V_1^2 - V_0^2)}{2(x_1 - x_0)}$$

Check Units:

From Ⓘ $N!$

From Ⓙ $N - N - \frac{N}{m/s^2} \frac{m^2/s^2}{m}$

look at last term $\frac{kg \cdot m/s^2}{m/s^2} \frac{m/s^2}{m} = kg \cdot m/s^2 = N!$

EXECUTE the PLAN

Calculate Target Variable(s)

$$F_L = (8.90 \times 10^5 N) (\cos 30^\circ) = 7.7 \times 10^5 N$$

$$F_D = 1.07 \times 10^6 N - (8.90 \times 10^5) \sin 30^\circ - \frac{8.90 \times 10^5 N ((220 \text{ m/s})^2 - (90 \text{ m/s})^2)}{9.8 \text{ m/s}^2 \cdot 2(18,200)}$$
$$= 5.2 \times 10^5 N$$

EVALUATE the ANSWER

Is Answer Properly Stated?

Yes, in Newtons

Is Answer Unreasonable?

No, about the same as the weight, so not too unusual.

Is Answer Complete?

Yes, Lift + Drag are given.

(extra space if needed)