

NAME _____ BOX NUMBER _____

Problem 1 (25) _____

Problem 2 (25) _____

Problem 3 (25) _____

Problem 4 (25) _____

Total (100) _____

INSTRUCTIONS

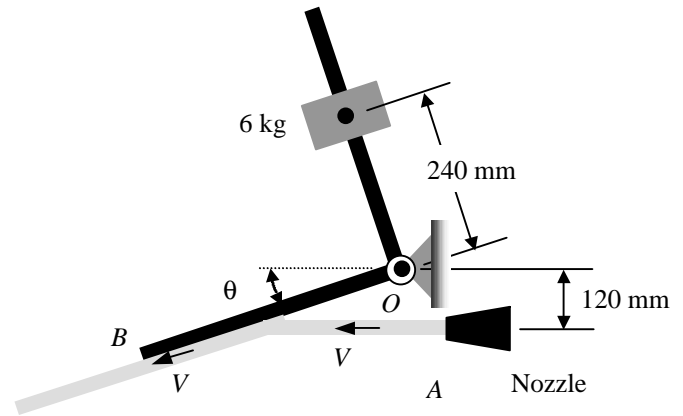
- **Closed book/notes exam. (Unit conversion page provided)**
 - **Help sheet allowed. (8-1/2 x 11" sheet of paper, one side)**
 - **Laptops may be used; however, no pre-prepared worksheets or files may be used.**
- 1) Show all work for complete credit.
 - Start all problems at the ANALYSIS stage, but clearly label any information you use for your solution.
- **Problems involving conservation principles MUST clearly identify the system and show a clear, logical progression from the basic principle.**
- Don't expect us to read your mind as to how or why you did something in the solution. Clearly indicate how you arrived at your answer.
 - **Always crunch numbers last on an exam.** The final numerical answer is worth the least amount of points. (Especially if all I would have to do is plug in the numbers into a well-documented solution.)
- 2) Useful Rule of Thumb (Heuristic): $(100 \text{ point exam}) / (50 \text{ min}) = 2 \text{ points/minute}$. That means a 10 point problem is not worth more than 5 minutes of your time (at least the first time around).
 - 3) Please remain seated until the end of class or everyone finishes. (Raise your hand and I'll pick up your exam if you have other work you need or want to do.)

Useful InformationAcceleration of Gravity: $g = 9.810 \text{ m/s} = 32.174 \text{ ft/s}$

Problem 1 (25 Points)

A high-speed jet of air issues from the 40-mm-diameter nozzle A with a velocity of $V = 240$ m/s and impinges on the vane OB , shown in its edge view below. The mass flow rate of the air is 0.364 kg/s. The vane and its right-angle extension have negligible mass compared with the attached 6-kg cylinder and are freely pivoted about a horizontal axis through O . The air density under the prevailing condition is 1.206 kg/m³.

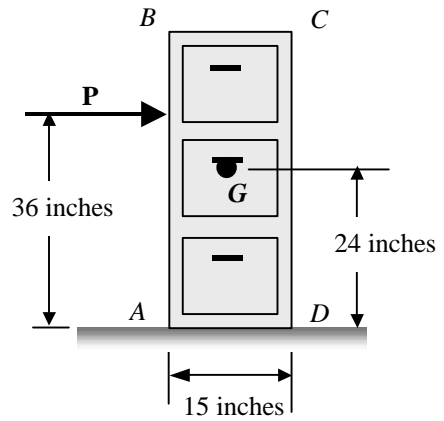
Determine the angle θ that the vane assumes with the horizontal when the vane is in equilibrium, i.e. stationary.



Problem 2 (25 points)

A horizontal force \mathbf{P} acts on a cabinet that rests on a floor as shown. The cabinet weighs 120 lbf. It is known that the coefficient of static friction is $\mu_s = 0.30$ and the coefficient of kinetic friction is $\mu_k = 0.24$.

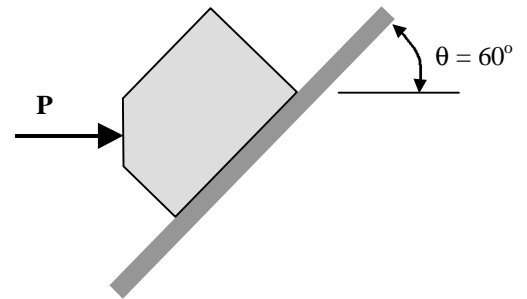
- (a) If *slipping* impends, what is the magnitude of \mathbf{P} ?
- (b) If *tipping* impends,
 - (i) what is the magnitude of \mathbf{P} , and
 - (ii) at what point will the resultant floor reaction act?
- (c) What is the *smallest* magnitude of \mathbf{P} that will cause the cabinet to move, i.e. either tip or slip?



Problem 3 (25 points)

A block with a mass $m = 200$ kg rests on an inclined plane with an applied load \mathbf{P} . Depending upon the magnitude of \mathbf{P} , the block may move up the incline, down the incline, or remain stationary. Between the surfaces of contact, the coefficient of static friction is $\mu_s = 0.25$ and the coefficient of kinetic friction is $\mu_k = 0.20$.

Determine the range of the magnitude of the horizontal force \mathbf{P} , in newtons, that will keep the block in equilibrium, i.e. not moving.



Problem 4 (25 points)

The ducted fan unit shown in the figure has mass $m = 100$ kg and is supported in the vertical position on its flange at A . The unit draws in air with a density $\rho = 1.200$ kg/m³ and a velocity $V_1 = 5$ m/s through an inlet with diameter $D_1 = 1.00$ m. It discharges air through two outlets at the bottom of the fan. The mass flow rate through each outlet is $1/2$ of the entering mass flow rate, and the velocity at each outlet is $V_2 = V_3 = 15$ m/s. Both inlet and outlet pressures are atmospheric.

Determine the vertical force R , in newtons, applied to the flange of the fan unit by the supporting slab.

