Rotor rooter

Problem 182 — What goes up doesn't necessarily stay up, as this month's problem by John Olson of Shelton, Conn., demonstrates.

"Our usual bet?" quipped Phineas Gotrocks.

One of the semi-annual model plane races of the Squaunder Club was just getting underway, and Gotrock's bet with fellow member Lottie Dough as to who would win the race was a club legend.

"I've made some modifications this time," continued Gotrocks. "I'll be entering a radio-controlled model *helicopter*, instead."

"Why, you ..." muttered Lottie. "Never mind! I'll still beat you, especially at that stretch where the models fly up the 720-ft-high cliff."

Gotrocks panicked. "I hadn't thought of that! It'll never make the climb."

Lottie chuckled, "That'll be cash, Gotrocks. No checks!"

The helicopter Gotrocks had made to specification features a 40-ft-diam main rotor and an 8-ft-diam tail rotor. The rotors are geared together, and the clearance between their blade-tip paths is 6 in. Tail rotor thrust moment-arm is 24.5 ft perpendicular to the main rotor shaft. At 100% rpm, the tip speed of both rotors is 700 fps. The engine produces 1,200 hp, 90% of which goes to the main rotor by means of a multiple-reduction belt drive with a reduction ratio of 12.5:1. Engine power does not change with rpm.

The race began. When the models reached the cliff, the helicopter was 20 ft off the ground, and its engine rpm was down to 90% and continuing to drop at a rate of 8% per min. The chopper's rate of *climb* is a constant 500 fpm. Tail rotor's maximum available thrust decreases proportionally to the square of the quotient of beginning and ending rpm percentage. At the start of the climb, tail rotor's maximum available thrust is down to 1,150 lb.

Ignore wind and other aerodynamic forces on the helicopter's fuselage. Also, neglect drive train losses. Will the helicopter be able to climb the cliff? Compute both the necessary and available tail rotor thrusts during the climb to see if Gotrocks needs to stop at the bank before the awards ceremony.

Send your answer to:

Fun With Fundamentals
POWER TRANSMISSION DESIGN
1100 Superior Ave.
Cleveland, OH 44114-2543

Deadline is May 10. Good luck!

Technical consultant, Jack Couillard, Menasha, Wis.

Contest winner — *There were a variety of correct answers, and we included anyone who came up with a logical combination of coins in the drawing.* Congratulations to R. Roberts of Emporia, Ky., who won our February contest by having his name drawn from the 147 contestants who answered out of a total of 189 for that month. A TI-68 calculator is in the mail to him.

The TI-68 Advanced Scientific Calculator by Texas Instruments can solve five simultaneous equations with real and complex coefficients and has 40 number functions that can be used in both the rectangular and polar coordinate systems. Other functions include formula programming, integration, and polynomial root finding. The calculator also features a last-equation replay function that lets you double-check your work.

To enter the contest, send your answer on a postcard or letter to POWER TRANSMISSION DESIGN, 1100 Superior Ave., Cleveland, OH 44114-2543.

You can also receive a TI-68 and credit in the magazine if you send in an *original* problem with solution, and we publish it.

Solution to last month's problem 181 — You are a champion clock watcher, if you answered **1:05:27**. Here's how Baath and McBean ended up doing time.

Let:

V_m = Speed of minute hand, is $^1/_{60}$ rpm
V_h = Speed of hour hand, is $^1/_{720}$ rpm
t = Time from 1:00 p.m. until hands line up, min
D_m Distance traveled by minute hand during time t, rev
D_h Distance traveled by hour hand during time t, rev

Since time is distance divided by speed:

$$t = \frac{D_m}{V_m} = \frac{D_h}{V_h} \qquad (1)$$

We also know that the hour hand moves 1/12 rev or "5 min" for every revolution of the minute hand, or:

$$D_m = D_h + \left(\frac{1}{12}\right)\text{rev}$$

Insert the value for D_m into (1) to get:

$$\frac{D_h + \left(\frac{1}{12}\right)\text{rev}}{\left(\frac{1}{60}\right)\text{rpm}} = \frac{D_h}{\left(\frac{1}{720}\right)\text{rpm}}$$

Cross multiply and solve for D_h:

$$\left(\frac{1}{720}\right)D_h + \left(\frac{1}{720}\right)\left(\frac{1}{12}\right) = \left(\frac{1}{60}\right)D_h$$

$$D_h + \left(\frac{1}{12}\right) = 12D_h$$

$$D_h = \left(\frac{1}{132}\right)\text{rev}$$

Use the value of D_h to solve for t:

$$t = \frac{D_h}{V_h} = \frac{\left(\frac{1}{132}\right)\text{rev}}{\left(\frac{1}{720}\right)\text{rpm}} = 5.45\text{ min}$$

0.45 min = 27 sec

Baath and McBean get caught by the 1:05:30 downloading and thus their own futures are in jeopardy!