FLUIDS-BERNOULLI

Unit 18 , Dr. John P. Cise, Professor of Physics , Austin Com. College, Austin Tx. USA jpcise@austincc.edu & New York Times , May 11, 2018 by Kenneth Chang. Dedicated to Wright Brothers

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A Helicopter on Mars? NASA Wants to Try

By Kenneth Chang , NASA currently has two cars roaming Mars — the Opportunity and Curiosity rovers. But the next one it will send there will carry a vehicle with a new approach for planetary exploration: a helicopter. The space agency announced the decision on Friday to add a small helicopter — **about four pounds with a fuselage the size of a softball and blades that span just over three and a half feet, tip to tip** — to its Mars 2020 mission, which is to launch in July 2020 and arrive at Mars the following February.“We're very excited about this and the potential it has for opening up a whole new paradigm for how to explore Mars,” said David Lavery, the program executive for solar system exploration at NASA headquarters. He likened it to Sojourner, NASA's first Mars rover, which was about the size of a microwave oven and trundled around Mars in 1997. “That said, ‘Hey, mobile exploration on another planet is not only possible, but adds a lot of value to how you do things,’” Mr. Lavery said. For its trip to Mars, the helicopter will be packed on the underside of the rover. After the rover lands, the helicopter will be placed on the ground. The rover will then drive 50 to 100 yards away — close enough to stay in radio contact, far enough to not be endangered by any mishaps.The helicopter is to make five short flights over 30 days. The first will go up about 10 feet and hover for 30 seconds. Later flights will be more ambitious, up to 90 seconds, and cover a few hundred yards. The helicopter will carry two cameras, one looking down and one pointed ahead. Between flights, a solar panel will recharge its batteries. Flying on the red planet is not easy. The thin air at the **surface of Mars is the equivalent of being (((100,000 feet above Earth)))** — well beyond the limits of terrestrial helicopters — although the weaker gravity helps. **Two pairs of rotor blades will spin in opposite directions at nearly (((50 revolutions per second.)))** A prototype has been tested in a chamber that mimics the Martian atmosphere at NASA's Jet Propulsion Laboratory.

NASA:EARTH DATA

Geo potential Altitude above Sea Level - h - (m)	Temperature - t - (°C)	Acceleration of Gravity - g - (m/s^2)	Absolute Pressure - p - (10^4 N/m^2)	Density - ρ - (10^{-1} kg/m^3)	Dynamic Viscosity - μ - (10^{-5} N s/m^2)
-1000	21.50	9.810	11.39	13.47	1.821
0	15.00	9.807	10.13	12.25	1.789
1000	8.50	9.804	8.988	11.12	1.758
2000	2.00	9.801	7.950	10.07	1.726
3000	-4.49	9.797	7.012	9.093	1.694
4000	-10.98	9.794	6.166	8.194	1.661
5000	-17.47	9.791	5.405	7.364	1.628
6000	-23.96	9.788	4.722	6.601	1.595
7000	-30.45	9.785	4.111	5.900	1.561
8000	-36.94	9.782	3.565	5.258	1.527
9000	-43.42	9.779	3.080	4.671	1.493
10000	-49.90	9.776	2.650	4.135	1.458
15000	-56.50	9.761	1.211	1.948	1.422
20000	-56.50	9.745	0.5529	0.8891	1.422
25000	-51.60	9.730	0.2549	0.4008	1.448
30000	-46.64	9.715	0.1197	0.1841	1.475
40000	-22.80	9.684	0.0287	0.03996	1.601
50000	-2.5	9.654	0.007978	0.01027	1.704
60000	-26.13	9.624	0.002196	0.003097	1.584
70000	-53.57	9.594	0.00052	0.0008283	1.438
80000	-74.51	9.564	0.00011	0.0001846	1.321

NASA: MARS DATA

Martian Atmosphere

Surface pressure: 6.36 mb at mean radius (variable from 4.0 to 8.7 mb d
[6.9 mb to 9 mb (Viking 1 Lander site)]
Surface density: ~0.020 kg/m^3
Scale height: 11.1 km
Total mass of atmosphere: ~2.5 x 10^{16} kg
Average temperature: ~210 K (-63 C)
Diurnal temperature range: 184 K to 242 K (-89 to -31 C) (Viking 1 Lande
Wind speeds: 2-7 m/s (summer), 5-10 m/s (fall), 17-30 m/s (dust storm)
Mean molecular weight: 43.34
Atmospheric composition (by volume):
Major : Carbon Dioxide (CO_2) - 95.32% ; Nitrogen (N_2) - 2.7%
Argon (Ar) - 1.6%; Oxygen (O_2) - 0.13%; Carbon Monoxide
Minor (ppm): Water (H_2O) - 210; Nitrogen Oxide (NO) - 100; Neon (Ne)
Hydrogen-Deuterium-Oxygen (HDO) - 0.85; Krypton (Kr) -
Xenon (Xe) - 0.08

“We've been able to develop it to the point that we're able to make the case that we can actually test at Mars in the Martian environment,” Mr. Lavery said. The $55 million project is not part of the main Mars 2020 mission, which is to look for signs of past ancient life in the rocks of Mars. “It'll be interesting to see what it is actually capable of doing,” Kenneth Farley, the mission's project scientist, said of the helicopter. After the 30 days of testing are over, the helicopter will be left behind, and the rover will move on.

INTRODUCTION: Bernoulli's concept essentially is about energy conservation for fluids. From Bernoulli's equation the lift on a airplane wing or helicopter blade is proportional to three factors: air density, area of wings or copter blades and speed of air over wings squared = $F_{LIFT} = \frac{1}{2} \rho A V^2$. In order for this Marscopter to function(have adequate lift)as on the earth the earth lift ($F_{EARTH\ LIFT}$) must be similar to the Mars lift($F_{MARS\ LIFT}$). $V = R\ \omega = R\ 2\pi f$. As the article states the blades on the Marscopter must rotate quite fast at 50 rev./s. compared to the normal earth copters which rotate at about 460 rpm(data from Boeing aircraft company). The purpose of this application is to show $F_{EARTH\ LIFT}$ = (similar) $F_{MARS\ LIFT}$ or

$\frac{1}{2} \rho_{earth} A V_e^2 = \frac{1}{2} \rho_{mars} A V_m^2$ where $V_e = 2\pi f_e$ & $V_m = 2\pi f_m$, thus does ~~½ A 4π²~~ **$\rho_{earth} f_e^2$ =** (~ similar) ~~½ A~~ **$4\pi^2 \rho_{mars} f_m^2$ eq.1**

QUESTIONS: (a) Find f_e (normal frequency of earth copter blades) in rev./second?, (b) ρ_{earth} = 1.225 kg./m.³ from middle table above. Mars air density is similar to earth density at 100,000 ft on earth article states. From the right and center table the Mars air density at surface is thus about 0.03 kg./m.³. . For proper Mars Copter Lift both sides of eq. 1 must be similar. See if both sides of eq. 1 compare? Show computation work.

HINTS: 60 s./min.

ANSWERS: (a) f_e = 7.66 rev./s. , (b) 72 = ~ 75 , COMMENT: Mars lift force is similar to earth due to blades much higher frequency due to thinner air.