2021 Shardhunt Physics Challenge

Instructions:

- All answers should be rounded to the nearest integer.
- The earth's acceleration due to gravity is assumed to be 10 m/s^2.
- Air resistance is negligible.
- All units are SI unless otherwise stated.
- Rotating hexes is not necessary.

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Section A

A1 Etienne and Joseph launch their manned hot air balloon from the ground at a speed of 3.5 m/s. If the balloon only travels directly upwards and isn't accelerating, how many meters high will it be after 8.5 minutes?

A2 Ferdinand's rigid airship starts at rest and accelerates at a constant rate of 5 m/s^2 over a lake. If the lake is 362,902.5 meters across, how fast is the airship traveling when it reaches the opposite bank?

A3 Orville and Wilbur's flier has a mass of 476 kg. Given that it accelerates at 4 m/s^2, how much net force is being applied to the flier?

A4 How heavy is Tony's commercial flight if it has 2,395,000 Joules of kinetic energy while traveling at 50 m/s?

A5 Lowell, Leslie, Eric, and John are trying to figure out the fastest way to complete their circumnavigation of the world. What's the furthest distance they can travel between stops given that the fuel tank holds 214 liters of fuel, and each liter allows the plane to fly at 150 m/s for one minute? Give your answer in kilometers.

A6 In flying from Norway to the North Pole, the density of the air around Richard's airplane increases by 25%. If the lift force in Norway was 1,541.6 N, and no other variables have changed, what is the lift force over the North Pole?

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Section B

B1 Charles flies 5,790 km from New York to Paris. If each liter of fuel allows him to travel 3 km, and he has exactly enough fuel for his journey, how many liters of fuel is he carrying when he starts?

B2 Max's zeppelin catches fire, increasing the temperature of the surrounding 380 kilograms of air by 5.088° Celsius. Given that the specific heat capacity of air is 1.005 J/kg·C, how much energy is transferred to the air?

B3 What is the lift acting on Amelia's ill-fated airplane, given that the density of the air in New Guinea is 1.225 kg/m^3, the wings of the airplane have a surface area of 2.5 m^2 and a lift coefficient of 0.25, and the plane is traveling at 71.207 m/s?

B4 Chuck's 67,500 kg aircraft experiences a forward thrust of 13000 N and a drag force of 1145.161 N. Starting from rest, how long does it take him to break the sound barrier of 343 m/s?

B5 What is the tangential velocity of Mikhail's satellite if it has a centripetal acceleration of 0.5903 m/s^2 and orbits at 150 kilometers above the equator of the earth?

B6 Yuri launches in a spacecraft with a dry mass of 344.452 kg and a wet mass of 4,725 kg. Given an effective exhaust velocity of 750 m/s, what is the maximum velocity the rocket can achieve?

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Section C

C1 Neil's rocket weighs 335.75 tons on the Moon. Given that the moon's gravitational field is 17% of Earth's, how many tons would it weigh at Cape Canaveral?

C2 JPL's first interstellar probe needs to travel at 11000 m/s to escape Earth's gravity. Given a dry mass of 8,104.068 kg and an effective exhaust velocity of 2000 m/s, give the total wet mass needed for the rocket, in thousands of kilograms.

C3 Dick and Jeana are carrying exactly enough fuel to travel the circumference of the world without pausing. Given that one liter of fuel allows them to travel 151.11 kilometers, and each liter of fuel weighs 0.75 kg, calculate the lift force needed to counter the weight of the airplane's fuel tank.

C4 What is the rotational inertia of Edwin's namesake telescope if it has a rotational kinetic energy of 175.96 Joules and is traveling at an angular velocity of 0.42 rad/s?

C5 What is the centripetal acceleration of a multi-nation space station if it orbits at 6,551 km above the center of the Earth, with a velocity of 3619.67 km/s? Give your answer in km/s^2.

C6 NASA's ingenious helicopter flies for the first time at 295.62 m above the surface of Mars, which has a gravitational field of 3.8 m/s^2. If the helicopter weighs 1.8 kg, what is the gravitational potential energy of the craft?

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Section ⬢