Physics 107 / Exam 2 Spring 2001

SR-71 Blackbird – The Fastest Plane In The World (35,000 points)

2.) The SR-71 was designed and built by the Lockheed Skunk Works. Approximately 32 were built, plus 18 earlier variants. SR-71s are powered by two Pratt and Whitney J-58 axial-flow turbojets with afterburners, each producing 32,500 pounds of thrust (145,000 N each). Three are still in operation with NASA. For a plane flying horizontally at a constant speed, we have a classic Free Body Diagram as shown. Halfway through its fuel load, the plane has a mass of 37,250 kg, flies at over 85,000 feet (26,000 m) and is cruising at a speed of over Mach 3.2 (3.2 times the speed of sound or 2200 mph = 3540 kph = 983 m/s). (a) Find the value of the lift force from the wings and body of the SR-71. 

Hint: Use the F.B.D.!

(b) Find the value of the drag due to air resistance for this SR-71.

(c) At 85,000 feet (26,000 m) and a speed of 2200 mph (983 m/s) what is the total mechanical energy of a 37,250 kg SR-71? Which is the bigger piece – the kinetic energy or the potential energy?

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Fact or Fiction (30,000 points) Multiple-Guess-Pick-The-Best-Answer-Fill-In-The-Bubbles

1.) (a) The coefficient of _______ friction is always smaller than the other kind of friction.
A = Static  B = Kinetic  C = Potential  D = Radial
E = Tangent  F = Radial Outward

(b) In Uniform Circular Motion, the centripetal acceleration points _______.
A = Static  B = Kinetic  C = Potential  D = Radial Inward
E = Tangent  F = Radial Outward

(c) In Uniform Circular Motion, the velocity points _______.
A = Static  B = Kinetic  C = Potential  D = Radial
E = Tangent  F = Radial Outward

(d) _______ Energy is the energy of motion.
A = Static  B = Kinetic  C = Potential  D = Radial
E = Tangent  F = Radial Outward

(e) _______ Energy is arbitrarily set to zero as you choose.
A = Static  B = Kinetic  C = Potential  D = Radial
E = Tangent  F = Radial Outward

(f) The fictitious “centrifugal force” would have to point ___________ and it can’t, so it doesn’t exist.
A = Static  B = Kinetic  C = Potential  D = Radial
E = Tangent  F = Radial Outward

In parts (g)-(i), select which of Newton’s 3 laws or the 2 Conservation laws that best describes the situation.

(g) An elevator going up at a constant speed.
A = Newton’s 1st  B = Newton’s 2nd  C = Newton’s 3rd
D = Momentum  E = Energy  F = None of these

(h) The normal force of a book sitting on a table and the normal force of a table with a book on it.
A = Newton’s 1st  B = Newton’s 2nd  C = Newton’s 3rd
D = Momentum  E = Energy  F = None of these

(i) The gravitational attraction between the Moon and the Earth.
A = Newton’s 1st  B = Newton’s 2nd  C = Newton’s 3rd
D = Momentum  E = Energy  F = None of these

(j) A roller coaster going up and down its hills.
A = Newton’s 1st  B = Newton’s 2nd  C = Newton’s 3rd
D = Momentum  E = Energy  F = None of these
(d) Flying in an SR-71 is a dangerous job. About a third of the planes suffered catastrophic failures in flight resulting in the two-man crew having to eject and parachute to earth. If we ignore air resistance and terminal velocity, if a 27.5 kg piece of the plane fell from rest from an altitude of 85,000 feet (26,000 m), how fast would that piece be going when it struck the ground at sea level (y = 0)?

(e) Given those two powerful engines, and a fully fueled takeoff of 140,000 pounds (m = 52,250 kg) – how far down the runway does an SR-71 travel from rest up to a speed of 250. mph (112 m/s)? We’re ignoring friction and air resistance here.

My Other Car Is An SR-71

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A Mission to Mars (35,000 points)

3.) (a) Man has dreamed of going to Mars (mass = 6.42 × 10^{23} kg ; radius = 3.37 × 10^{6} m ) for a long time – and someday we probably will. It is a smaller planet than our Earth and its gravity is weaker. Here on Earth, a man of mass 100. kg has a weight of 980. N. What would this 100. kg man weigh on Mars?

\[ G = 6.67 \times 10^{-11} \text{ N m}^2/\text{kg}^2 \]

(b) To travel to Mars, it would be best to construct a rotating space ship to provide artificial gravity. If the cylinder has a diameter of 20.0 meters and the centripetal acceleration at the rim is \( \frac{1}{2}g \), then find the time \( T \) it takes for the cylinder to make one complete revolution.

(c) Back here on Earth, one of our heroic Buzz Lightyear astronauts is driving along a Houston freeway at the posted speed limit of 65.0 mph (29.1 m/s). If the coefficients of friction between the car’s tires and the concrete are 1.05 and 0.805, what is the shortest distance that this car (m = 1950 kg) can be brought to rest?

(d) Our astronaut’s car (m_1 = 1950 kg, v_1 = 29.1 m/s) accidentally runs into a pickup truck (m_2 = 2480 kg). The wreck moves at \( V = +11.3 \text{ m/s} \). What was the speed and direction of the pickup truck before the crash?

(e) This collision is a Totally Inelastic Collision. Show that K.E. is not conserved in this collision, that is, that the total K.E. before is not equal to the total K.E. after. If you can’t get an answer to (d), see Dr. Phil.