# WORK-ENERGY & NEWTON'S 2ND LAW

Units 10,11,6 & 7

Dr. John P. Cise, Professor of Physics, Austin Com. College, 1212 Rio Grande St., Austin Tx. 78701 jpcise@austincc.edu

& New York Times, Octo, 2016 by Kenneth Chang. Dedicated to my Roger Bacon HS, St. Bernard Ohio, Math teacher, Mr. Peters.

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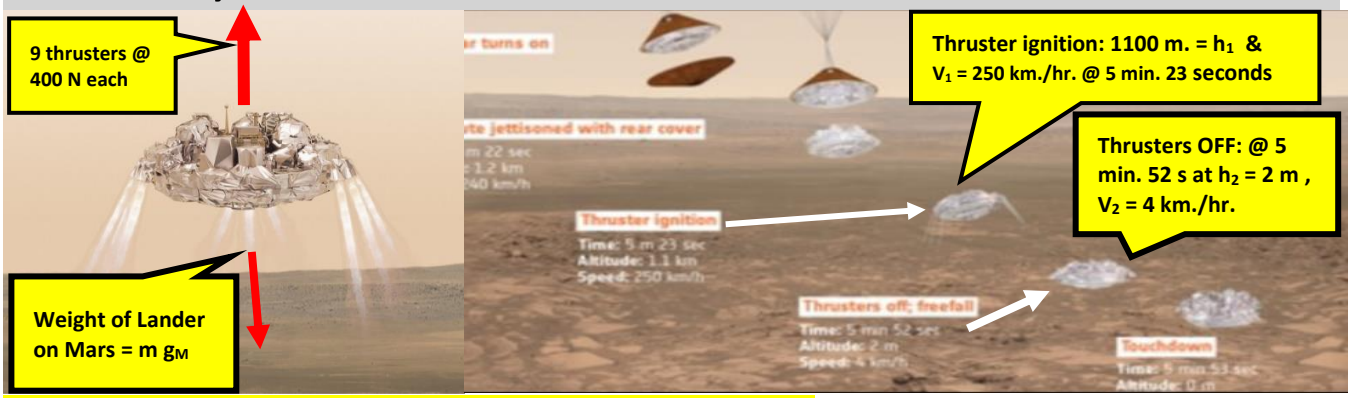
## ExoMars, Poised to Reach Red Planet and Gather Clues




A rendering of the ExoMars 2016 spacecraft's lander that is scheduled to set down on Mars.

ExoMars 2016, a spacecraft launched by the European and Russian space agencies, is to arrive at the red planet on Wednesday and begin gathering data on gases that are barely present in the atmosphere but may provide important clues about geological processes, or even hints of life. On Wednesday, the orbiter's engine is to fire, slowing the spacecraft so it can be captured by Martian gravity. But Schiaparelli is to speed onward, at 13,000 miles per hour, into the atmosphere. Slowed first by the heat shield, then parachutes and **finally thrusters,** the probe's descent to the surface should take less than six minutes. Schiaparelli is to land on a plain named Meridiani Planum, the region that NASA's Opportunity rover has been exploring for a dozen years. The European Space Agency is to broadcast on the web the arrival of the Trace Gas Orbiter and Schiaparelli beginning at 9 a.m. Eastern on Wednesday. Schiaparelli will take measurements of wind speed, air temperature, dust, humidity and other aspects of the atmosphere, but only for a few days until its batteries die. **The probe's main purpose, however, is to test its landing technologies, which will also be used for a more ambitious mission that is to put an**ExoMars rover **on the planet in April 2021.**

**INTRODUCTION:** On Oct. 19,2016, the European Space Agency(ESA) Lander(Schiaparelli) will land on Mars using retrorocket thrusters in the last 29 seconds of landing (see above graphics). Lander mass = 600 kg. = m

**QUESTIONS:** (a) Convert $V_1$ and $V_2$ from km./hr. to m./s.?, (b) When thrusters are ignited @ 5 min. 23 s. find find Lander's kinetic energy ($K_1$) and gravitational potential energy ($U_1$) ?, (c) When thrusters are turned OFF @ 5 min. 52 s. find lander's kinetic energy ($K_2$) and gravitational potential energy ($U_2$) ? , (d) Find work done by thrusters In reducing lander's kinetic and gravitational potential energy? , (e) Find force (F) provided by thruster's to slow Lander down to almost zero speed ( 4 km./hr.)? , (f) Using a kinematic equation (suggest using $V_2^2 = V_1^2 + 2\,a\,x$ ) Find deceleration (a) while thrusters are ON for 29 seconds? (g) Find $F_{NET}$ ON lander due to combination of thruster force (F) UP and Martian weight DOWN ( m $g_{Mars}$ ) . Use Newton's second law $F_{NET}$ = m a ? (h) Using Newton's second law, find thruster Force (F)? e.g. F – m $g_{MARS}$ = m a , (i) Comment on thruster force (F) obtained from Work – energy concepts (W = ΔK + ΔU) in (e) and thruster force (F) found in (h) ?

**HINTS:** 0.27777 m./s. = km./hr. , K = ½ m $V^2$ , U = m g h , work = F x , $g_{MARS}$ = 3.711 m./s. ,

**ANSWERS**: (a) $V_1$ = 69.44 m./s. , $V_2$ = 1.111 m./s., (b) $K_1$ = 1,446,574 J , $U_1$ = 2,449,260 J , (c) $K_2$ = 370.36 J , $U_2$ = 4823.56 J , (d) Work by thrusters = W = 3,891,010.44 J , (e) F(by thrusters) = 3543,72 N , (f) a = +2.24 m./s.$^2$ (g) $F_{NET}$ = m a = 1344 N , (h) F = 3570.6 N, (i) Thruster force F found each way close !