Year 1 Assessed Problems

SEMESTER 2

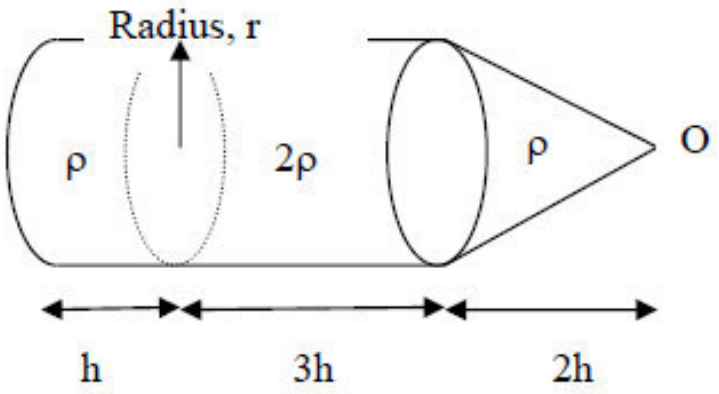
Problem Sheet 7

SOLUTIONS TO BE SUBMITTED ON CANVAS by 17:00 on

Wednesday 12 March 2025

Classical Mechanics and Special Relativity 2
Assessed problem 3

A rocket is built from a cylindrical section of radius *r* and length 4*h*. A nose cone of radius r and of length 2*h* is attached to one end. The density of the nose cone and the rear quarter of the cylindrical section is half that of the remainder.



Quiz Question 1:
What is the distance of the centre of mass of the nose cone from the apex, *O*, along the axis of the cone?

[5]

Quiz Question 2:
Relative to the apex *O*, what is the position of the centre of mass of the front three-quarters of the cylindrical section?

[1]

Quiz Question 3:
Relative to the apex *O*, what is the position of the centre of mass of the rear quarter of the cylindrical section?

[1]

Quiz Question 4:
What is the position of the centre of mass of the entire rocket relative to the apex *O*?

[3]

Temperature and Matter

Assessed Problem 4

Quiz Question 1:

Consider the isothermal compression of 0.1 mole of an ideal gas at a temperature T = 27°C. Initially, the gas is at atmospheric pressure, and the final volume is one-eighth of the initial volume. What is the work done on the gas?

[2]

Quiz Question 2:

What is the change in internal energy of the gas during the isothermal compression described in Question 1?

[1]

Quiz Question 3:

During the isothermal compression, which of the below describes the heat exchange of the gas with its surroundings? [Note: The answers state magnitude in Jules and direction]

[1]

Quiz Question 4:

A petrol engine takes in air at 20.0°C and atmospheric pressure and compresses it adiabatically to one-third the original volume. What is final temperature of the air, assuming air is an ideal gas with $\gamma = 1.4$.

[2]

Quiz Question 5:

For the adiabatic compression in Question 4, what is the final pressure of the air?

[1]

Quiz Question 6:

During an adiabatic expansion, the temperature of 0.6 moles of oxygen drops from 30.0°C to 10.0°C. The oxygen may be treated as an ideal gas with heat capacity at constant volume, $C_V=5R/2$. How much heat is added to the gas?

[1]

Quiz Question 7:

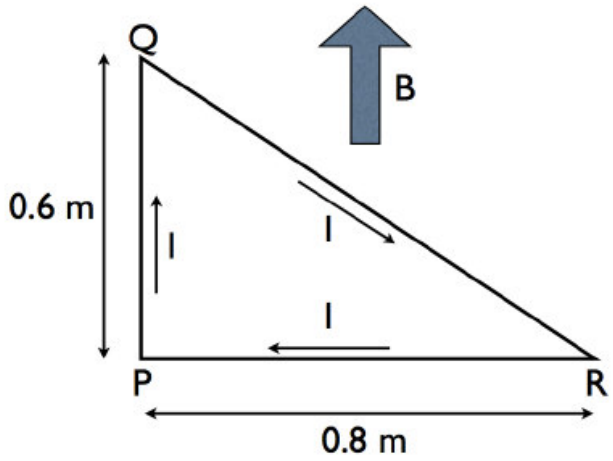
For the adiabatic expansion in Question 6, how much work is done on the gas?

[2]

Electromagnetism I – Problem sheet 7

Assessed Problem 4

The loop of wire in the figure below forms a right triangle and carries a current I=5A in the direction shown. The loop is in a uniform magnetic field that has magnitude B=3T and the same direction as the current inside PQ of the loop.



Quiz Question 1:

What is the magnitude of the force exerted by the magnetic field on side PQ of the triangle?

[1]

Quiz Question 2:

What is the magnitude of the force exerted by the magnetic field on side PR of the triangle?

[1]

Quiz Question 3:

What is the magnitude of the force exerted by the magnetic field on side QR of the triangle?

[1]

Quiz Question 4:

What is the magnitude of the net torque on the loop?

[1]

Quiz Question 5:

Does the torque tend to rotate point Q into the plane of the figure or out of the plane?

[1]

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Quiz Question 6:

An interstellar dust grain of mass $m=10^{-16}$kg is (roughly) spherical with a radius of 3×10^{-7}m. It has acquired a negative charge such that its potential is −0.15V. To the nearest whole number, how many extra electrons has the dust grain picked up?

[2]

Quiz Question 7:

What is the strength of the electric field on the surface of the dust grain?

[1]

Quiz Question 8:

What is the strength of the electric field on the surface of the dust grain?

[1]

Quiz Question 9:

What is the strength of the electric field on the surface of the dust grain?

[1]