PRIFYSGOL ABERYSTWYTH UNIVERSITY

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DEPARTMENT OF PHYSICS

SEMESTER 1 EXAMINATIONS, JANUARY 2026

PH04020 – Introduction to Fundamentals of Physics I

Time allowed – 2 hours

- **Full marks can be attained for complete answers to ALL six questions in Section A and TWO questions from Section B**
- **The numbers in brackets after the questions indicate the allocation of marks for each question.**
- **Only calculators from the Casio FX83, FX85 or FX991 range may be used.**
- **A booklet of mathematical formulae and standard constants will be provided.**
- **MAE MODD I FYFYRWYR GYFLWYNO ATEBION I'R PAPUR HWN NAILL AI YN Y GYMRAEG NEU'R SAESNEG**
- **STUDENTS MAY SUBMIT ANSWERS TO THIS PAPER IN EITHER WELSH OR ENGLISH**

Once seated, students may complete the front cover of the answer book(s) and the attendance slip ONLY.

DO NOT TURN THE EXAMINATION QUESTION PAPER OVER UNTIL INSTRUCTED TO DO SO.

Section A

Attempt ALL questions in the booklets provided

1 State the equation defining the first law of thermodynamics and the equation defining work. Clearly identify each variable. [5]

2 At room temperature and typical pressures, a sample of Ethane (C_2H_6) is a gas and a sample of Octane (C_8H_{18}) is a liquid. Explain the difference in their states despite their similar chemical composition. [5]

3 A sample of water absorbs 10 kJ as heat, and the temperature of the sample raises by 20 K without any change in state. Determine the mass of the sample.

You may assume a specific heat capacity $c = 4184$ J kg^{-1} K^{-1}. [5]

4 Observations are made of a sample undergoing radioactive decay. The activity is observed to drop by 10% over the course of 2300 seconds. Recalling that

$$N(t) = N_0 e^{-\lambda t}$$

What is the decay constant of the sample? [5]

5 Explain the meaning of *inertial reference frame*.
If you are in an accelerating train, are you in an inertial reference frame? [5]

6 State the principle of mechanical energy conservation. A pistol bullet is being shot into the sky with an initial speed of 150 m/s. Estimate bullet's speed when it is 200 m above the ground. Here it is assumed that the air friction force can be neglected. [5]

7 A projectile is thrown horizontally from an 80m tall cliff at a velocity of 15 ms^{-1}. Calculate:

i) the time it takes for the projectile to reach the ground.

ii) the speed of the projectile just before it hits the ground.

You may assume that $g = 10$ ms^{-2}. [5]

8 Draw an approximate sketch of a Maxwell-Boltzmann speed distribution for Hydrogen gas at room temperature. On the same sketch, draw the distribution for when the temperature of the gas is significantly hotter than room temperature. On both curves, label the most probable speed, and the rms speed. [5]

Section B

Answer TWO questions

9 A mass is suspended by a hanging metallic wire of length 80 cm and cross-sectional area 8×10^{-7} m^2. That mass is increased over time and the properties of the wire observed.

a) Describe **compressive**, **tensile** and **shear loading**, and identify which of the three accurately describes the example wire. You may wish to include diagrams.

[4]

b) When a weight of 400 N is applied, the wire appears to extend by 0.5 cm. Compute the Young's modulus of the wire's material.

[5]

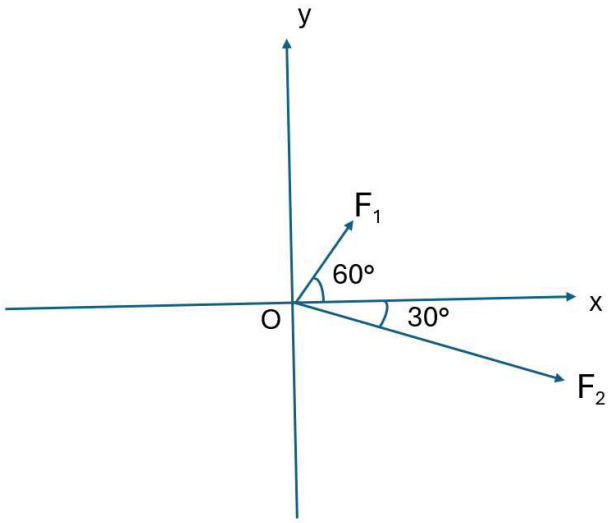
c) Sketch a labelled plot of the Stress against Strain curve you expect to see for the wire.

[6]

d) Describe what happens to the internal, microscopic structure of the wire as the mass is increased and the wire deforms.

[5]

10 Two forces ($F_1 = 10\sqrt{3}$ N, $F_2 = 30$ N) as shown in the figure below acting on a 5kg steel ball A for the duration of 1 second. The ball initially is at rest.



a) Show that by the end of the 1 second, the steel ball's speed is roughly 6.93 m/s.

[7]

b) Steel ball A then collides with another steel ball B of 4kg which is at rest before the collision. Find the speed of both balls after the collision (Note, the collision is elastic so the total kinetic energy of the system remains the same both before and afte the collision).

[8]

c) Suppose ball A is in cicular motion inside a large horizontal circular loop with a speed of 10 m/s. The radius of the loop is 20 m. Find the magntitude of the centripetal force. Find the magmitude of the supporting force from the wall to the ball.

[5]

11 a) State Kepler's three laws of planetary motion. Use a sketch to additionally illustrate your answer for Kepler's second law.

[4]

b) Starting from Newton's law of universal gravitation, derive a proof for Kepler's third law, given a circular orbit.

[4]

c) The planet Mars has two moons, Deimos and Phobos, with orbits that may be considered to be circular. The table below collates the masses, orbital periods and orbital radii of both moons.

	Orbital period (Earth days)	**Orbital radius (km)**	**Mass (kg)**
Deimos	1.2625	2.3460×10^{4}	1.50×10^{15}
Phobos	0.3188	0.9377×10^{4}	1.08×10^{16}

i) Show that Kepler's third law appropximately holds for this system, and offer a possible reason for any small discrepancies arising.

[2]

ii) Estimate the mass of Mars.

[2]

iii) If Deimos were to drift away from Mars to an orbital radius of 3.0×10^{5} km, calculate the change in its gravitational potential energy.

[4]

iv) Comment on your answer to iii. Explain whether Deimos would gain or lose gravitational potential energy, and what this physically implies. Use a sketch of the gravitational potential versus distance from the centre of Mars to help illustrate your answer.

[4]

END OF PAPER