Summer Assignment 1 - Set on 10th July 2025, Video Solutions on 23rd July 2025

Introduction

This assignment is split into three sections:

- Section A: 20 marks of multiple choice questions, split into 3 parts:
  - Q1-6 = fairly easy
  - Q7-13 = BPhO Senior Challenge level
  - Q14-20 = questions taken from past PAT papers

  Even though they are multiple choice, don't forget to show your working!
- Section B: Three questions worth 20 marks.
- Section C: One long question worth 20 marks, taken from a past PAT paper. (Please note, though, 20-mark questions are no longer used in the PAT. Instead there is a variety of shorter questions. But this one is still good practice!)

Section A

1. A pair of pliers is a simple machine consisting of two levers. For the pliers shown in the diagram, the mechanical advantage is:

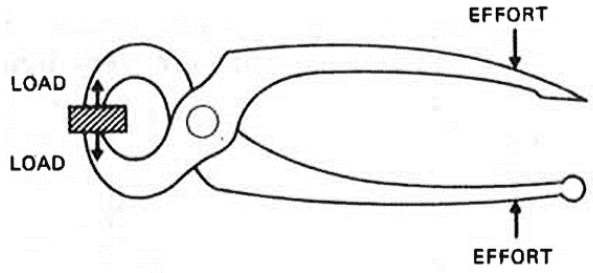
   (a) less than one

   (b) equal to one

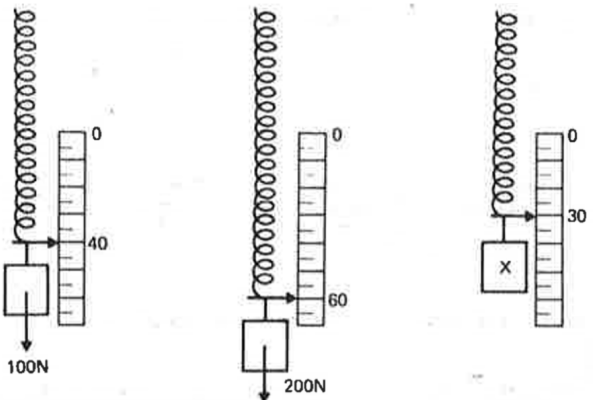
   (c) greater than one

   (d) less than 100%

   (e) equal to 100%



The diagrams below show a spring with a pointer attached, hanging next to a scale. Three different weights are hung from it in turn as shown.



2. If all weight is removed from the spring, which mark on the scale will the pointer indicate?

   (a) 0
   (b) 10
   (c) 20
   (d) 25
   (e) 30

3. What is the weight of X?

   (a) $-10\,\mathrm{N}$
   (b) $0\,\mathrm{N}$
   (c) $30\,\mathrm{N}$
   (d) $50\,\mathrm{N}$
   (e) $75\,\mathrm{N}$

4. A person when asleep has a power output of 60 W. In 10 minutes, their food must provide:

   (a) 0.1 J

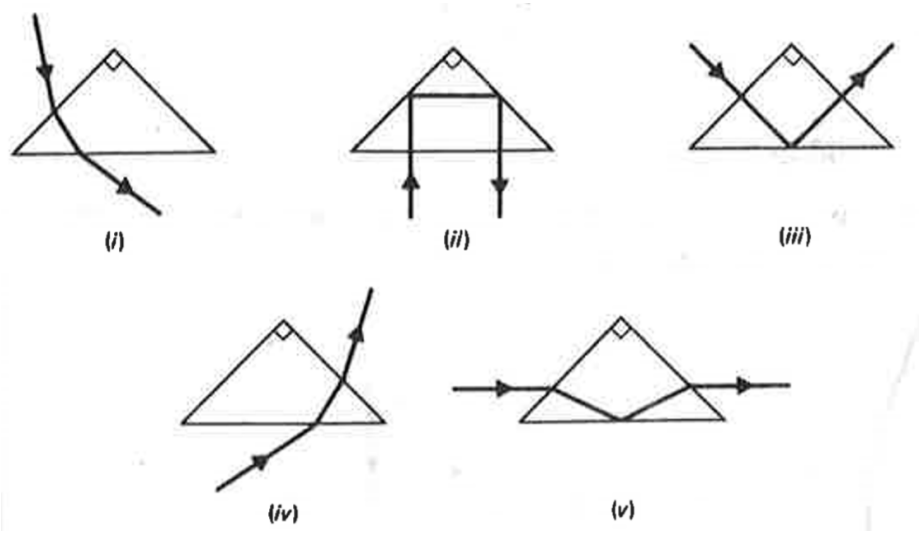
   (b) 6 J

   (c) 60 J

   (d) 600 J

   (e) 36 000 J

The following diagrams show a ray of light passing through a glass prism with angles of 45°, 45° and 90°.



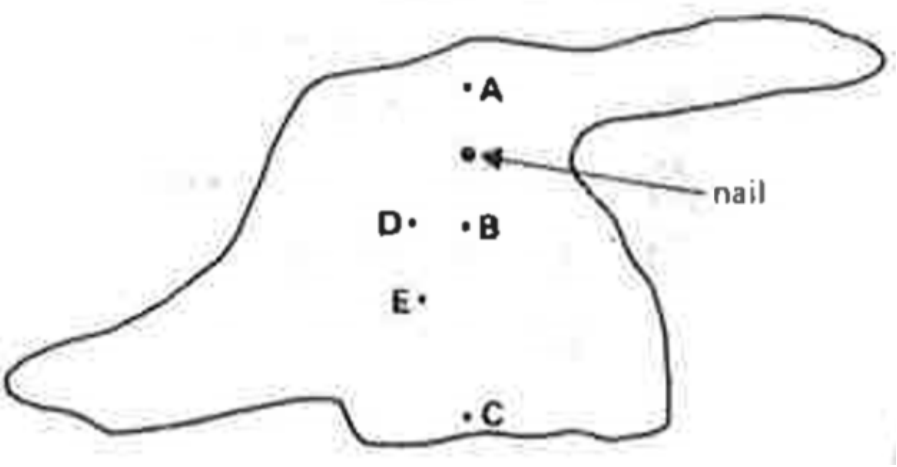
5. The correct diagrams are:

   (a) (i) and (iv) only
   (b) (ii) and (iii) only
   (c) (i), (iv) and (v) only
   (d) (i), (ii), (iii) and (iv) only
   (e) All of them

6. Which diagram shows a prism used as in a periscope?

   (a) (i)
   (b) (ii)
   (c) (iii)
   (d) (iv)
   (e) (v)

7. The diagram shows a piece of cardboard hanging freely from a nail. Which point is most likely to indicate the centre of gravity (centre of mass) of the cardboard?



(a) A
(b) B
(c) C
(d) D
(e) E

8. A steel ball bearing is dropped onto a concrete floor and rebounds to 80% of its initial height. The percentage of kinetic energy lost in the collision is:

(a) 80%
(b) 64%
(c) 36%
(d) 20%

9. The Moon takes 2 minutes to sink below the horizon at the equator when observed at night (about the same time as the Sun takes to set). If the radius of the Earth is 6400 km and the radius of the Moon is 1700 km, what is the angular size of the Earth when observed from the Moon?

   (a) 3.8°

   (b) 3.5°

   (c) 1.9°

   (d) 0.3°

10. Which are the correct dimensions of energy in terms of mass [M], length [L] and time [T]?

   (a) $\frac{\mathrm{MT}^2}{\mathrm{L}}$

   (b) $\frac{\mathrm{ML}}{\mathrm{T}^2}$

   (c) $\frac{\mathrm{ML}^2}{\mathrm{T}^2}$

   (d) $\frac{\mathrm{ML}^2}{\mathrm{T}}$

11. Jack and Jill decide to throw pennies out of a window. They lean out and Jill throws hers straight down to the ground with an initial speed of $4\,\mathrm{ms}^{-1}$ whilst Jack throws his straight upwards with an initial speed of $4\,\mathrm{ms}^{-1}$. How do the speeds and kinetic energies of the pennies compare when they each hit the ground? You should ignore air resistance.

    (a) Jack's penny has a greater speed and greater KE

    (b) Jack's penny has the same speed but greater KE

    (c) Jill's penny has the same speed but greater KE

    (d) Jill's penny has the same speed and same KE

12. The Earth has a mass of $6.0 \times 10^{24}\,\mathrm{kg}$ and an orbital velocity of $30\,\mathrm{km\,s^{-1}}$ about the Sun. What is its kinetic energy?

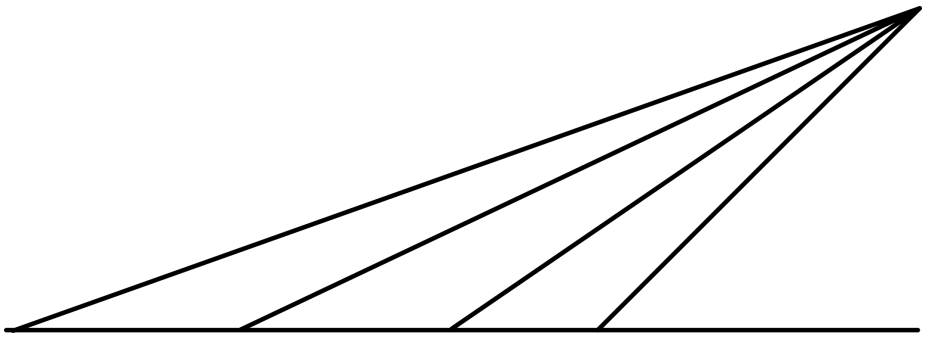
    (a) $2.7 \times 10^{27}\,\mathrm{J}$

    (b) $9.0 \times 10^{28}\,\mathrm{J}$

    (c) $2.7 \times 10^{33}\,\mathrm{J}$

    (d) $5.4 \times 10^{33}\,\mathrm{J}$

13. A particle slides from rest without friction down a set of slopes of different gradients as shown below.



For each slope the particle reaches the bottom after:

(a) Taking the same time

(b) Undergoing the same acceleration

(c) Reaching the same speed

(d) Undergoing the same change of displacement

14. A mass m is lifted at a constant slow speed. The force of gravity when it is held in your hand is mg. When it is being lifted the force required is

    (a) Slightly less than mg

    (b) Equal to mg

    (c) Slightly more than mg

    (d) Dependent on how fast it is being raised

15. A symmetric seesaw is 3 m long from end to end. If a boy of mass 20 kg sits on one end, how far away from him should a girl of mass 30 kg sit to balance the seesaw?

    (a) 0.5 m

    (b) 1.0 m

    (c) 2.0 m

    (d) 2.5 m

16. A solar eclipse can only occur when the Moon's phase is:

    (a) New moon

    (b) Full moon

    (c) Waning

    (d) Waxing

17. A 3.6 V mobile phone battery can produce 0.7 A of current for 1 hour. This can be charged using a square solar panel 25 cm on each side. Assuming an efficiency of 10% and an incident solar power of $1\,\mathrm{kW\,m^{-2}}$, what time is needed to charge the battery?

    (a) 0.10 hours

    (b) 0.28 hours

    (c) 0.40 hours

    (d) 1.5 hours

18. Positron Emission Tomography (PET) scanners frequently operate using the radioactive isotope ^{18}F which has a half-life of about two hours. The isotope is incorporated into a drug, half of which is excreted by the body every two hours. How long will it take before the quantity of radioactive drug in the body halves?

    (a) 0.5 hours

    (b) 1 hour

    (c) 1.5 hours

    (d) 2 hours

19. A spring that obeys Hooke's Law has a spring constant k. Two such springs are linked to form a spring twice the length. What is the spring constant of this new longer spring?

    (a) $\frac{k}{2}$

    (b) $\frac{k}{\sqrt{2}}$

    (c) $\sqrt{2}k$

    (d) $2k$

20. A car accelerates steadily from $0\,\mathrm{ms}^{-1}$ to $20\,\mathrm{ms}^{-1}$ in a distance d and a time t. Another car takes time $2t$ to accelerate steadily from stationary to the same final velocity. What distance does the second car cover during the new acceleration?

    (a) $\frac{d}{4}$

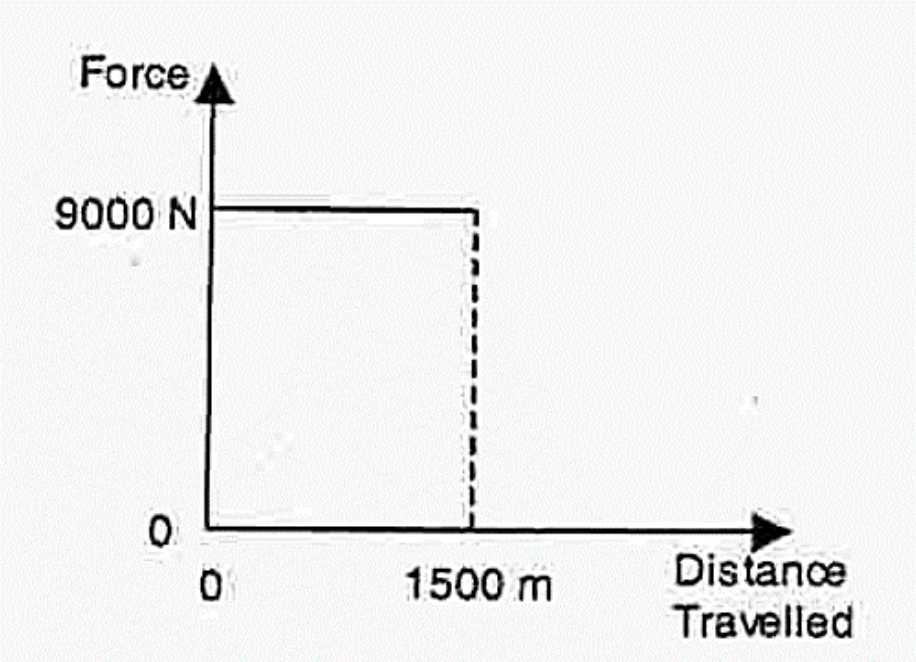
    (b) $\frac{d}{2}$

    (c) d

    (d) $2d$

Section B

21. The graph below shows the force on a bus as it accelerates from rest. It reaches full speed after travelling 1500 m. The bus' mass is 30 000 kg. You may assume frictional forces are negligible.



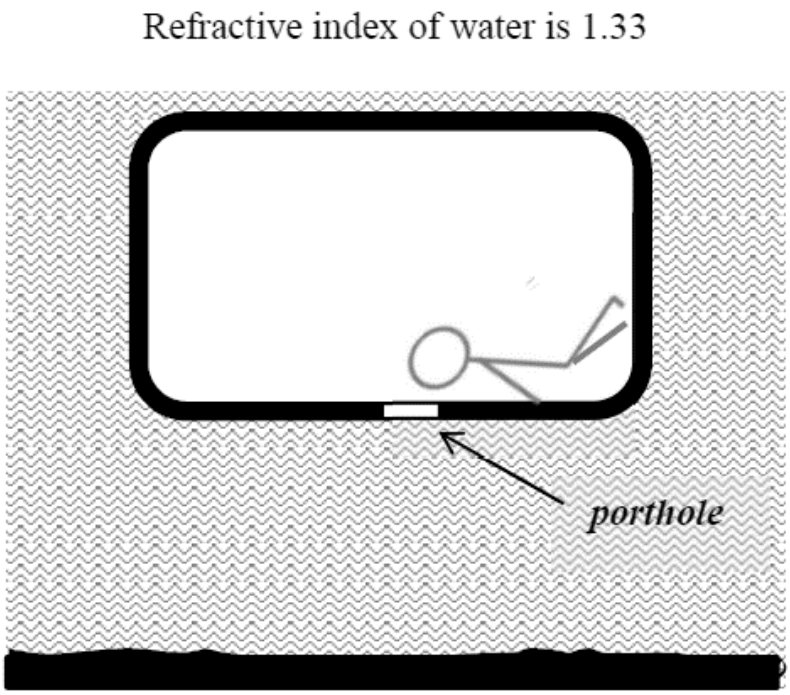
(a) Determine the acceleration of the bus. [1]

(b) Find the area under the graph with the correct units. [2]

(c) Sketch a velocity-time graph of this motion. [2]

(d) By finding the final velocity of the bus, comment on its KE. [1]

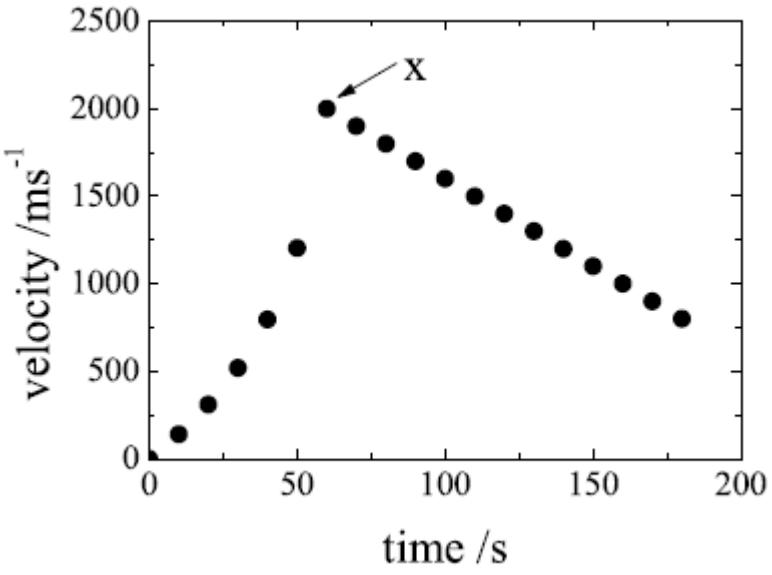
22. A diver in a submarine views the seabed through a glass porthole. The diameter of the porthole is 0.20 m and it is set into the bottom of the submarine as shown. The thickness of the glass can be ignored.



(a) With the aid of a clear diagram, explain why the diver can only view a small area of the seabed through the porthole, no matter how close she can get her eye to it. [2]

(b) If the bottom of the submarine is 4.0 m above the seabed, determine the maximum area of seabed which she can view. [4]

23. The graph below shows the velocity of a rocket as a function of time.



(a) Suggest what has happened at point X. [1]

(b) State and explain when the acceleration of the rocket is at a maximum.[2]

(c) Describe the subsequent motion of the rocket. [2]

(d) Using the graph, how could the maximum height reached be determined?[1]

Section C

24. A 2 m tall birdwatcher with a mass of 100 kg is observing a nest. When standing 18m away from the tree, the line of sight to the nest makes an angle of 45° parallel to the ground.

    (a) The birdwatcher sees one egg fall. Ignoring air resistance, how long does it take to reach the ground? [3]

    (b) How fast is the egg travelling when it reaches the ground? [2]

(c) On hitting the ground, the egg is brought to rest in 1 mm. Assuming a mass of 20 g for the egg, calculate the force required. (Assume a constant braking force). [3]

(d) Calculate the work done by the braking force and compare it with the GPE of the egg. [3]

(e) The egg smashes on impact. To prevent this happening again a pad of 10 cm thick foam is placed on the ground, under the tree. This foam compresses to half its initial thickness on impact. Find the new braking force when a second egg falls and the time taken to bring it to a halt. [3]

(f) The birdwatcher considers whether to return the second egg to the nest. Calculate the minimum energy that would be required for them to do this. [2]

(g) Instead, the birdwatcher decides to keep the egg incubated by placing it in a cup of water and using a small electrical heater powered from a hand generator. Assuming there is 100 ml of water at 15°C with specific heat capacity of $4\,\mathrm{kJ\,kg^{-1}K^{-1}}$, calculate the maximum rate of heat loss from the system so that it requires no more energy to keep the egg incubated at 37°C for two weeks than it does to return it to the nest. [4]