# 2024 Specimen Paper

(pasted from Pearson Vue)

## OXFORD UNIVERSITY

Physics Admissions Test

Welcome to the PAT

**Time allowed: 2 hours**

*For candidates applying to Physics, Physics and Philosophy, Engineering, or Materials Science*

**Total 40 questions [100 Marks]**

You should attempt as many questions as you can.

**No tables, or formula sheets or physical calculators may be used.**

An online scientific calculator is accessible by clicking on “Calculator” button near the top of the screen.

The numbers on the right-hand-side in square brackets indicate the marks expected to be assigned to each question. You are advised to divide your time according to the marks available.

1. What is the next number in the sequence $\frac{1}{5}, \frac{3}{25}, \frac{7}{125}, \frac{3}{125}, \frac{31}{3125}$

[2]

- $\frac{59}{15625}$
- $\frac{59}{3125}$
- $\frac{63}{15625}$
- $\frac{27}{3125}$
- $\frac{7}{125}$

2. If $\frac{dy}{dx} = x^2 + \frac{1}{x^3}$ and $y = 0$ when $x = 1$, what is $\int_1^3 y\,dx$?

[3]

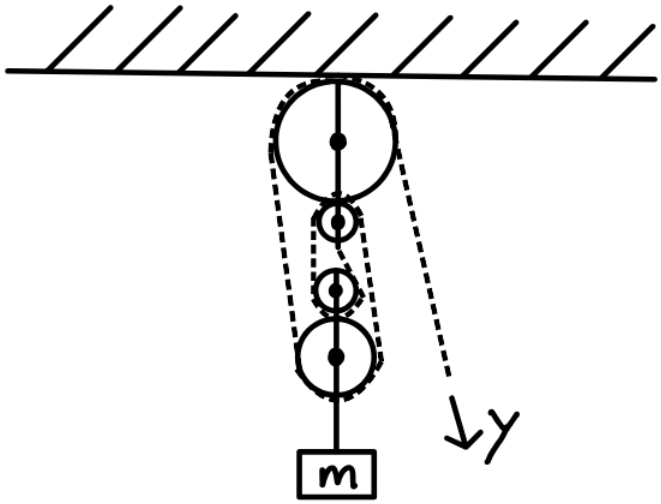
- $\frac{20}{3}$
- $8$
- $\frac{8}{3}$
- $\frac{4}{3}$
- $\frac{22}{3}$

3. What is the (integer) $m$ such that $\sum_{n=1}^{m} (3 + 2n) = 140$ ?

[3]

- 14
- 16
- 8
- 10
- 12
- 20
- 6

4. Consider the pulley system in the diagram, containing 4 wheels. If you pull the free end a distance *y*, how far will *m* rise by?




[2]

- 2*y*
- *y*/2
- *y*/16
- *y*/4
- 16*y*
- 4*y*

5. The stable isotopes of carbon, nitrogen and oxygen are represented symbolically below:

$^{12}_{6}\mathrm{C}$ , $^{13}_{6}\mathrm{C}$ , $^{14}_{7}\mathrm{N}$ , $^{15}_{7}\mathrm{N}$ , $^{16}_{8}\mathrm{O}$ , $^{17}_{8}\mathrm{O}$ , $^{18}_{8}\mathrm{O}$

Select **all** of the following statements that are true:

[3]

- ☐ $^{18}_{8}\mathrm{O}$ has a larger mass per unit charge than $^{12}_{6}\mathrm{C}$
- ☐ $^{14}_{7}\mathrm{N}$ has a larger number of neutrons than $^{13}_{6}\mathrm{C}$
- ☐ $^{13}_{6}\mathrm{C}$ has a larger number of protons than $^{12}_{6}\mathrm{C}$
- ☐ $^{16}_{8}\mathrm{O}$ has a larger nuclear charge than $^{15}_{7}\mathrm{N}$
- ☐ $^{15}_{7}\mathrm{N}$ has a larger mass than $^{14}_{7}\mathrm{N}$

6. A seed packet contains 100 seeds. When planted, 75 will successfully become plants, but of these only a third will have flowers, and of these only one fifth will produce fruit. How many seeds produce fruiting plants?

[2]

- 10
- 20
- 5
- 15
- 50
- 1
- 25

7. Two black holes orbit each other and emit gravitational waves arising from the periodic nature of the orbit. The orbital separation is around 10 km, the relative speeds of the black holes are close to the speed of light, and gravitational waves travel at the speed of light. Which of the following would best describe the frequency of the emitted radiation?

[3]

- $10^{-2}$ Hz
- $10^{7}$ Hz
- $10^{10}$ Hz
- $10^{4}$ Hz
- $10$ Hz

8. Consider $f(x) = x^2$ . You want to transform the function so you get a new function $g(x)$ stretched by a vertical scale factor of 2, with a line of symmetry about $x = 1$ and which is never positive. $g(x)$ would be equal to which of the following functions?

[2]

- $-f(2x - 2)$
- $-2f(x + 1)$
- $-2f(x - 1)$
- $-f(x + 1)$
- $-f(x - 1)$

9. If $y = \left(2 + \frac{x}{2}\right)^4$, which of the following is $\frac{\mathrm{d}y}{\mathrm{d}x}$?

[2]

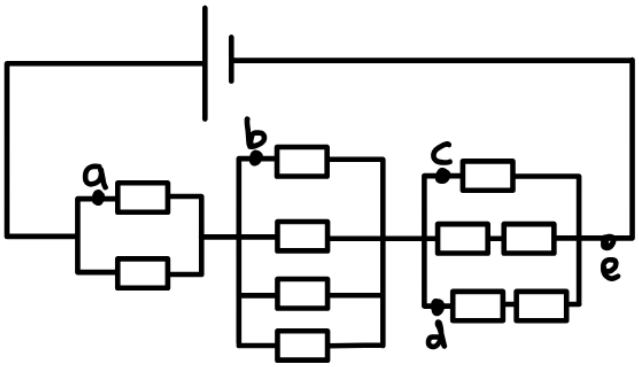
- $2 + x + \frac{3x^2}{8} + \frac{x^3}{8}$
- $32 + 24x + 6x^2 + \frac{x^3}{2}$
- $4 + 2x + \frac{3x^2}{4} + \frac{x^3}{4}$
- $8 + 6x + \frac{3x^2}{2} + \frac{x^3}{8}$
- $16 + 12x + 3x^2 + \frac{x^3}{4}$

10. What speed does a bull elephant (mass 4900 kg) have to move at to have the same kinetic energy as a cyclist (mass 100 kg) moving at $30\,\mathrm{km\,h^{-1}}$ ?

[2]

- $0.6\ \mathrm{m\,s^{-1}}$
- $8.3\ \mathrm{m\,s^{-1}}$
- $16.6\ \mathrm{m\,s^{-1}}$
- $4.2\ \mathrm{m\,s^{-1}}$
- $1.2\ \mathrm{m\,s^{-1}}$

11. All resistors in the circuit below have the same value. If an ammeter is placed in the circuit in turn at points (a) through to (e), which of the following sets of points will give the same reading?




[2]

- a,c
- a,b
- b,e
- c,d
- a,b,c

12. A particle of mass $m$ , travelling freely at an initial speed $v$ , can be stopped in a distance $d$ by a constant retarding force $F$ . What magnitude of force (applied in a direction perpendicular to the motion) would be needed to change the trajectory of the same particle (at the same speed $v$ ) into a circular arc of radius $d$ ?

[2]

- $\sqrt{2}F$
- $F$
- $F/\sqrt{2}$
- $2F$
- $F/2$
- $4F$

13. A device uses 3kW of power at a voltage of 60V. It is connected to a power supply via an ideal transformer. The transformer has $N$ turns on the winding connected to the device and $20N$ turns on the winding connected to the power supply. What current flows in the winding connected to the power supply?

[2]

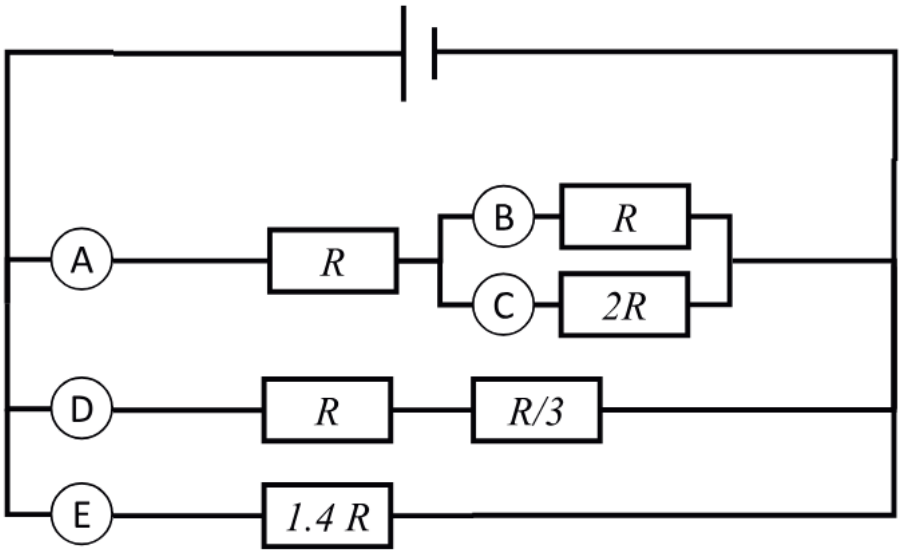
- 50A
- 2.5A
- 1kA
- 0.4A
- 1mA

14. A triangle $ABC$ has vertices at points in two-dimensional Cartesian co-ordinates: $A : (0, 1)$, $B : (1, 2)$, and $C : (-1, 2)$. It is reflected in the line $y = x$ and then rotated around the origin by 90 degrees in a clockwise direction. Which single transformation maps the initial triangle to the final state of the above transformations?

[4]

- rotation by $180°$ anti-clockwise around the origin
- reflection in $x = 0$
- scale factor of $-1$
- reflection in $y = 0$
- rotation by $90°$ anti-clockwise around $(2, 0)$

15. Which ammeter A, B, C, D, E gives the highest reading?




[3]

16. Solve $\log_2 x + \log_2(2x + 3) = 1$ for $x$.

[3]

- $x = -2$
- $x = 0$
- $x = \frac{1}{2}$
- $x = -2$ and $\frac{1}{2}$
- $x = 1$

17. If the gravitational field strength at the Earth's surface is $g_E = 10\,\mathrm{N/kg}$ , and at a distance $R > R_E$ from its centre the field strength is $g_R = 2\,\mathrm{N/kg}$ , what is the radius of the Earth $R_E$ in terms of $R$ ?

[2]

- $R/\sqrt{2}$
- $R/\sqrt{10}$
- $R/5$
- $R/\sqrt{5}$
- $R$
- $R/25$

18. Consider the function $y(x) = \sin(\frac{100}{x})$ . The angle is in degrees, so that $\sin(180) = 0$ . How many maxima of $y(x)$ occur for $x > 0.1$ ?

[3]

- 0
- 1
- 3
- 14
- $\infty$

19. What is the order, from shortest to longest, of the wavelengths of the peak electromagnetic emission from each of the following objects?

1. an electric torch
2. a microwave oven
3. a radioactive source
4. a hot cooking stove
5. a short-wave radio transmitter

[2]

- 3,1,2,4,5
- 5,4,2,1,3
- 5,2,4,1,3
- 3,4,1,5,2
- 3,1,4,2,5

20. A particle of type X decays with equal probability either to a pair of particles of type Y or a pair of particles of type Z. Both Y and Z particles are stable.

The decays of two X particles are observed. A pair of Y particles is found among the decay products. What is the probability that a pair of Z particles is among these decay products?

[2]

- 1/2
- 1/3
- 2/3
- 1/4
- 1

21. Ten students need to complete their compulsory practicals for their high school examinations as detailed in the table below:

| No. of students | No. of different practicals to complete |
|---|---|
| 2 | 1 |
| 4 | 2 |
| 4 | 3 |

The school only has one laboratory in which several different experiments can be set up simultaneously. A maximum of six students are allowed in the school's laboratory for a lesson. Each practical takes one lesson. What is the minimum number of lessons required to complete all the practicals?

[2]

- 10
- 4
- 5
- 3
- 6

22. What is the next number in the sequence? 37, 41, 43, 47, 53, 59

[2]

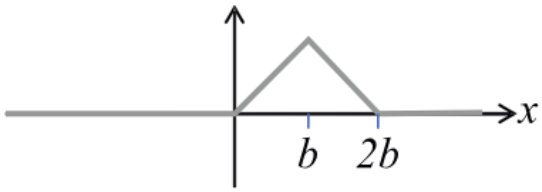
- 64
- 65
- 62
- 61
- 67

23. A stone of average diameter 10 cm is hit with a hammer and splits into pieces. Every time the stone or one of its pieces is hit, it splits into three further pieces of equal volume and similar shape. How many hits will it take before a piece reaches the size of a typical atom?

[3]

- 56
- 12
- 81
- 22
- 9

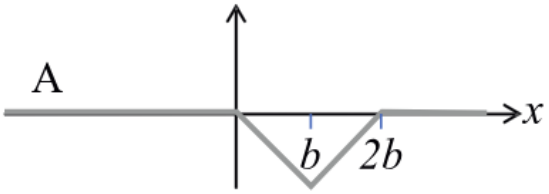
24. The graph below shows a function $f(x)$ .



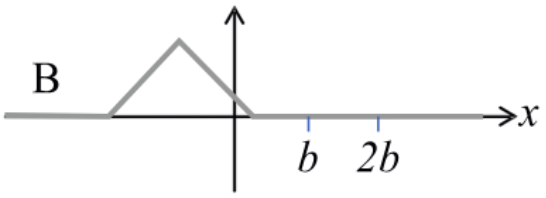

If $a$ is a constant such that $0 < a < b$ , identify the sketch of $g(x) = -f(a - x)$ from the sketches below.

[3]

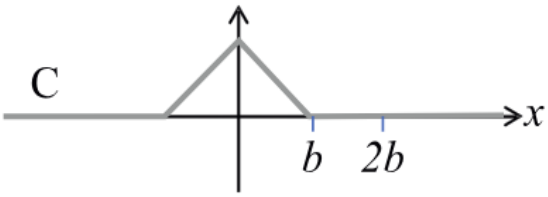
○ A



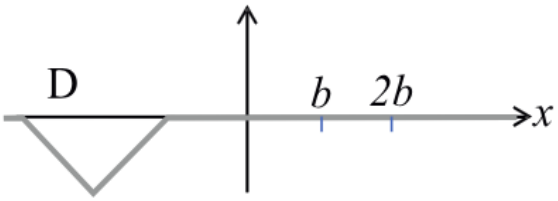

○ B



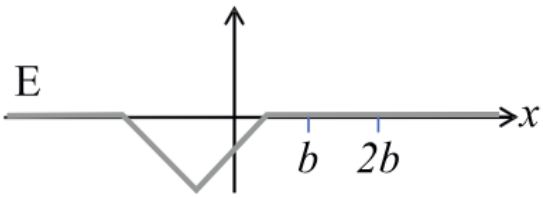

○ C




○ D




○ E



25. What is the next number in the sequence? -972, 324, -108, 36, -12

[2]

- -4
- 9
- -3
- 4
- 3

26. Which values of $x$ and $y$ solve the following equations simultaneously:

$$\log x + 2\log y = \log 32$$
$$\log x - \log y = -\log 2$$

[3]

- $x = 2,\ y = 4$
- $x = -2,\ y = -4$
- $x = 2,\ y = -4$
- $x = -2,\ y = 4$
- No solution exists

27. Consider a system of many interacting particles. Let each particle have a potential energy $V(r)$ with respect to any other particle, where $V(r) \propto r^n$ where $r$ is the distance to another particle and $n$ is an integer. For such systems the Virial Theorem relates the time averaged total kinetic energy of all particles $\langle T_{\text{tot}} \rangle$ to the time averaged total potential energy $\langle V_{\text{tot}} \rangle$ as follows:

$$2\langle T_{\text{tot}} \rangle = n\langle V_{\text{tot}} \rangle$$

If the particles in our system interact only via gravity, what is the time averaged total energy $\langle E_{\text{tot}} \rangle$ of the system?

[3]

- $\langle E_{\text{tot}} \rangle = 0$
- $\langle E_{\text{tot}} \rangle = \langle V_{\text{tot}} \rangle / 2$
- $\langle E_{\text{tot}} \rangle = 2\langle V_{\text{tot}} \rangle$
- $\langle E_{\text{tot}} \rangle = -\langle V_{\text{tot}} \rangle$
- $\langle E_{\text{tot}} \rangle = -2\langle V_{\text{tot}} \rangle$

28. The acceleration g due to gravity on a spherical planet in any universe is given by:

$$g = \frac{GM}{R^2}$$

where $M$ is the mass, $R$ the radius of the planet and $G$ is the gravitational constant in that planet's universe.

In a different universe the gravitational constant is $G'$ and has twice the value of the gravitational constant in our Universe $G$ .

Find the ratio $\frac{g_{\text{planet}}}{g_{\text{Earth}}}$ for a planet in the different universe which has half the radius and twice the density of the Earth.

[2]

- $\frac{g_{\text{planet}}}{g_{\text{Earth}}} = 2$
- $\frac{g_{\text{planet}}}{g_{\text{Earth}}} = \frac{1}{2}$
- $\frac{g_{\text{planet}}}{g_{\text{Earth}}} = \frac{1}{4}$
- $\frac{g_{\text{planet}}}{g_{\text{Earth}}} = 1$
- $\frac{g_{\text{planet}}}{g_{\text{Earth}}} = 4$

29. In which range of $\alpha$ does the following equation have real solutions?

$\frac{1}{\cos^2\theta} + \alpha \tan\theta = 0$

[3]

- $\alpha \leq -2$ or $\alpha \geq 2$
- $\alpha \leq -2$
- $\alpha \geq 2$
- $\alpha \geq 0$
- $\alpha \leq 0$
- None

30. A bag contains b blue balls and r red balls. If two balls are picked at random and removed from the bag, what is the probability P that they are different colours?

[3]

- $2br$
- $\frac{br}{(b+r)^2}$
- $\frac{2br}{(b+r)^2}$
- $\frac{br}{(b+r)(b+r-1)}$
- $\frac{2br}{(b+r)(b+r-1)}$

31. We wish to represent integer numbers by using our ten fingers. A finger is assumed to be either stretched out or curled up. How many different integers can we represent with our fingers?

[3]

- 32
- 1024
- 1000
- 10
- 512
- 20

32. A long, thin, straight wire carrying an electric current $I$ causes a magnetic field of flux density $B$ at a perpendicular distance $r$ from the wire. The magnitude of this flux density is given by the following relation:

$$B = \frac{\alpha I}{r}$$

where $\alpha$ is a constant. The magnetic field points circumferentially around the wire. A second, identical wire is placed parallel to the first one at a distance $D$ . Find the current $I_2$ that has to flow in the second wire if the flux density at a line half way between and parallel to the wires is to double, compared to the flux density from only one wire at current $I$ .

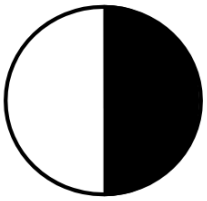
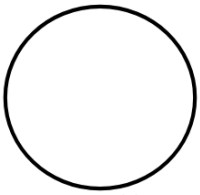
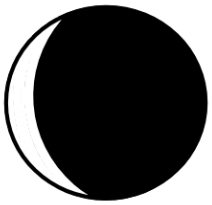
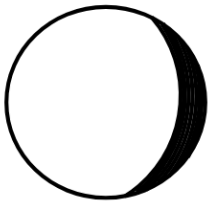
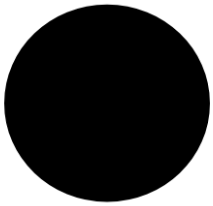
[3]

- $I_2 = I$
- $I_2 = -I/2$
- $I_2 = 2I$
- $I_2 = -I$
- $I_2 = -2I$

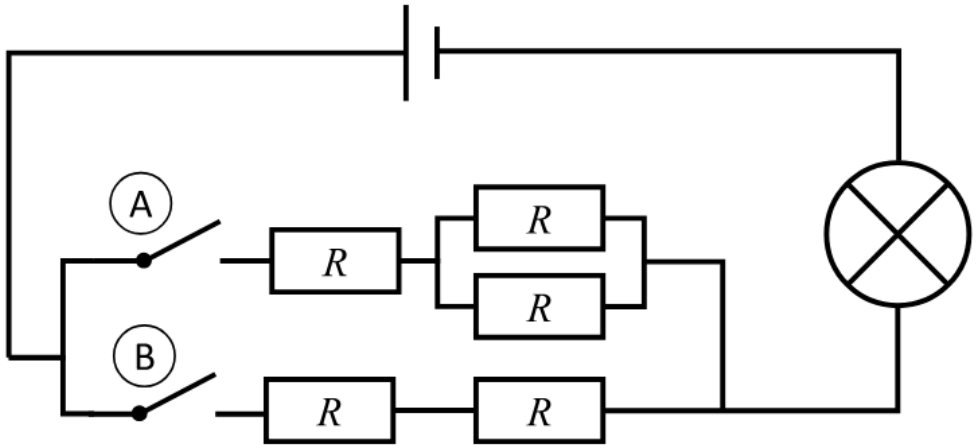
33. When the phase of the Moon as seen from the Earth is Full, what phase of the Earth is seen by an observer on the Moon?

(These symbols above show phases of the Earth as seen from the Moon.)

[2]

- 
  Quarter
  (or ‘half’)
- 
  Full
- 
  Crescent
- 
  Gibbous
- 
  New

34. In the circuit shown below all resistors have the same resistance R and the light bulb has a fixed resistance. You wish to change the state of the switches so that the brightness of the bulb increases from its minimum to its maximum. Which sequence of switch states will achieve this?




[3]

- both closed; then only B closed; then only A closed
- both closed; then only A closed; then only B closed
- only B closed; then only A closed; then both closed
- only A closed; then only B closed; then both closed
- all states have the same brightness

35. An organ pipe is open at one end and closed at the other. The lowest note you can play on this pipe has frequency $f_{\min}$ . If the speed of sound in the pipe is $v$ , what is the length $L$ of the pipe?

[2]

- $L = \frac{v}{4f_{\min}}$
- $L = \frac{4v}{f_{\min}}$
- $L = \frac{v}{f_{\min}}$
- $L = \frac{v}{2f_{\min}}$
- $L = \frac{2v}{f_{\min}}$

36. Which combination of units is the odd one out?

[3]

- $\mathrm{kg\,m\,s^{-2}}$
- $\mathrm{A\,T\,m}$
- $\mathrm{C\,m\,s^{-1}}$
- $\mathrm{J\,m^{-1}}$
- $\mathrm{A\,V\,m^{-1}}$

37. 90 people enter a maze. At each junction a third will go left and two thirds will go right. After three such junctions, what is the most likely combination of turns people will have taken?

[2]

- Gone right three times
- Gone left three times
- Gone right twice and once left
- Gone twice left and once right
- It is impossible to tell

38. A person drinks many cups of tea. The first cup the person drinks is filled completely. They don't want to drink too much tea in total so the second cup is filled with only a fraction ( $\alpha$ ) of the tea in the first cup, the third cup contains the same fraction $\alpha$ of the second cup and so on. What is the maximum value of $\alpha$ so that the person drinks no more than 3 times the amount of tea in the first cup however many drinks they take?

[2]

- $\alpha = \frac{2}{3}$
- $\alpha = \frac{1}{2}$
- $\alpha = \frac{1}{3}$
- $\alpha = \frac{3}{4}$
- $\alpha = \frac{1}{4}$

39. A rectangular building with sides 50 m and 100 m long has a flat roof on top of it.
The roof has a mass per unit area of $100\,\mathrm{kg\ m^{-2}}$ . What is the total force on the vertical walls supporting the building?

[2]

- $4.9 \cdot 10^6\ \mathrm{N}$
- $5 \cdot 10^5\ \mathrm{N}$
- $1.2 \cdot 10^6\ \mathrm{N}$
- $2.5 \cdot 10^6\ \mathrm{N}$
- $9.8 \cdot 10^6\ \mathrm{N}$

40. What is the equation of the line which intersects $y = 2x - 2$ at right angles and at position $x = 1$ ?

[3]

- $y = -\frac{1}{2}x$
- $y = x$
- $y = -\frac{1}{2}x + \frac{1}{2}$
- $y = \frac{1}{2}x - \frac{1}{2}$
- $y = 2x$