Diploma Programme
Programme du diplôme
Programa del Diploma

Physics
Standard level
Paper 1

Monday 3 May 2021 (afternoon)

45 minutes

Instructions to candidates

- Do not open this examination paper until instructed to do so.
- Answer all the questions.
- For each question, choose the answer you consider to be the best and indicate your choice on the answer sheet provided.
- A clean copy of the **physics data booklet** is required for this paper.
- The maximum mark for this examination paper is **[30 marks]**.

2221 – 6510

13 pages

1. Which lists one scalar and two vector quantities?

A. Mass, momentum, potential difference

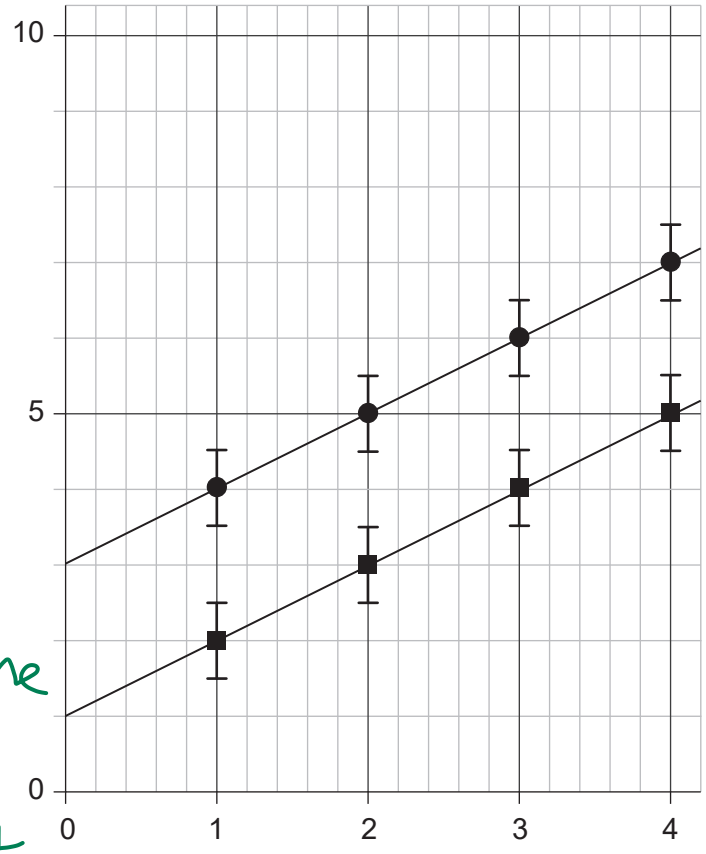
B. Mass, power, velocity

C. Power, intensity, velocity

D. Power, momentum, velocity

(D) is the only option with one scalar and two vectors

2. Two sets of data, shown below with circles and squares, are obtained in two experiments.
The size of the error bars is the same for all points.



The constant gradients of the lines indicates this is constant

for the same sized absolute uncertainty, the fractional uncertainty is larger as smaller values

What is correct about the absolute uncertainty and the fractional uncertainty of the *y* intercept of the two lines of best fit?

	Absolute uncertainty	Fractional uncertainty
~~A.~~	larger for squares	same
~~B.~~	larger for squares	larger for squares
~~C.~~	same	same
D.	same	larger for squares

↳ Therefore (D) remains

3. A large stone is dropped from a tall building. What is correct about the speed of the stone after 1 s?

A. It is decreasing at increasing rate.

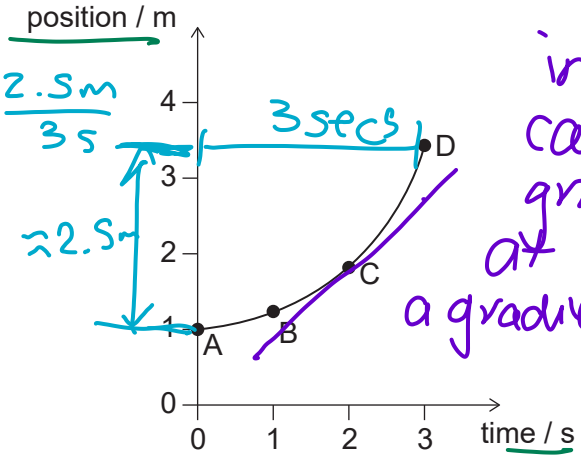
B. It is decreasing at decreasing rate.

C. It is increasing at increasing rate.

D. It is increasing at decreasing rate.

(D) is correct as the due to gravity the stone will be accelerating. However, it will be approaching its terminal velocity over time.

4. The graph shows how the position of an object varies with time in the interval from 0 to 3 s.



average speed ≈ 2.5m / 3s ≈ 5/6 ms⁻¹

3secs

≈2.5m

instaneous speed can be seen as the gradient of a curve at a point. We need a gradient of about 1 therefore (C)

At which point does the instantaneous speed of the object equal its average speed over the interval from 0 to 3 s?

5. A car takes 20 minutes to climb a hill at constant speed. The mass of the car is 1200 kg and the car gains gravitational potential energy at a rate of 6.0 kW. Take the acceleration of gravity to be 10 m s^{-2}. What is the height of the hill?

A. 0.6 m

B. 10 m

C. 600 m

D. 6000 m

20 minutes = 1200 seconds

6KW = 6000W = 6000 Joules/second

mgh

E = P x t

1200 x 10 x h = 1200 x 6000

gain in GPE = Energy transferred

10h = 6000

h = 600m

(C) is correct

be careful of the difference between A and B !
this would equal 2mv

2221 – 6510

6. A ball undergoes an elastic collision with a vertical wall. Which of the following is equal to zero?

A. The change of the magnitude of linear momentum of the ball

B. The magnitude of the change of linear momentum of the ball

C. The rate of change of linear momentum of the ball

D. The impulse of the force on the ball

$|mv| = |-mv|$

therefore (A)

7. Two forces act on an object in different directions. The magnitudes of the forces are 18 N and 27 N. The mass of the object is 9.0 kg. What is a possible value for the acceleration of the object?

A. $0\,m\,s^{-2}$

B. $0.5\,m\,s^{-2}$

C. $2.0\,m\,s^{-2}$

D. $6.0\,m\,s^{-2}$

NOTE: NOT OPPOSITE

$F_{NET\ min} = 27 - 18 = 9N$

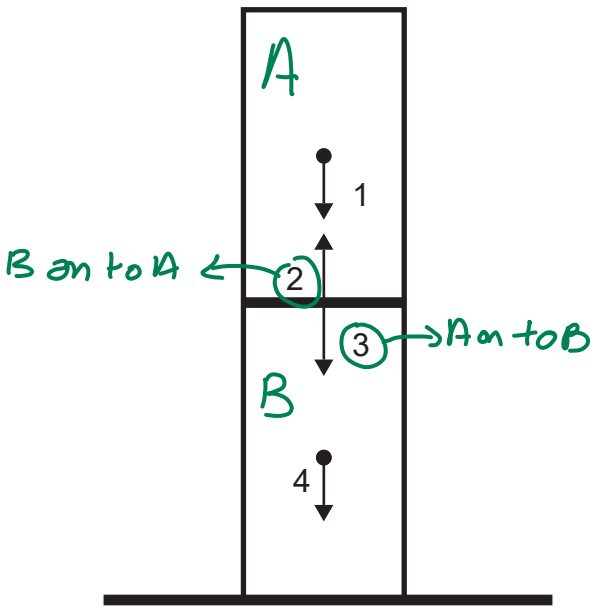
$F = ma \quad \frac{F}{m} = a$

$F_{NET\ max} = 27 + 18 = 45N$

$\frac{9}{9} = 1 ms^{-2} \quad \frac{45}{9} = 5 ms^{-2}$

$1 \leq a < 5$

8. Two identical boxes are stored in a warehouse as shown in the diagram. Two forces acting on the top box and two forces acting on the bottom box are shown.



Which is a force pair according to Newton's third law?

A. 1 and 2

B. 3 and 4

C. 2 and 3

D. 2 and 4

Each action has an equal an opposite reaction.

A exerts on to B
B exerts on to A

9. An electron has a linear momentum of $4.0 \times 10^{-25}\,\text{kg m s}^{-1}$. What is the order of magnitude of the kinetic energy of the electron?

A. $10^{-50}\,\text{J}$

B. $10^{-34}\,\text{J}$

C. $10^{-19}\,\text{J}$

D. $10^{6}\,\text{J}$

$E_K = \frac{p^2}{2m} = \frac{(4\times10^{-25})^2}{2\times 9\times10^{-31}}$

$= \frac{(10^{-25})^2}{10^{-31}} = \frac{10^{-50}}{10^{-31}} = \frac{10^{31}}{10^{50}} = 10^{-19}$

10. Which aspect of thermal physics is best explained by the molecular kinetic model?

A. The equation of state of ideal gases

B. The difference between Celsius and Kelvin temperature

C. The value of the Avogadro constant

D. The existence of gaseous isotopes

11. When 40 kJ of energy is transferred to a quantity of a liquid substance, its temperature increases by 20 K. When 600 kJ of energy is transferred to the same quantity of the liquid at its boiling temperature, it vaporizes completely at constant temperature. What is

$$\frac{\text{specific latent heat of vaporization}}{\text{specific heat capacity of the liquid}}$$

for this substance?

A. $15\,\text{K}^{-1}$

B. 15 K

C. $300\,\text{K}^{-1}$

D. 300 K

$\frac{L}{c}$ [kg/J/K]

$Q = mc\Delta T$ $\quad 40{,}000 = mc \times 20$ $\quad \frac{40{,}000}{20} = mc$ $\quad 2000 = mc$ $\quad \frac{2000}{m} = c$

$Q = mL$ $\quad 600{,}000 = mL$ $\quad \frac{600{,}000}{m} = L$

$\frac{600{,}000/m}{2000/m} = 300\,\text{K}$

12. A quantity of 2.00 mol of an ideal gas is maintained at a temperature of 127°C in a container of volume $0.083\,\text{m}^3$. What is the pressure of the gas?

change to kelvin

A. 8 kPa

B. 25 kPa

C. 40 kPa

D. 80 kPa

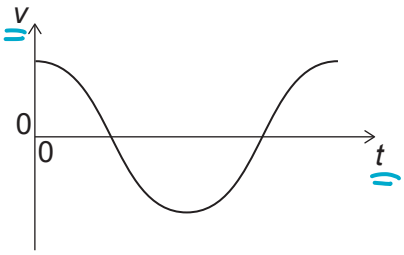
$pV = nRT$

$p = \frac{nRT}{V} = \frac{2\times 8.31\times(127+273)}{0.083}$

$= \frac{2\times8\times400}{0.08} = \frac{6400}{0.083}$

$= \frac{6400}{1}\times\frac{100}{8} = \frac{640000}{8} = 80\,\text{kPa}$

13. An object performs simple harmonic motion (shm). The graph shows how the velocity v of the object varies with time t.



cos(x) graph

The displacement of the object is x and its acceleration is a. What is the variation of x with t and the variation of a with t?

$x = \int v\,dt$

$x = \int \cos(t)\,dt$

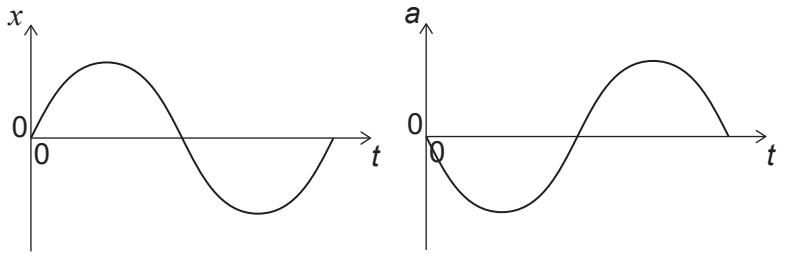
$x = \sin(t)$

$a = \frac{dv}{dt}$

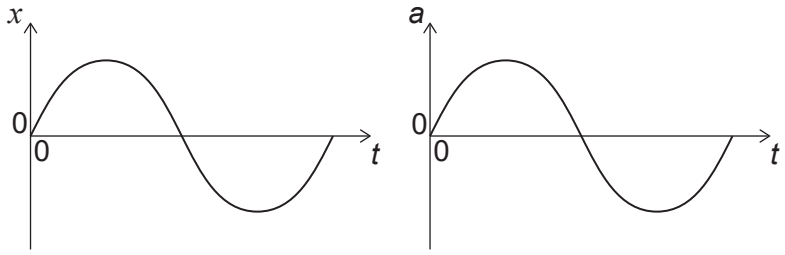
$a = \frac{d}{dt}\cos(t)$

$a = -\sin(t)$

A.



B.



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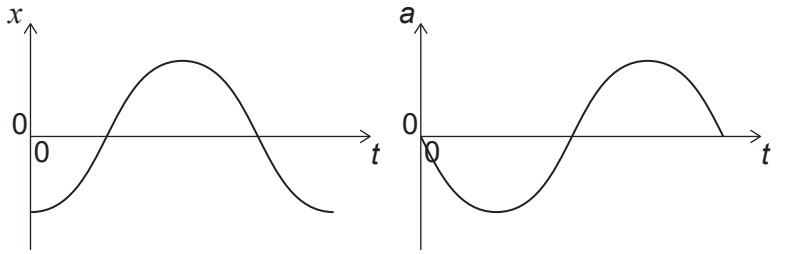
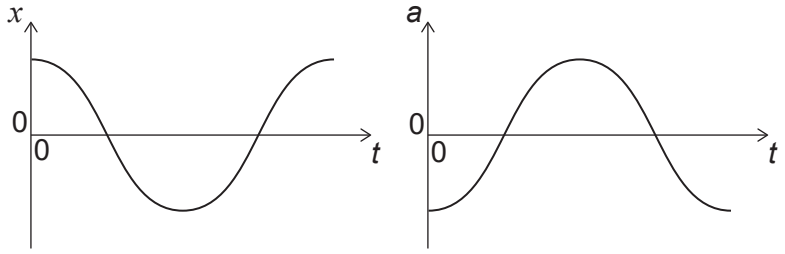


D.



14. A sound wave has a frequency of 1.0 kHz and a wavelength of 0.33 m. What is the distance travelled by the wave in 2.0 ms and the nature of the wave?

	Distance travelled in 2.0 ms	Nature of the wave
A.	0.17 m	longitudinal
B.	0.17 m	transverse
C.	0.66 m	longitudinal
D.	0.66 m	transverse

15. Two identical waves, each with amplitude X_0 and intensity I, interfere constructively. What are the amplitude and intensity of the resultant wave?

	Amplitude of the resultant wave	Intensity of the resultant wave
A.	X_0	$2I$
B.	$2X_0$	$2I$
C.	X_0	$4I$
D.	$2X_0$	$4I$

16. Three quantities used to describe a light wave are

I. frequency
II. wavelength
III. speed.

Which quantities increase when the light wave passes from water to air?

A. I and II only
B. I and III only
C. II and III only
D. I, II and III

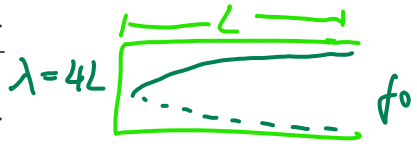
17. A pipe of length L is closed at one end. Another pipe is open at both ends and has length $2L$. What is the lowest common frequency for the standing waves in the pipes?

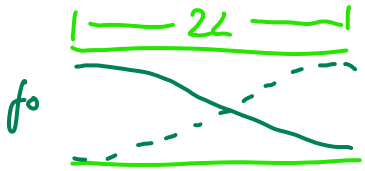
A. $\frac{\text{speed of sound in air}}{8L}$

B. $\frac{\text{speed of sound in air}}{4L}$

C. $\frac{\text{speed of sound in air}}{2L}$

D. $\frac{\text{speed of sound in air}}{L}$





$c = f_0 4L$

$\frac{c}{4L} = f_0$

$c = f_0 4L$

$\frac{c}{4L} = f_0$

18. Two charges Q_1 and Q_2, each equal to 2 nC, are separated by a distance 3 m in a vacuum. What is the electric force on Q_2 and the electric field due to Q_1 at the position of Q_2?

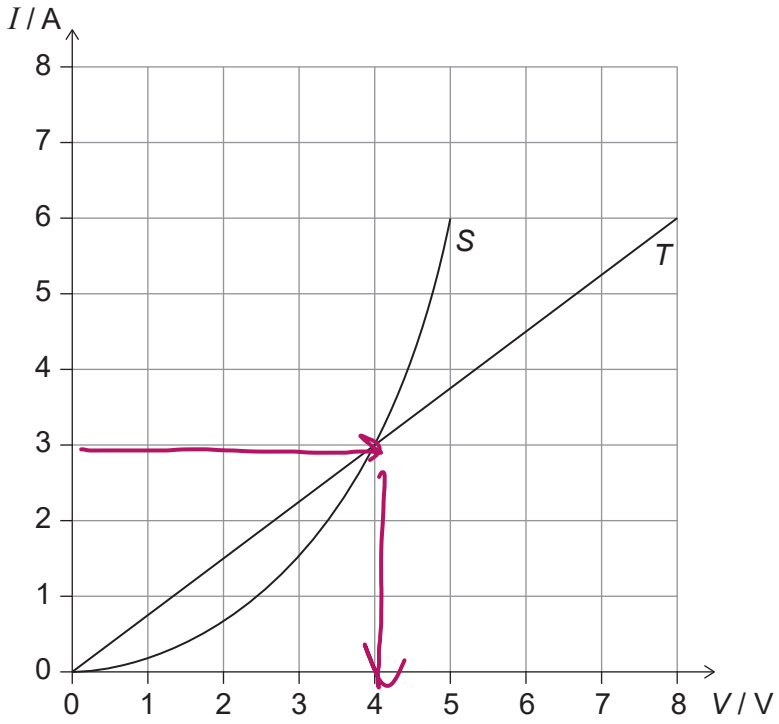
	Electric force on Q_2	Electric field due to Q_1 at the position of Q_2
A.	4×10^{-9} N	2 N C^{-1}
B.	~~4 N~~	2 N C^{-1}
C.	4×10^{-9} N	~~2×10^{-9}~~ N C^{-1}
D.	~~4 N~~	~~2×10^{-9}~~ N C^{-1}

$q_1 = q_2 = 2 \times 10^{-9}$ C $k \simeq 1 \times 10^{10}$

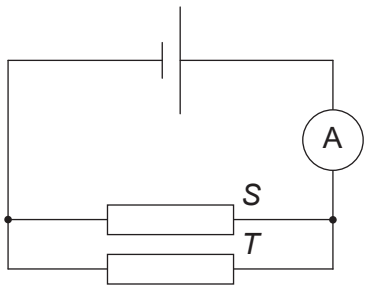
$F = \frac{Kq_1q_2}{r^2} = \frac{10^{10} \times 2 \times (2 \times 10^{-9})}{10} = 10^9 \times 4 \times 10^{-18} = 4 \times 10^{-9}$ N

$E = \frac{F}{q} = \frac{4 \times 10^{-9}}{2 \times 10^{-9}} = 2$ N C^{-1}

19. Two conductors *S* and *T* have the *V*/*I* characteristic graphs shown below.



When the conductors are placed in the circuit below, the reading of the ammeter is 6.0A.



Voltage same for both components in parallel.

This only occurs at 4V.

What is the emf of the cell?

A. 4.0V

B. 5.0V

C. 8.0V

D. 13V

20. For a real cell in a circuit, the terminal potential difference is at its closest to the emf when

A. the internal resistance is much smaller than the load resistance.

B. a large current flows in the circuit.

C. the cell is not completely discharged.

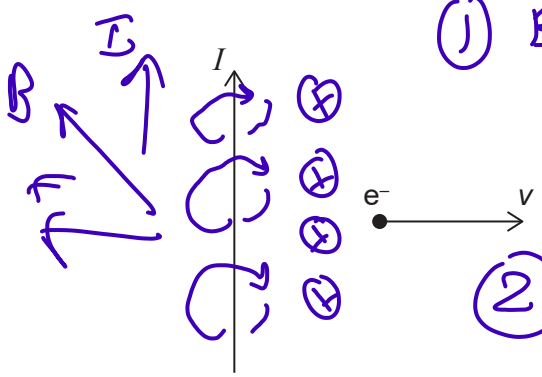
D. the cell is being recharged.

$\mathcal{E} = I(R+r)$

$\mathcal{E} = IR + Ir$

$\mathcal{E} = V$ + small

21. A long straight vertical conductor carries a current I upwards. An electron moves with horizontal speed v to the right.



(1) B into the page from right hand grip rule

(2) left hand rule on the electron

What is the direction of the magnetic force on the electron?

A. Downwards

B. Upwards

C. Into the page

D. Out of the page

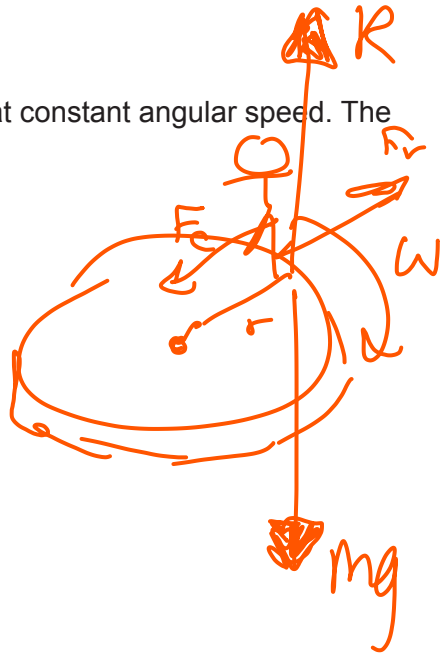
22. A child stands on a horizontal rotating platform that is moving at constant angular speed. The centripetal force on the child is provided by

A. the gravitational force on the child.

B. the friction on the child's feet.

C. the tension in the child's muscles.

D. the normal reaction of the platform on the child.



$g = \frac{F}{m}$

23. Which is the definition of gravitational field strength at a point?

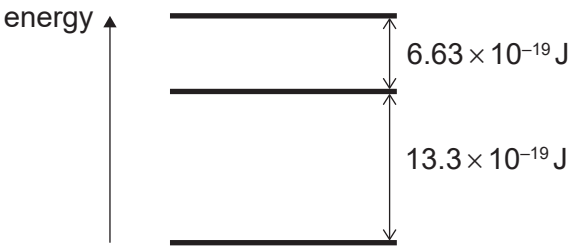
A. The sum of the gravitational fields created by all masses around the point

B. The gravitational force per unit mass experienced by a small point mass at that point

C. $G\frac{M}{r^2}$, where M is the mass of a planet and r is the distance from the planet to the point

D. The resultant force of gravitational attraction on a mass at that point

24. A simple model of an atom has three energy levels. The differences between adjacent energy levels are shown below.



$E = hf$

$\frac{E}{h} = f$

What are the two smallest frequencies in the emission spectrum of this atom?

A. 0.5×10^{15} Hz and 1.0×10^{15} Hz

B. 0.5×10^{15} Hz and 1.5×10^{15} Hz

C. 1.0×10^{15} Hz and 2.0×10^{15} Hz

D. 1.0×10^{15} Hz and 3.0×10^{15} Hz

$\frac{6.63 \times 10^{-19}}{6.63 \times 10^{-34}}$ 1×10^{15} Hz

$\frac{13.3 \times 10^{-19}}{6.63 \times 10^{-34}}$ 2×10^{15} Hz

25. What is the relation between the value of the unified atomic mass unit in grams and the value of Avogadro's constant in mol^{-1}?

A. Their ratio is 1.

B. Their product is 1.

C. Their sum is 1.

D. Their difference is 0.

$\frac{6 \times 10^{23} \text{ molecules}}{1 \times \text{mol}}$

$u = 1.66 \times 10^{-27}$ kg

$u = 1.66 \times 10^{-24}$ g

$6 \times 10^{23} \times \frac{5}{3} \times 10^{-24}$

$\frac{30}{3} \times 10^{-1}$

$10^1 \times 10^{-1} = 10^0 = 1$

26. Three particles are produced when the nuclide $^{23}_{12}\text{Mg}$ undergoes beta-plus (β^+) decay. What are two of these particles?

A. $^{23}_{11}\text{Na}$ and $^{0}_{0}\nu_e$

B. $^{0}_{-1}\text{e}$ and $^{0}_{0}\nu_e$

C. $^{23}_{11}\text{Na}$ and $^{0}_{0}\overline{\nu}_e$

D. $^{0}_{1}\text{e}$ and $^{0}_{0}\overline{\nu}_e$

$^{23}_{12}\text{Mg} \longrightarrow {}^{0}_{+1}\beta + {}^{23}_{11}\text{Na} + \nu_e$

27. A particle reaction is

$$p^+ + e^- + \overline{\nu}_\mu \rightarrow n + \mu^+ + \nu_e.$$

Which conservation law is violated by the reaction?

A. Baryon number

B. Charge

C. Lepton number

D. Momentum

LHS has neutral charge

RHS has positive charge

28. Which change produces the largest percentage increase in the maximum theoretical power output of a wind turbine?

A. Doubling the area of the blades

B. Doubling the density of the fluid

C. Doubling the radius of the blades

D. Doubling the speed of the fluid

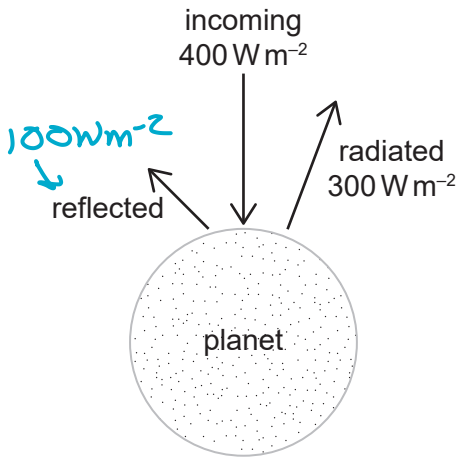
$P = \frac{1}{2} A \rho v^3$

highest power

29. A black body at temperature T emits radiation with peak wavelength λ_p and power P. What is the temperature of the black body and the power emitted for a peak wavelength of $\frac{\lambda_p}{2}$?

	Temperature of the black body	Power emitted by the black body
A.	$\frac{T}{2}$	$\frac{P}{16}$
B.	$\frac{T}{2}$	$\frac{P}{4}$
C.	$2T$	$4P$
D.	$2T$	$16P$

30. In a simple climate model for a planet, the incoming intensity is $400\,\text{W m}^{-2}$ and the radiated intensity is $300\,\text{W m}^{-2}$.



The temperature of the planet is constant. What are the reflected intensity from the planet and the albedo of the planet?

	Reflected intensity from the planet	Albedo of the planet
A.	$100\,\text{W m}^{-2}$	0.25
B.	$100\,\text{W m}^{-2}$	0.75
C.	$300\,\text{W m}^{-2}$	0.25
D.	$300\,\text{W m}^{-2}$	0.75