Physics Standard level Paper 1
Monday 3 May 2021 (afternoon)
45 minutes

Answers with explanation

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E 281 BASEMENT M BLOCK MAIN ROAD GREATER KAILASH 2 NEW DELHI
+91- 9958461445
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# IB PHYSICS SL PAPER-1 3 MAY-2021 SOLUTION WITH EXPLANATION

1. Which lists one scalar and two vector quantities?

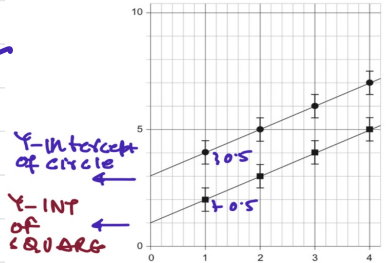
A. Mass, momentum, potential difference
B. Mass, power, velocity
C. Power, intensity, velocity
D. Power, momentum, velocity ✓

Mass - scalar
momentum - Vector → $\vec{p} = m\vec{v}$
Potential difference → $V = \frac{W}{q}$ = scalar
Power = $\vec{F} \cdot \vec{v}$ → scalar
Velocity → $\vec{v}$ → Vector
Intensity → scalar

Same question is asked in H.L PAPER-2021


2221–6507

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.




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 |

(I) At $x = 0$
$Y = Y_{INTERCEPT}$
SAME $(\Delta Y) = \pm \Delta Y$
HENCE - SAME FOR BOTH

(2) FRACTIONAL UNCERTANITY
$= \frac{\Delta Y}{Y_{INTERCEPT}}$

FOR SQUARE $= \frac{0.5}{1} = 0.5$
FOR CIRCLE $= \frac{0.5}{3} = 0.17$

$FU_{SQUARE} > FU_{CIRCLE}$

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

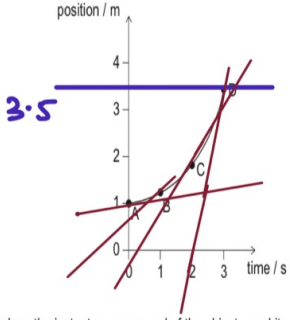
A. It is decreasing at increasing rate.

B. It is decreasing at decreasing rate.

C. It is increasing at increasing rate.

D. It is increasing at decreasing rate.

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




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

**ANS – 2**

$mg - F_{air} = ma$

$a = \frac{mg - F_{air}}{m}$

$F_{air} \propto v$


$v$ increases then $F_{air}$ ↑ Hence $a = \frac{mg - F_{air}}{m}$

Acceleration is rate of speed change hence (D)

**ANS – 3**

Avg speed over (1 – 3 sec)

$v_{avg} = \frac{3.5}{3-0} = 1.17$ mt/sec

↓

This velocity is approx equal to slope of G

(C)

Option is missing in the question paper

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 10ms-2. What is the height of the hill?

A. 0.6 m
B. 10m
C. 600 m
D. 6000 m

4. 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 $ms^{-2}$. What is the height of the hill?

A. 0.6 m
B. 10 m
C. 600 m
D. 6000 m

ANS-4 → Power = Work / time

Work = Power × time

$mgh = 6.0 \times 10^3 \times 20 \times 60$

$h = \frac{6.0 \times 10^3 \times 1200}{1200 \times 10}$

= 600 mt

NOTE
→ Remember gravitational force is conservative force

Same question is asked in HL-paper 2021



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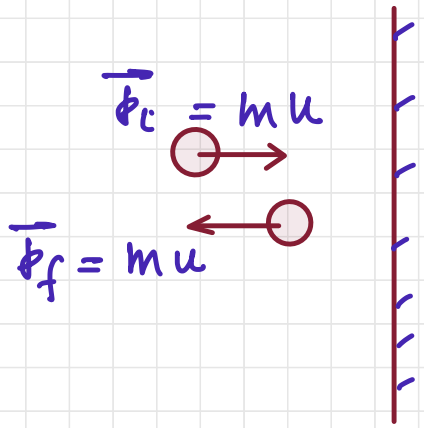
6. A ball undergoes an elastic collision with a vertical wall. Which of the following is equal to zero?

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




$\Delta \vec{p}$ = change of magnitude of the ball $= |p_f| - |p_i|$.

$= |mu| - |-mu| = 0$

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

$F_{NET} = \sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos\theta}$

For $f_{max}$, $\theta = 0°$, $f_{max} = F_1 + F_2$

for $f_{min}$, $\theta = 180°$, $f_{min} = F_1 - F_2$

$f_{max} = 18 + 27 = 45$ N

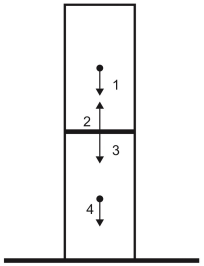
$f_{min} = 27 - 18 = 9$ N

$a_{max} = \frac{f_{max}}{9} = \frac{45}{9} = 5\ m s^{-2}$

$a_{min} = \frac{f_{min}}{9} = \frac{9}{9} = 1\ m s^{-2}$.

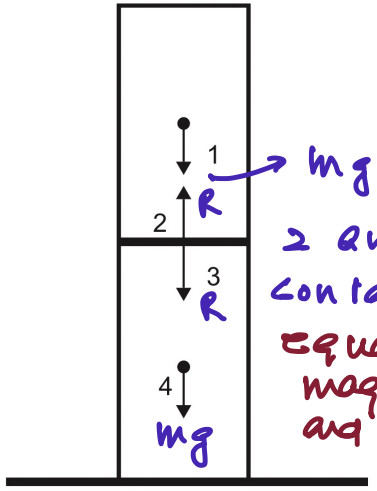
} ANSWER should be in between $5\ m s^{-2}$ & $1\ m s^{-2}$

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




2 and 3 are contact force equal in magnitude and opposite in direction

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

A. $10^{-50}$
B. $10^{-34}$
C. $10^{-19}$ ✓
D. $10^{6}$

$$\vec{p} = m\vec{v}$$

$$KE = \frac{1}{2}\frac{mv^2 \times m}{m} = \frac{1}{2}\frac{m^2v^2}{m} = \frac{1}{2}\frac{p^2}{m}$$

$$KE = \frac{1}{2}\frac{(4.0\times10^{-25})^2}{9\times10^{-31}} = \frac{16\times10^{-50}}{18\times10^{-31}}$$

$$= \frac{16}{18}\times10^{-19}\ J$$

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

Equation of state of ideal gas can be obtained by molecular kinetic model.

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
for this substance?
A. 15 K-1
B. 15K
C. 300 K-1
D. 300 K

Same question is asked in HL paper

ANS-11

CASE-I

$40 \times 10^3 = m(s)(20)$ — (1)

CASE-2

$600 \times 10^3 = mL$ — (2)

$\frac{\text{EQUATION (1)}}{\text{EQUATION (2)}} \Rightarrow \frac{40 \times 10^3}{600 \times 10^3} = \frac{ms20}{mL}$

$\frac{1}{15} = \frac{s(20)}{L}$

$\frac{L}{s} = 300\ K$



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12. A quantity of 2.00 mol of an ideal gas is maintained at a temperature of 127ûC in a container of volume 0.083 m3. What is the pressure of the gas?

A. 8 kPa
B. 25 kPa
C. 40 kPa
✓ D. 80 kPa

$PV = nRT$

$P = \frac{nRT}{V}$

$n = 2.0$ mol

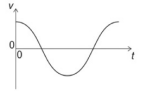
$T = 127 + 273 = 400$ K

$V = .083\ m^3$

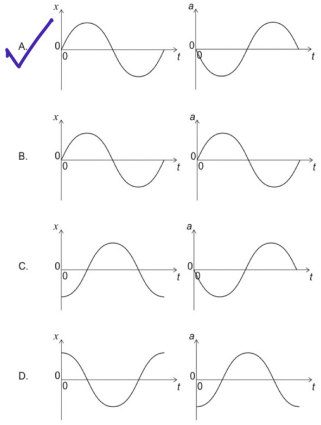
$R = 8.37$ (FROM DAPA BOOK)

$P = \frac{2 \times 8.37 \times 400}{.083} = 80$ kPa

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



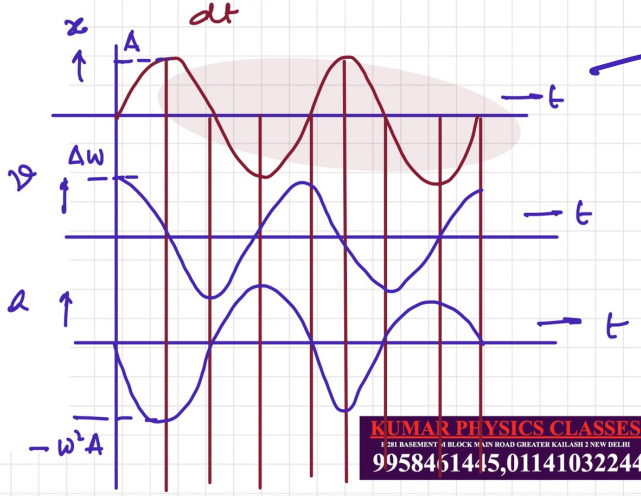

The displacement of the object is $x$ and its acceleration is $a$. What is the variation of $x$ with $t$ and the variation of $a$ with $t$?




If $x = A \sin \omega t$

$v = \frac{dx}{dt} = A\omega \cos \omega t$

$A = \frac{dv}{dt} = -\omega^2 A \sin \omega t$




→ same question is asked in HL paper



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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 |

Sound WAVE → Always longitudanal

Same Question Asked in H.L

$f = 1 \times 10^3$ Hz

$\lambda = 0.33$ mt

$t = 2.0 \times 10^{-3}$ sec

$v = f\lambda$

$v = 1 \times 10^3 \times 0.33$

$= 1000 \times \frac{33}{100} = 330 \frac{mt}{sec}$

$v = \frac{d}{t}$

$d = (v)(t)$

$= (330)(2 \times 10^{-3})$

$= 660 \times 10^{-3} = 0.66$ mt

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. | $2X_0$ | $4I$ |

$I = I_1 + I_2 + 2\sqrt{I_1}\sqrt{I_2}\cos\phi$

$R^2 = a^2 + b^2 + 2ab\cos\phi$

for constructive interference

$\cos\phi = 1$

$R^2 = a^2 + b^2 + 2ab$

$= X_0^2 + X_0^2 + 2X_0^2 = 4X_0^2$

$R = 2X_0$

$I_R = I + I + 2\sqrt{I}\sqrt{I}$

$= 4I$

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

Always frequency remains constant

$\mu = \frac{v_a}{v_m}$ , $\mu = \frac{f\lambda_a}{f\lambda_m} = \frac{\lambda_a}{\lambda_m}$

$v_a = \mu v_m$ $\quad$ $\lambda_a = \mu \lambda_m$

velocity increases $\quad$ wavelength increases

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

$f = \frac{v}{\lambda}$

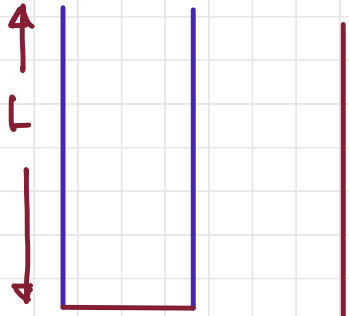
$f_1 = \frac{v}{4L}$

$f_2 = \frac{3v}{4L}$

$f_3 = \frac{5v}{4L}$

$f_4 = \frac{7v}{4L}$

$f_5 = \frac{9v}{4L}$





$f_1 = \frac{v}{2(2L)}$

$f_2 = \frac{2v}{2(2L)}$

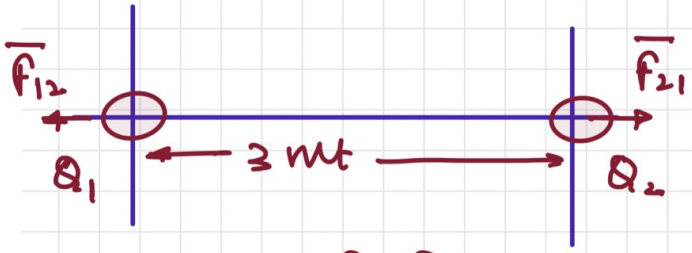
$f_3 = \frac{3v}{3(2L)}$

$f_4 = \frac{3v}{4(2L)}$

$\frac{v}{4L} = f$ — common in both

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. | $4 \times 10^{-9}$ N | 2 N C$^{-1}$ |
| B. | 4 N | 2 N C$^{-1}$ |
| C. | $4 \times 10^{-9}$ N | 2 x $10^{-9}$ N C$^{-1}$ |
| D. | 4 N | 2 x $10^{-9}$ N C$^{-1}$ |




Same question asked in HL 2021

$$|f_{12}| = |f_{21}| = \frac{1}{4\pi\epsilon_0}\frac{Q_1 Q_2}{r^2}$$

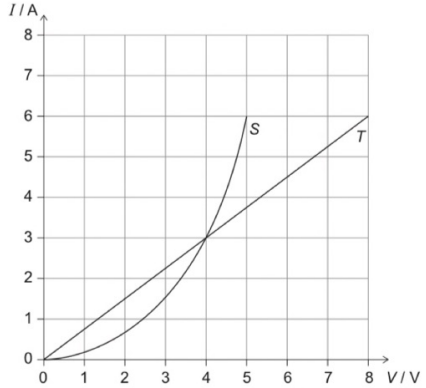
$$= \frac{9\times10^9\,(Q)^2}{(3)^2} = \frac{9\times10^9\times4\times10^{-18}}{9}$$

$$= 4\times10^{-9}\ N/C$$

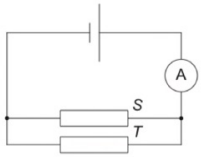
Electric field to $Q_1$ due to $Q_2$

$$E_{21} = \frac{\overline{F_{21}}}{Q_2} = \frac{4\times10^{-9}}{2\times10^{-9}} = 2\ N/C$$

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.



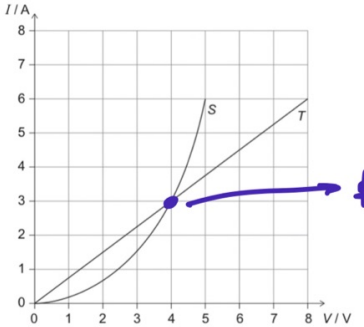

What is the emf of the cell?

A. 4.0 V

B. 5.0 V

C. 8.0 V

D. 13 V




potential is 4 Volt

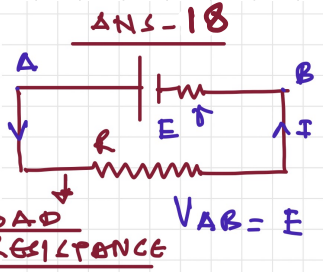
And summation of current at this point (both the conductors) = 3 + 3 = 6 Amp

same question asked in HL, IB - 2021.

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.

Same H.L question 2021

ANS - 18




$V_{AB} = E - Ir$

$I = \frac{E}{r+R}$

$V_{AB} = E - \left(\frac{E}{r+R}\right) r$

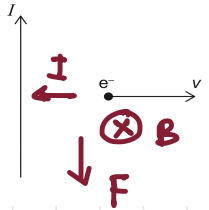
$V_{AB} = E \left[\frac{r+R-r}{r+R}\right] = E \left(\frac{R}{r+R}\right)$

$= E \left(\frac{1}{r/R+1}\right)$

If $R \gg r$

$V_{AB} = E$

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




As per fleming left hand rule Force is acting downward.

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.

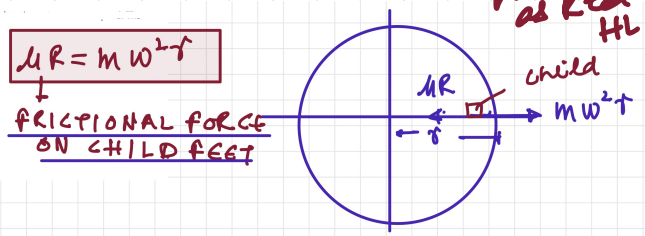
D. the normal reaction of the platform on the child.

same question as Recd in HL-2024

$\mu R = m\omega^2 r$

↓

FRICTIONAL FORCE ON CHILD FEET




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

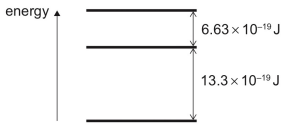
D. The resultant force of gravitational attraction on a mass at that point

$$F = \frac{GMm}{r^2}$$

$$\frac{F}{m} = \frac{GM}{r^2}$$

$m = 1\ kg$ → force per unit mass

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




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

A. $0.5 \times 10^{15}$ Hz and $1.0 \times 10^{15}$ Hz

B. $0.5 \times 10^{15}$ Hz and $1.5 \times 10^{15}$ Hz

C. ✓ $1.0 \times 10^{15}$ Hz and $2.0 \times 10^{15}$ Hz

D. $1.0 \times 10^{15}$ Hz and $3.0 \times 10^{15}$ Hz

$$E_1 = h f_1 \Rightarrow f_1 = \frac{E}{h} = \frac{6.63 \times 10^{-19}}{6.6 \times 10^{-34}}$$

$$= 1 \times 10^{15} \text{ Hz}$$

$$E_2 = h f_1 \Rightarrow f_2 = \frac{E}{h}$$

$$= \frac{13.3 \times 10^{-19}}{6.6 \times 10^{-34}}$$

$$= 2 \times 10^{15} \text{ Hz}$$

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.

ams and the value

ANS- 21

same as IB-HL-2021 Question

$N_A$ (amu)

$6.02 \times 10^{23}\ mol^{-1} \times 1.661 \times 10^{-24}\ grm$

$= 1$

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

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

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

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

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

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

27. A particle reaction is

$p + e^- + \bar{\nu}_\mu \rightarrow n + \mu^+ + \nu_e$. . Which conservation law is violated by the reaction?

A. Baryon number
B. Charge
C. Lepton number
D. Momentum

$P + \bar{e}^1 + \bar{\nu}_\mu \rightarrow n + \mu^+ + \nu_e$

A. Baryon number → $1 \rightarrow 1$
B. Charge → $-1 - 1 + 0 = 0 + 1 + 0$ (Violated)
C. Lepton number → $-1 + 1 = -1 + 1$
D. Momentum → Conservation of momentum can never be violated.

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

Ans-28

$E = \frac{1}{2} m v^2 = \frac{1}{2} A l (\rho) v^2$

$\text{Power} = \frac{\text{Energy}}{\text{time}} = \frac{1}{2} A \left(\frac{l}{t}\right) \rho v^2$

$= \frac{1}{2} A \rho v^3 \qquad \frac{l}{t} = v$

$P \propto A \rho v^3$

If $v \rightarrow$ double then power becomes 8 times

same question asked in IB HL Physics 2021

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

| | 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. ✓ | $2T$ | $16P$ |

$$P = e\sigma A T^4$$

$$\lambda_{max} = \frac{b}{T}$$

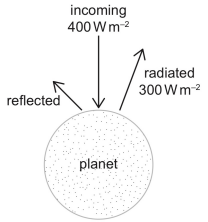
| CASE-I | CASE-II |
|---|---|
| $T$ | $T' = ?$ |
| $\lambda_p$ | $\lambda_p/2$ |
| $P$ | $P' = ?$ |

$$\frac{\lambda_p}{\lambda_p/2} = \frac{T'}{T} \Rightarrow T' = 2T$$

$$\frac{P}{P'} = \frac{T^4}{(2T)^4} = \frac{1}{16}$$

$$P' = 16P$$

30. In a simple climate model for a planet, the incoming intensity is 400 W $m^{-2}$ and the radiated intensity is 300Wm-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 W $m^{-2}$ | 0.25 |
| B. | 100 W $m^{-2}$ | 0.75 |
| C. | 300 W $m^{-2}$ | 0.25 |
| D. | 300 W $m^{-2}$ | 0.75 |

Reflected intensity
= Incoming intensity
− Radiated intensity
= 400 W/$mt^2$ − 300 W/$m^2$
= 100 W/$mt^2$

ALBEDO = $\frac{\text{TOTAL SCATTERED POWER}}{\text{TOTAL INCIDENT POWER}}$

$= \frac{100}{400} = 0.25$

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# IB PHYSICS SL PAPER-1 3 MAY-2021 SOLUTION WITH EXPLANATION

## ROUGH WORK