
BUNDAY TUTORIAL
PHY 101
CONSOLIDATING SOLUTIONS TO
PAST QUESTIONS
WE OFFER INTENSIVE TUTORIALS TO 100LEVEL STUDENTS
VENUE: SCIENCE ROOM 2
TIME: MON - FRIDAYS (4PM TO 6:30PM)
BY MR BUNDAY (07011534711)

LAGOS STATE UNIVERSITY, OJO

DEPARTMENT OF PHYSICS

2010/2011 1ST SEMESTER EXAM

Course Code: PHY 101, MECHANICS & PROPERTIES OF MATTER I Option A

Instruction: Answer all the ALL questions in 120 MINUTES (120 mins.) Please shade the right BOX & show your workings

1. Which of the following is true? (a) Both a spring balance and the chemical balance are used to measure the mass of an object, (b) Hooke's law forms the basis of operation of the spring balance (c) If the acceleration due to gravity changes, the reading of spring balance and the chemical balance will not change. (d) A micrometer screw gauge can be used to measure the internal diameter of a tube.
2. In the following list, the unit of each quantity is indicated in bracket, which is true. (a) Work[kgm^2s^{-2}] (b) Power [Js] (c) Specific latent heat [$Jkg^{-1}K^{-1}$] (d) Elastic modulus [Nm^{-1}]
3. A girl walks 12m northwards, 5m eastwards and 7m southwards. Her total displacement is. (a) 5m north (b) 5m east (c) 7.07m, S45°W (d) 7.07m, N45°E
4. The inertia of a body may be defined as the... (a) reluctant to start moving if in a state of rest (b) reluctant to keep moving if already in motion (c) ability to overcome the earth's gravitational pull (d) readiness to start moving if in a state of rest.
5. A fruit drops from a tree 20 m tall. The time it takes to get to the ground is (a) 5.0s (b) 4.0s (c) 2.5s (d) 2.0s.
6. A body of mass m_1 moving with the velocity of u collides with a stationary body of m_2. Both bodies move together after the collision with a velocity of (a) $\frac{m_1u}{m_1-m_2}$ (b) $\frac{m_1u}{m_1+m_2}$ (c) $\frac{m_2u}{m_1+m_2}$ (d) $\frac{m_2u}{m_1-m_2}$
7. For a body in static equilibrium under parallel forces which of the following is true?
   (a) The sum of all the forces must be zero.
   (b) The total force in one direction is equal to the total force in the opposite direction.
   (c) The sum of the resolved components of forces along one direction equals to the sum of the resolved components in a perpendicular direction.
   (d) The body can undergo rotational but not translational motion.
8. Weights of 0.2N and 0.5N are placed at the 30cm and 80cm marks respectively on a uniform meter rule. If the meter rule balances horizontally on a knife edge at the 60cm mark, the weight of the meter rule is (a) 0.1N (b) 0.3N (c) 0.4N (d) 0.7N
9. A uniform meter rod of mass 1.5Kg is pivoted at one end. A weight of 7N is placed at the centre of the rod. The vertical force which should be applied at the other end to maintain the rod in equilibrium in the horizontal position is (a) 22.0N (b) 11.0N (c) 10.5N (d) 8.5N
10. An object of mass 20kg is released from a height of 10m above the ground level. The kinetic energy of the object just before it hits the ground is (a) 4000J (b)2000J (c)500J (d)200J
11. A bullet of mass 40g travelling at $300ms^{-1}$ strikes a target normally and penetrates at a distance of 20cm before coming to rest. The average force exerted on the bullet by the target is (a) 90N (b) 400N (c) 900N (d) 9000N
12. An object slides down an inclined plane from an initial height of 30m. It's velocity at the foot of the plane is $20ms^{-1}$. The percentage of its initial potential energy which is dissipated as heat is (a) $33\frac{1}{3}$% (b) 50% (c) $66\frac{1}{3}$% (d) 75%
13. A pulley system has a velocity ratio of 6 and an efficiency of 75%. The effort needed to lift a load of mass 135Kg is (a) 1013N (b)300N (c) 225N (d)30N
14. A block and a tackle system made up of five pulleys is used to raise a load of 700N with an effort of 200N. The efficiency of the system is (a) 29% (b) 57% (c) 70% (d) 85%.
15. A body of mass 20kg is pushed up a smooth plane inclined at an angle of 30° to the horizontal. The force needed to push the body up the plane is (a) 200N (b) 100N (c) 20N (d) 10N.
16. Which of the following is false?
   (a) Within the elastic limit, the strain in a wire doubles if the stress is doubled.
   (b) The area under the force vs. the extension plot is equal to the potential energy
   (c) The slope of the stress vs. strain plot during elastic deformation is a constant which varies from one material to another.
   (d) If two wires of identical dimensions are subjected to the same stress, the one with the higher Young's modulus will show a larger strain.
17. An elastic string stretches to the total length of 30cm under a load of 500N, with the additional load of 100N, the string stretches by another 2cm. The natural length of the string is (a)25cm (b)24cm (c)20cm (d)15cm
18. A spring has a total length of 17.5cm under a load of 250g and 20.0cm under a load of 300g. The extension of the string per unit load is (a) $5 \times 10^{-5} mN^{-1}$ (b) $8 \times 10^{-5} mN^{-1}$ (c) $5 \times 10^{-2} mN^{-1}$ (d) $8 \times 10^{-2} mN^{-1}$
19. The following phenomena are evidences of the particle nature of matter except (a) diffusion (b) photoelectric effect (c) diffraction (d) Brownian motion
20. The action of a towel in drying the body after a bath is explained by (a) diffusion (b) capillarity (c) osmosis (d) evaporation

. A group of variables that cannot be combined ...
dependent (b) dimensionally independent (c) dimensionally uniform (d) none
For what value of x and y is required to make $zg^{y}t^{x}$ nondimensional? The dimension of z, g, and t are L, LT^{-2}, T (a)
$(1,-2)$ (b)) $(-1,2)$ (c)) $(-1,-2)$ (d)) $(1,2)$
. An example of a dimensional equation is: (a) $Q = (\alpha^{x} - \beta^{y})$.(b) $Q = [\alpha^{x}\beta^{y}]$ (c) $Q = \{(\alpha^{x}\beta^{y})\}$ (d)) $Q =$

. The reciprocal of speed v in a gas is given by the formula $\frac{1}{v} = \sqrt{\frac{\rho+x^{-1}}{3y}}$ where ρ is the density of the gas. The dimension
of y is .(a) $ML^{-1}T^{2}$ (b) $ML^{2}T^{-1}$ (c) $M^{-1}LT^{-2}$ (d) $M^{-1}L^{2}T^{-1}$

. The reciprocal of speed v in a gas is given by the formula $\frac{1}{v} = \sqrt{\frac{\rho+x^{-1}}{3y}}$ where ρ is the density of the gas. The dimension
of x is (a) $ML^{-1}T^{2}$ (b) $ML^{2}T^{-1}$ (c) $M^{-1}L^{3}T^{0}$ (d) $M^{-1}L^{2}T^{-1}$.

. The position vectors of points P and Q are given by $r_1 = 2i + 3j - k, r_2 = 4i - 3j + 2k$. Determine PQ in terms of
i, j, k and find its magnitude: (a) $2i - 6j + 3k, \& 7$ (b) $2i + 6j + 3k, \& 7$ (c) $2i - 6j - 3k, \& 7$ (d)) $2i - 6j - 3k, \& 9$

. $If\ A = 3i - j - 4k, B = -2i + 4j - 3k, C = i + 2j - k\ find\ |3A - 2B + 4C|$ (a) $\sqrt{298}$ (b) $\sqrt{388}$ (c) $\sqrt{498}$ (d) $\sqrt{398}$

8. $If\ A = 3i - j - 4k, B = -2i + 4j - 3k, C = i + 2j - k\ find\ |A + B + C|$ (a) $\sqrt{93}$ (b) $\sqrt{73}$ (c) $\sqrt{83}$ (d) $\sqrt{63}$

9. The following forces act on a particle P: $F_1 = 2i + 3j - 5k, F_2 = -5i + j + 3k, F_3 = i - 2j + 4k, F_4 = 4i - 3j - 2k$
measured in Newton. Find the resultants of forces (a) $2i + k$ (b) $2i - j$ (c) $2i + j$ (d) $2i - k$

0. Evaluate the triple product of $A = 2i + j - 3k, B = i - 4j, C = 4i + 3j - k$ and comment: (a) 0 & linearly dependent
(b) 0 & linearly independent (c) 0 & indeterminate (d) none of the above.

1. Find the angle between $A = 2i + 3j - k\ and\ B = 6i - 3j + 2k$, (a) 69° (b) 79° (c) 89° (d) 29°

2. Determine the value of a so that $A = 2i + aj + k, and\ B = 4i - 2j - 2k$, are perpendicular. (a) 2 (b) 3 (c) 0 (d) 1

3. Find the work done in moving an object along a vector that $\vec{r} = 3i + 2j - 5k$, if the applied force is $F = 2i - j - k$ (a) 3J (b) 9J (c) 10J (d) 11J

4. $If\ A = 3i - j + 2k, B = 2i + j - k, C = i - 2j + 2k$ find $(AxB)xC$, (a) $24i - 7j - 5k$ (b) $-i + 7j + 5k$ (c) $-i + 7j - 5k$ (d) $24i + 7j - 5k$

35. Find the area of a triangle with vertices at $P(1,3,2)$, $Q(2,-1,1)$ & $R(-1,2,3)$ (a) $\frac{1}{2}\sqrt{117}$ (b) $\frac{1}{2}\sqrt{107}$ (c) $\frac{1}{2}\sqrt{127}$ (d) $\frac{1}{2}\sqrt{137}$

36. The correct expansion of the triple vector product , $Ax(BxC)$ is (a) $B(A.C) - C(A.B)$ (b)) $C(B.A), - A(B.C)$ (c)) $A(C.B) - B(C.A)$ (d)) $A(B.C) - C(B.A)$

37. The correct expansion of the triple vector product , $Bx(CxA)$ is (a) $B(A.C) - C(A.B)$ (b)) $C(B.A) - A(B.C)$ (c)) $A(C.B) - B(C.A)$ (d)) $A(B.C) - C(B.A)$

38. The correct expansion of the triple vector product , $Cx(AxB)$ is (a) $B(A.C) - C(A.B)$ (b)) $C(B.A) - A(B.C)$ (c)) $A(C.B) - B(C.A)$ (d)) $A(B.C) - C(B.A)$

39. The missing link in this triple product $A.(BxC) = ? = C.(AxB)$ is (a) $A.(BxC)$ (b) $-B.(CxA)$ (c) $-A.(BxC)$ (d) $B.(CxA)$

40. Find the shortest distance, |AB| between vectors; $A = 3i - j + 2k\ and\ B = 2i + j - k$, (a) $\sqrt{14}$ (b) $\sqrt{13}$)c) $\sqrt{6}$ d $\sqrt{24}$

41. A boat sails with velocity of 20km/hr in a direction N30°E. If the current of the river is 5km/hr westward, calculate the velocity of the boat as measured by a stationary observer at the bank. (a) 12m/s (b) 18m/s (c) 30m/s (d) 40m/s

42. The engine of a car which started from rest and which moved with an acceleration of $2ms^{-2}$ was turned off after 3s. The car accelerated for 10s at $25cms^{-2}$ before brakes are applied after which comes to rest in 3s later. Calculate the total distance through which the car moved. (a) 30.75m (b) 61.75m (c) 50.75m (d) 80.75m

43. Two objects of masses 2kg and 3kg are connected by string which passes over a frictionless pulley whose mass is negligible. Find the tension in the string (a) 23.53N (b) 33.53 (c) 53.23N (d) 53.33N

44. What force must be applied to make a car of mass 1500kg balance on a hilly road inclined at 30° if the coefficient of static friction of the road is 0.25? (a) 4617.4N (b) 4176.4N (c) 4167.4N (d) 4716.4N

45. A vehicle of mass 2000kg is accelerated from rest on a road inclined at 30° and whose coefficient of friction is 0.3 by applying a force of 15000N. Find the velocity attained in 5s. (a) 0.25m/s (b) 0.52m/s (c) 0.15m/s (d) 0.35m/s

46. An object of mass 1.5kg is tied to the end of a 0.8m cord and spurned at 2 revolutions/s in a vertical circle calculate the tension in rope when the mass is at the highest point of the circle (a) 0.25N (b) 0.38N (c) 0.52N (d) 0.83N

47. The bob of a pendulum is displaced at an angle of 45° with the vertical and releases. Find its velocity when the string of 1m forms an angle of 5° with the vertical. (a) 3.4m/s (b) 2.4m/s (c) 4.4m/s (d) 1.6m/s

48. A mass of 2kg attacked to a spiral spring to execute a SHM with amplitude of 0.12m. Its kinetic energy is 0.38J when its displacement is 0.07m. Compute the total energy of this mass. (a) 0.961J (b) 0.196J (c) 0.691J (d) 0.916J

49. A towing van drove a lorry which was coupled at 30° above the horizontal. If the speed of van was 10m/s and it got to its destination in 30mins with what average force was the lorry pulled. The work done by the van which was moving at a constant speed was 5mJ. (a) 221N (b) 111N (c) 321N (d) 441N

50: What is the period of a geostationary satellite? (a) $1.02x10^{5}km$ (b) $2.03x10^{5}km$ (c) $3.05x10^{5}km$ (d) $5.01x10^{5}km$

(1, −2) (b) (−1, 2) (c) (−1, −6) (d) (4, 4)
an example of a dimensional equation is: (a) $Q = (\alpha^x - \beta^y)$ (b) $Q = [\alpha^x \beta^y]$ (c) $Q = ((\alpha^x \beta^y))$ (d) Q =

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1) B

2) CHECK:

A — Work = Force × distance = mass × acceleration × distance

$= [kg\,m\,s^{-2}][m]$

$= [kg\,m^2 s^{-2}]$ ✓

B — Power = $\frac{\text{Workdone}}{\text{Time}} = \frac{[J]}{[s]} = [Js^{-1}]$

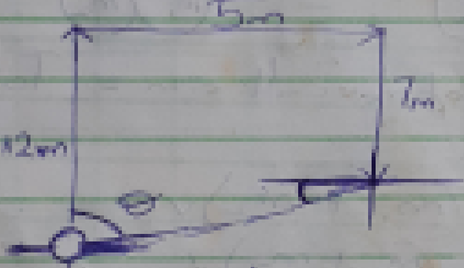
But B = Power $[Js]$ ✗

C — Specific ~~Latent~~ heat $[Jkg^{-1}K^{-1}]$ ✗ Jkg^{-1}

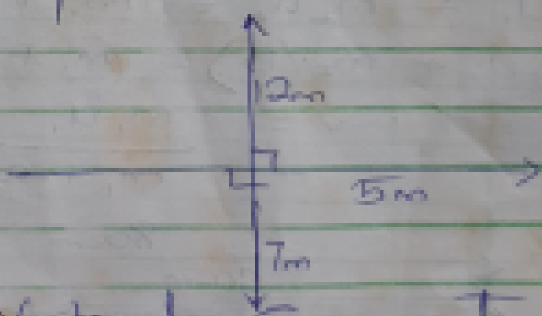
D — Elastic modulus $[Nm^{-1}]$ ✗

Ans = A

3)



Resolving to Components



Horizontal Components

12m : $12\cos 90^\circ = 0$

5m : $5\cos 0^\circ = 5$

7m : $7\cos 90^\circ = 0$

$\overline{\quad 5 \quad}$

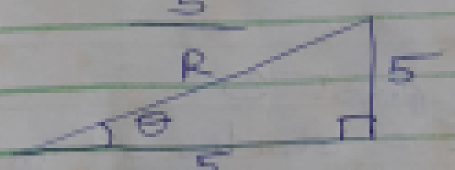
Vertical Components

$12\sin 90^\circ = 12$

$5\sin 0^\circ = 0$

$-7\sin 90^\circ = -7$

$\overline{\quad 5 \quad}$



$R^2 = 5^2 + 5^2$

$R = \sqrt{50}$

$R = 7.07m$

$\tan\theta = \frac{5}{5}$

dent (b) dimensionally independent (c) ... is required to make ... nondimensional? The dimension of ...

$\tan\theta = 1$

$\theta = \tan^{-1} 1$

$\theta = 45^\circ$

$\therefore$ Total displacement is $7.07m$, N45°E

4) B

5) $u=0$

$s = 20m$, $g = 10ms^{-2}$

$s = ut + \frac{1}{2}gt^2$

$20 = 0(t) + \frac{1}{2} \times 10t^2$

$20 = 5t^2$

$t^2 = 4$

$t = \sqrt{4} = 2s$ Ans = D

6) $m_1 \xrightarrow{u_1}$ + $m_2 \xrightarrow{u_2 = 0}$ = $m_1 m_2 \xrightarrow{v}$

Total momentum before collision = Total momentum after collision.

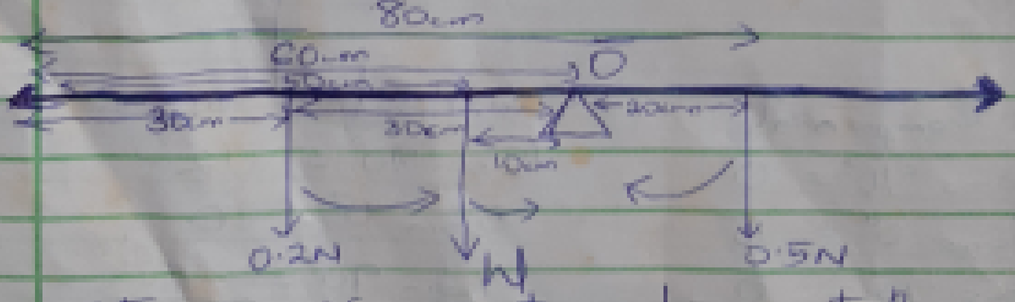
$m_1u_1 + m_2u_2 = (m_1 + m_2)v$

$m_1u_1 + m_2(0) = (m_1 + m_2)v$

$v = \frac{m_1u_1}{m_1 + m_2}$ Ans = B

7) B

8)



The weight of a uniform metre rule is at the centre (50cm position)

Taking moment at the pivot O

Anticlockwise moment = clockwise moment

$W \times 10 + 0.2 \times 30 = 0.5 \times 20$

$10W + 6 = 10$

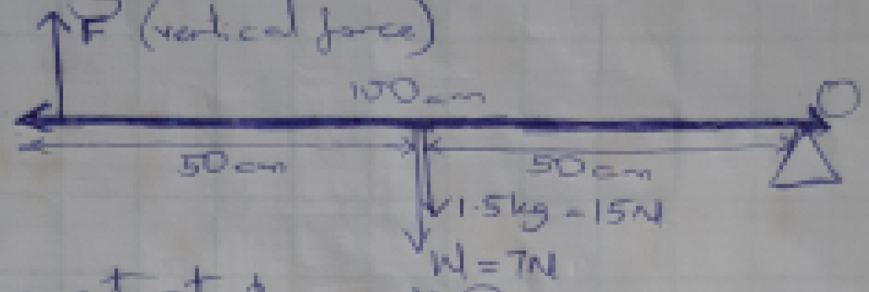
group of variables that cannot be combined ... (c) dimensionally uniform (d) none
pendent (b) dimensionally independent ... The dimension of x, g, and t are L, LT^{-2}, T (a)

$10W = 10 - 6$

$10W = 4$

$W = \frac{4}{10} = 0.4N$ Ans = C

9) mass = 1.5kg



Weight of a uniform metre rule is at the centre

Taking moment at the pivot O

Total Upward forces = Total downward forces

$F \times 100 = 7 \times 50 + 15 \times 50$

$100F = 350 + 750$

$100F = 1100$

$F = \frac{1100}{100} = 11N$ Ans = B

(10) mass, m = 20kg

height, h = 10m

Kinetic energy before it hits the ground = Potential energy

$= mgh = 20 \times 10 \times 10 = 2000$ Joules Ans = B

11)

mass = 40g = 0.04kg

distance = 20cm = 0.2m

Workdone by the bullet = Kinetic energy of the bullet

$F \times d = \frac{1}{2}mv^2$

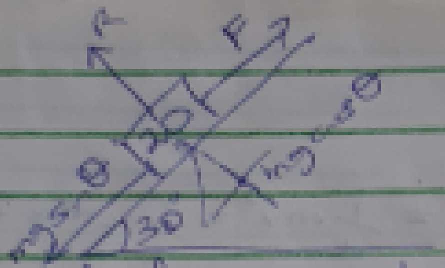
$2Fd = mv^2$

$F = \frac{mv^2}{2d} = \frac{0.04 \times 300^2}{2 \times 0.2} = \frac{0.04 \times 90000}{0.4}$

$= 9000N$

Ans = D

(15)



Force needed to push the body up the plane

$F = mg\sin\theta$

$F = 20 \times 10 \sin 30^\circ = 100N$ Ans = (B)

16) D

17) Let the original length be l_1

total length, $l_2 = 30cm$

$e_1 = l_2 - l_1$

$e_1 = 30 - l_1$ with force 500N

another force, 100N with $e_2 = 2cm$

$$\frac{F_1}{e_1} = \frac{F_2}{e_2}$$

$$\frac{500}{30-l_1} = \frac{100}{2}$$

$100(30 - l_1) = 1000$

$30 - l_1 = 10$

$l_1 = 30 - 10 = 20cm$ Ans = (C)

18) $l_1 = 17.5cm$

$l_2 = 20cm$

$e = 20 - 17.5 = 2.5cm = 0.025m$

Load, $F_1 = 250g$

Load, $F_2 = 300g$

$\Delta F = 300g - 250g = 50g = 0.05kg$

$\Delta F = 0.05kg \times 10 = 0.5N$

Extension per unit load $= \frac{0.025m}{0.5\ N}$

$= 0.05mN^{-1} = 5 \times 10^{-2} mN^{-1}$

Ans = (C)

... dimensional equation is: (a) $Q = (\alpha^x - \beta^y)$ (b) $Q = [\alpha^x \beta^y]$ (c) $Q = [(\alpha^x \beta^y)]$ (d) $Q =$

The reciprocal of speed v in a gas is given by the formula $\frac{1}{v} = \sqrt{\frac{\rho}{3\gamma}}$ where ρ is the density ...

12) height, $h = 30m$

$v = 20ms^{-1}$

Kinetic energy of the object $= \frac{1}{2}mv^2 = \frac{1}{2} \times m \times 20^2 = \frac{\overset{2}{\cancel{400}}m}{\cancel{2}}$

$= 200m$

Potential energy at the foot $= mgh = m \times 10 \times 30 = 300m$

Initial potential energy $= P.E - K.E = 300m - 200m = 100m$

% of initial potential energy $= \frac{1\cancel{00}}{3\cancel{00}} \times 100\% = 33\frac{1}{3}\%$

Ans = A

13) Velocity ratio, $V.R = 6$

Efficiency $= 75\%$ $\qquad M.A = \frac{Load}{Effort}$

Load $= 135kg = 1350N$

Efficiency $= \frac{M.A}{V.R} \times 100\%$

$75 = \frac{M.A}{6} \times 100$

$450 = M.A \times 100$

$M.A = \frac{450}{100} = 4.5 \Rightarrow M.A = \frac{Load}{Effort}$

$4.5 = \frac{1350}{E}$

$E = \frac{1350}{4.5} = 300N$

Ans = B

14) Velocity ratio of the block and tackle, $V.R = 5$

Load, $L = 700N$

Effort, $E = 200N \Rightarrow M.A = \frac{L}{E} = \frac{700N}{200N} = 3.5$

Efficiency $= \frac{M.A}{V.R} \times 100 = \frac{3.5}{\cancel{5}_1} \times \cancel{100}^{20}\%$

$= 70\%$ Ans = C

an example of a dimensional equation is: (a) $Q = (\alpha^2 - \beta^2)$ (b) $Q = [\alpha^2\beta^2]$ (c) $Q = ([\alpha^2\beta^2])$ (d) $Q =$

19) C

20)

21) B

22) To make $zg^x t^y$ non-dimensional

$zg^x t^y = M^0 L^0 T^0$

$L(LT^{-2})^x T^y = M^0 L^0 T^0$

$L L^x T^{-2x} T^y = M^0 L^0 T^0$

$L^{x+1} T^{-2x+y} = M^0 L^0 T^0$, equating the powers

$x + 1 = 0$

$x = -1$

$-2x + y = 0$

$-2(-1) + y = 0 \Rightarrow 2 + y = 0 \Rightarrow y = -2$

$\therefore$ The value $(x, y) = (-1, -2)$ Ans = C

23) B

A dimensional group is enclosed in the bracket [ ]

24) $\frac{1}{v} = \sqrt{\frac{\rho + x^{-1}}{3y}}$

$\rho = \frac{M}{\text{volume}} = \frac{M}{L^3} = ML^{-3}$

$v = \frac{\text{displacement}}{\text{time}} = \frac{L}{T} = LT^{-1}$

square both sides

$\frac{1}{v^2} \times \frac{\rho + x^{-1}}{3y}$

$3y = (\rho + x^{-1})v^2$

$3y = \rho v^2 + v^2 x^{-1}$

$3y = \rho v^2$ — (i) $3y = v^2 x^{-1}$ — (ii)

$3y = ML^{-3}(LT^{-1})^2$

$3y = ML^{-3}L^2T^{-2}$

$3y = ML^{-1}T^{-2}$

No Ans = ~~(A)~~

example of a dimensional equation is: (a) $Q = (\alpha^2 - \beta^2)$ (b) $Q = [\alpha^2\beta^2]$ (c) $Q = [(\alpha^2\beta^2)]$ (d) $V =$

reciprocal of speed v in a gas is given by the formula $\frac{1}{v} = \sqrt{\frac{\ldots}{3y}}$ where ρ is the density ...

25) From (24)

$3y = V^2 x^{-1}$

$3ML^{-1}T^{-2} = (LT^{-1})^2 x^{-1}$

$3ML^{-1}T^{-2} \times L^2T^{-2} \times \frac{1}{x}$

$x = \frac{L^2T^{-2}}{ML^{-1}T^{-2}} = M^{-1}L^{2-(-1)}T^{-2-(-2)}$

$= M^{-1}L^3T^0$ Ans = (C)

26) The position vectors

at P, $r_1 = 2i + 3j - k$

at Q, $r_2 = 4i - 3j + 2k$

$PQ = r_2 - r_1 = 4i - 3j + 2k - (2i + 3j - k)$

$= 2i - 6j + 3k$

The magnitude, $|PQ| = \sqrt{2^2 + (-6)^2 + 3^2} = \sqrt{4 + 36 + 9} = \sqrt{49} = 7$

Ans = (A)

27) $A = 3i - j - 4k$

$B = -2i + 4j - 3k$

$C = i + 2j - k$

$3A - 2B + 4C = 3(3i - j - 4k) - 2(-2i + 4j - 3k) + 4(i + 2j - k)$

$= 9i - 3j - 12k + 4i - 8j + 6k + 4i + 8j - 4k$

$= 17i - 3j - 10k$

$|3A - 2B + 4C| = \sqrt{17^2 + (-3)^2 + (-10)^2} = \sqrt{289 + 9 + 100}$

$= \sqrt{398}$ Ans = (D)

28) $A = 3i - j - 4k$

$B = -2i + 4j - 3k$, $C = i + 2j - k$

$A + B + C = 3i - j - 4k + (-2i + 4j - 3k) + (i + 2j - k)$

$= 3i - j - 4k - 2i + 4j - 3k + i + 2j - k$

$= 2i + 5j - 8k$

$|A + B + C| = \sqrt{2^2 + 5^2 + (-8)^2} = \sqrt{4 + 25 + 64} = \sqrt{93}$

Ans = (A)

29) $F_1 = 2i + 3j - 5k$, Pbrs

$F_2 = -5i + j + 3k$

$F_3 = i + 2j + 4k$

$F_4 = 4i - 3j - 2k$

Resultants of forces $= F_1 + F_2 + F_3 + F_4$

$= 2i - j + 0k = 2i - j$ Ans = B

30) $A = 2i + j - 3k$

$B = i - 4j$

$C = 4i + 3j - k$

Triple product of A, B, C

$$A\cdot(B \times C) = \begin{vmatrix} 2 & 1 & -3 \\ 1 & -4 & 0 \\ 4 & 3 & -1 \end{vmatrix}$$

$$= 2\begin{vmatrix} -4 & 0 \\ 3 & -1 \end{vmatrix} - 1\begin{vmatrix} 1 & 0 \\ 4 & -1 \end{vmatrix} + (-3)\begin{vmatrix} 1 & -4 \\ 4 & 3 \end{vmatrix}$$

$= 2(4) - 1(-1) - 3(3 + 16)$

$= 8 + 1 - 3(19) = 8 + 1 - 57 = 48 \neq 0$

Ans = D

31) $A = 2i + 3j - k$ $B = 6i - 3j + 2k$

$A \cdot B = |A||B| \cos\theta$

$$\cos\theta = \frac{A \cdot B}{|A||B|}$$

$A \cdot B = (2i + 3j - k)\cdot(6i - 3j + 2k)$

$= (2 \times 6) + (3 \times -3) + (-1 \times 2)$

$= 12 - 9 - 2 = 1$

$|A| = \sqrt{2^2 + 3^2 + (-1)^2} = \sqrt{4 + 9 + 1} = \sqrt{14}$

$|B| = \sqrt{6^2 + (-3)^2 + 2^2} = \sqrt{36 + 9 + 4} = \sqrt{49} = 7.$

$$\therefore \cos\theta = \frac{1}{\sqrt{14} \times 7} = \frac{1}{7\sqrt{14}}$$

$\cos\theta = 0.0382$

$\theta = \cos^{-1} 0.0382 =$

32) $A = 2i + aj + k$

$B = 4i - 2j - 2k$

A and B are perpendicular, angle between them is $90°$

$A \cdot B = |A||B| \cos\theta$

$A \cdot B = |A||B| \cos 90°$

$A \cdot B = 0$

$(2i + aj + k) \cdot (4i - 2j - 2k) = 0$

$(2 \times 4) + (a \times -2) + (1 \times -2) = 0$

$8 - 2a - 2 = 0$

$-2a = -6$

$a = \frac{-6}{-2} = 3$ Ans = B

33) $r = 3i + 2j - 5k$ (distance moved)

$F = 2i - j - k$

Workdone $= F \cdot r = (2i - j - k) \cdot (3i + 2j - 5k)$

$= (2 \times 3) + (-1 \times 2) + (-1 \times -5)$

$= 6 - 2 + 5 = 9J$ Ans = B

34) $A = 3i - j + 2k$

$B = 2i + j - k$

$C = i - 2j + 2k$

$(A \times B) \times C = ?$

$$(A \times B) = \begin{vmatrix} i & j & k \\ 3 & -1 & 2 \\ 2 & 1 & -1 \end{vmatrix} = i\begin{vmatrix} -1 & 2 \\ 1 & -1 \end{vmatrix} - j\begin{vmatrix} 3 & 2 \\ 2 & -1 \end{vmatrix} + k\begin{vmatrix} 3 & -1 \\ 2 & 1 \end{vmatrix}$$

$$= i(1-2) - j(-3-4) + k(3-(-2))$$

$$A \times B = -i + 7j + 5k$$

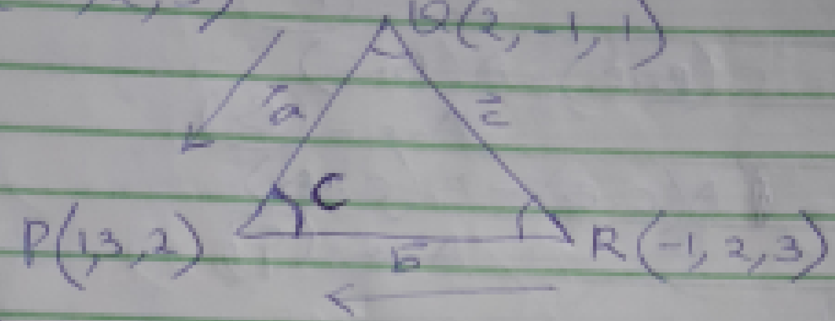
$$\therefore (A \times B) \times C = \begin{vmatrix} i & j & k \\ -1 & 7 & 5 \\ 1 & -2 & 2 \end{vmatrix} = i\begin{vmatrix} 7 & 5 \\ -2 & 2 \end{vmatrix} - j\begin{vmatrix} -1 & 5 \\ 1 & 2 \end{vmatrix} + k\begin{vmatrix} -1 & 7 \\ 1 & -2 \end{vmatrix}$$

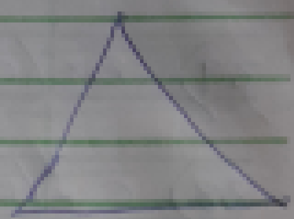
$= i\left(14-(-10)\right) - j\left(-2-5\right) + k\left(2-7\right)$

$= 24i + 7j - 5k$

Ans = (A)

35) Area of a Δ with vertices at $P(1,3,2)$, $Q(2,-1,1)$ and $R(-1,2,3)$





Recall that, Area of a Δ is $\frac{1}{2}ab\sin C$

vector $\vec{a} = \vec{PQ}$ and vector $\vec{b} = \vec{PR}$

C is the angle between $\vec{a}$ and $\vec{b}$

$\therefore a \times b = ab\sin C$

$|a \times b| = |a||b|\sin C$

$\therefore$ the area of the triangle is $\frac{1}{2}|a \times b|$

$\vec{a} = \vec{PQ} = (2-1)i + (-1-3)j + (1-2)k$

$= i - 4j - k$

$\vec{b} = \vec{PR} = (-1-1)i + (2-3)j + (3-2)k$

$= -2i - j + k$

$$a \times b = \begin{vmatrix} i & j & k \\ 1 & -4 & -1 \\ -2 & -1 & 1 \end{vmatrix}$$

$$= i\begin{vmatrix} -4 & -1 \\ -1 & 1 \end{vmatrix} - j\begin{vmatrix} 1 & -1 \\ -2 & 1 \end{vmatrix} + k\begin{vmatrix} 1 & -4 \\ -2 & -1 \end{vmatrix}$$

$= i(-4-1) - j(1-2) + k(-1-8)$

$= -5i + j - 9k$

$|a \times b| = \sqrt{(-5)^2 + (1)^2 + (-9)^2} = \sqrt{25 + 1 + 81}$

$= \sqrt{107}$

∴ The area of the triangle = $\frac{1}{2}|a \times b|$

$= \frac{1}{2}\sqrt{107}$ Ans = B

36) $A \times (B \times C) = B(A \cdot C) - C(A \cdot B)$

Ans = A

37) $B \times (C \times A) = C(B \cdot A) - A(B \cdot C)$

Ans = B

38) $C \times (A \times B) = A(C \cdot B) - B(C \cdot A)$

Ans = C

39) Ans = D

40) $A = 3i - j + 2k$

$B = 2i + j - k$

shortest distance between A and B i.e $|AB|$

$AB = (2-3)i + (+1-(-1))j + (-1-2)k$

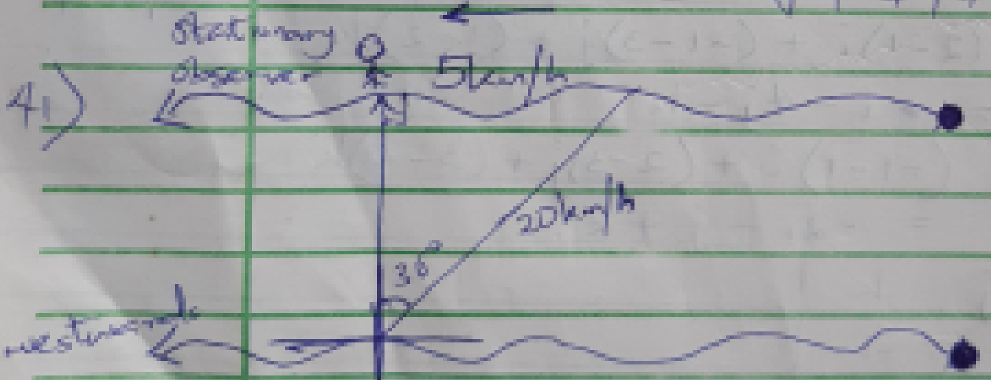
$= -i + 2j - 3k$

$|AB| = \sqrt{(-1)^2 + 2^2 + (-3)^2}$

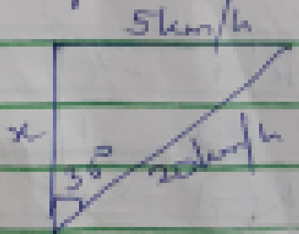
$= \sqrt{1 + 4 + 9} = \sqrt{14}$

Ans = A

41)



Direction of river



$5km/h = \frac{5 \times 1000}{3600} = 1.39ms^{-1}$

$20km/h = \frac{20 \times 1000}{3600} = 5.56ms^{-1}$

let x be the velocity of the boat as measured by a stationary observer

speed v in a gas is given by the formula ... where p is the ...
y is (a) $ML^{-1}T^{2}$ (b) ... (c) ... (d) ...

Using SOH CAH TOA

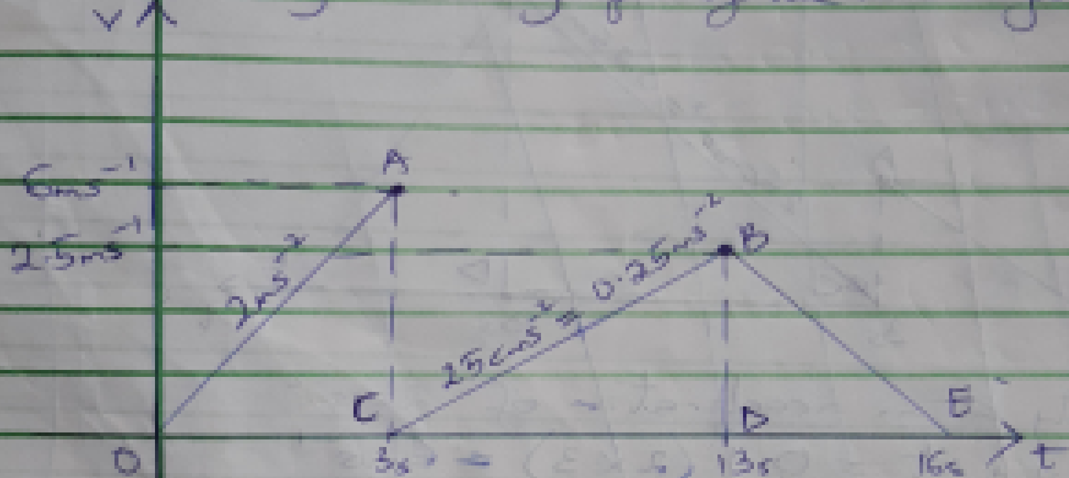
$\cos 30^\circ = \frac{x}{20}$

$x = 20\cos 30^\circ$

$x = 17.32\ km/h$

$17.32\ km/h = \frac{17.32 \times 1000}{3600} = 4.8\ ms^{-1}$ (No Answer)

42) The velocity-time graph of the whole journey.



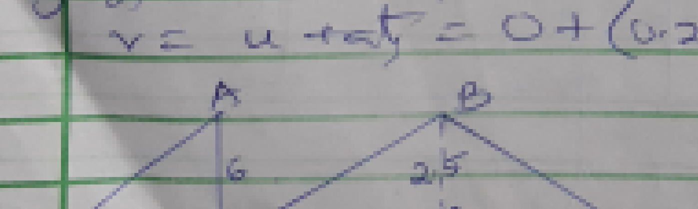
Velocity at an acceleration of $2ms^{-2}$

$v = u + at = 0 + (2 \times 3) = 6ms^{-1}$

$25cms^{-2} = 25 \times 0.01ms^{-2} = 0.25ms^{-2}$

Velocity of the car at an acceleration of $0.25ms^{-2}$

$v = u + at = 0 + (0.25 \times 10) = 2.5ms^{-1}$



Total distance covered = Area of ΔOAC + Area of ΔBCE

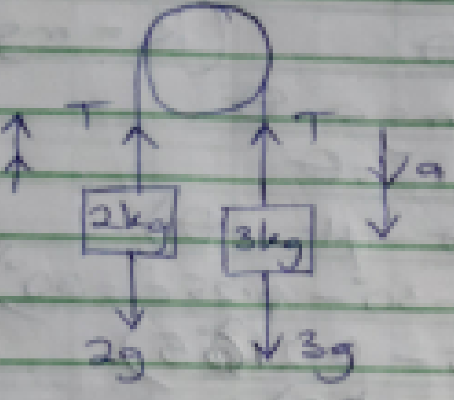
$= \frac{1}{2} \times 3 \times 6 + \frac{1}{2} \times 2.5 \times 13$

of y is (a) $ML^{-1}T^{2}$ (b) $ML^{2}T^{-1}$ (c) $ML^{-1}T^{-2}$ ... a gas is given by the formula ... where ρ is the density ...

$= 9 + 16.25$

$= 25.25\,m$ (No Answer)

43)



For the mass 2kg,

$T - 2g = 2a$ —— (1)

For the mass 3kg

$3g - T = 3a$ ——— (2)

Add (1) & (2)

$g = 5a$

$a = \frac{g}{5} = \frac{9.8}{5} = 1.96\,ms^{-2}$

substitute for a in eqn (1)

$T - 2g = 2(1.96)$

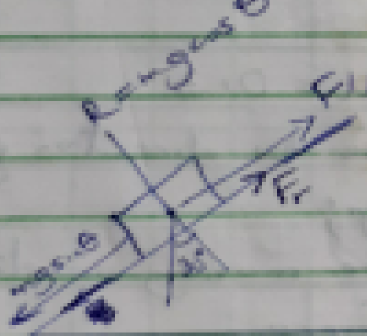
$T = 3.92 + 2g$

$T = 3.92 + 2(9.8)$

$= 3.92 + 19.6$

$= 23.52$ Ans = (A)

44)



$\mu = 0.25$ (coefficient of static friction)

mass, $m = 1500\,kg$

On the inclined plane (road), the car was slighting sliding down, before an external force F will be applied

∴ The sliding force is $mg \sin\theta$

The frictional force (F_r) will always be opposite to the direction of the motion

According to the rule of static equilibrium
Total forces in a direction = sum of forces in the other direction

$F + F_r = mg\sin\theta$

$F + \mu R = mg\sin\theta$ $(R = mg\cos\theta)$

$F + \mu mg\cos\theta = mg\sin\theta$

$F = mg\sin\theta - \mu mg\cos\theta$

$F = mg(\sin\theta - \mu\cos\theta)$

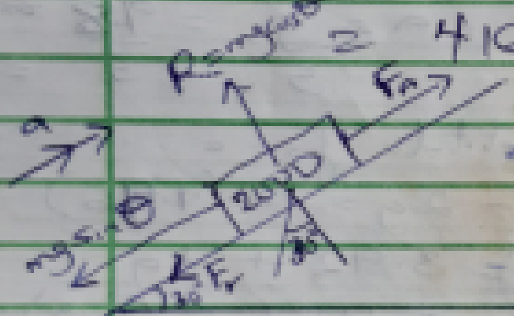
$= 1500 \times 9.8(\sin 30^\circ - 0.25\cos 30^\circ)$

$= 14700(0.5 - 0.2165)$

$= 14700(0.2835)$

$= 4167.4N$ Ans = (C)

45)



let F_A be force applied, $F_A = 15000N$
mass, $m = 2000kg$
μ (coefficient of friction), $\mu = 0.3$
Frictional force tends to oppose the direction of the motion
For the car to be accelerated up;
F_A must be greater than the moving or sliding force $(mg\sin\theta)$ and the frictional force
$\therefore$ the net force is

$F_A - (mg\sin\theta + F_r) = ma$

$F_A - (mg\sin\theta + \mu R) = ma$

$F_A - (mg\sin\theta + \mu mg\cos\theta) = ma$

$15000 - (2000 \times 9.8\sin 30^\circ + 0.3 \times 2000 \times 9.8\cos 30^\circ) = 2000a$

$15000 - 14892.23 = 2000a$

$107.77 = 2000a$

$a = \frac{107.77}{2000}$

$a = 0.05$

Velocity attained after 5s

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

$v = at = 0.05 \times 5 = 0.25\ ms^{-1}$ Ans = A

46) mass, $m = 1.5kg$

Length of the cord, $l = 0.8m$

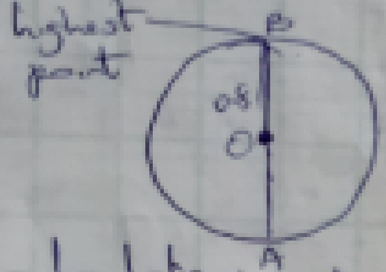
1 revolution = 2π radians

2 revolutions = 4π radians

Angular velocity, ω = 2 revolutions/s

$= 4\pi\ rads^{-1} = 4 \times 3.142$

$= 12.57\ rads^{-1}$



$v = \omega r$

$v = 12.57 \times 0.8$

$v = 10.06\ ms^{-1}$

To calculate the tension

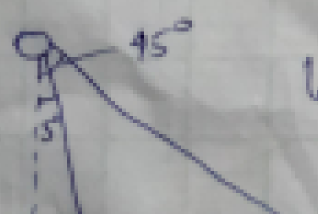
$T - mg\cos\theta = \frac{mv^2}{r}$

$T - (1.5 \times 9.8 \cos 180^\circ) = \frac{1.5 \times (10.06)^2}{0.8}$

$T - (-14.7) = 189.76$

$T + 14.7 = 189.76$

$T = 189.76 - 14.7 = 175.06N$ (No Answer)

47) 

length of string = 1m

at angle 45°, the radius

$r = l\sin\theta$

$r = 1\sin 45^\circ = 0.707m$

at angle 5°, the radius

$r = l\sin\theta$

$r = 1\sin 5^\circ = 0.087m$

... of speed v in a gas is given by the formula ... (a) $ML^{-2}T^{2}$ (b) ...

The velocity at 45°

$v_2 = \sqrt{rg\tan\theta} = \sqrt{0.707 \times 10 \tan 45^\circ}$

$= 2.66ms^{-1}$

The velocity at 5° from the vertical

$v_1 = \sqrt{rg\tan\theta} = \sqrt{0.087 \times 10 \tan 5^\circ}$

$= 0.28ms^{-1}$

∴ The velocity when the string forms an angle of 5°

$\Delta v = v_2 - v_1 = 2.66 - 0.28$

$= 2.38ms^{-1} \simeq 2.4ms^{-1}$ Ans (B)

48) mass, $m = 2kg$

Amplitude, $A = 0.12m$

Kinetic energy, $K.E = 0.38J$

displacement, $x = 0.07m$

Total Energy = ? P.E, potential energy = ?

$K.E = 0.38$

$\frac{1}{2}m\omega^2(A^2 - x^2) = 0.38$

$m\omega^2(A^2 - x^2) = 0.76$

$2\omega^2(0.12^2 - 0.07^2) = 0.76$

$2\omega^2 \times 0.0095 = 0.76$

$0.019\omega^2 = 0.76$

$\omega^2 = 40$

$\omega = \sqrt{40} = 6.325rads^{-1}$

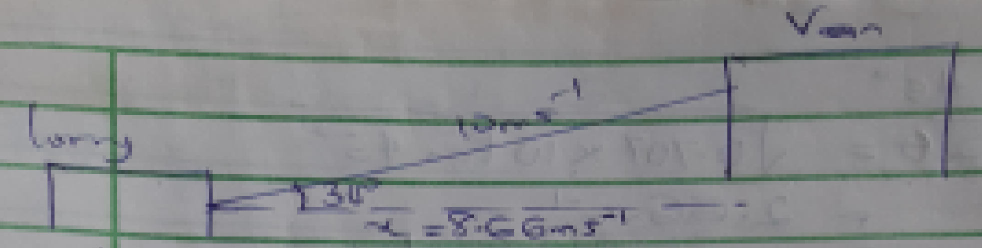
Total Energy $= K.E + P.E$

$= \frac{1}{2}m\omega^2(A^2 - x^2) + \frac{1}{2}m\omega^2x^2 = \frac{1}{2}m\omega^2A^2$

$= \frac{1}{2} \times 2 \times 6.325^2 \times 0.12^2$

$= 0.576J$ (No Ans)

49)



time, $t = 30\text{mins} = 30 \times 60 = 1800s$

Workdone, $W = 5mJ = 5 \times 10^{-3} J$

Using SOH CAH TOA, to find the horizontal distance (x)

$$\cos 30° = \frac{x}{10}$$

$$x = 10\cos 30° = 8.66ms^{-1}$$

acceleration, $a = \frac{v-u}{t} = \frac{8.66}{1800} = 0.005ms^{-2}$

distance moved, $v^2 = u^2 + 2as$

$$8.66^2 = 0^2 + 2(0.005)s$$

$$8.66^2 = 0.01s$$

$$s = \frac{8.66^2}{0.01} = 7499.5$$

Workdone = Force × distance

$$\text{Force} = \frac{\text{Workdone}}{\text{distance}} = \frac{5 \times 10^{-3}}{7499.5} = 6.67 \times 10^{-7} N$$

50) No Answer

The period of a geostationary satellite is 23 hours 56min

The circular orbit is 35,785km.

51) A