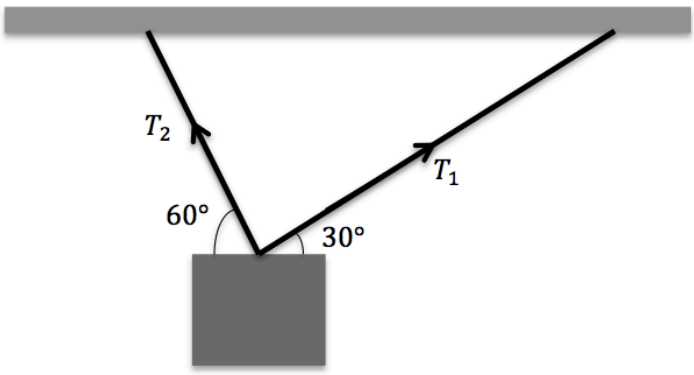
AHMES SECONDARY SCHOOL

FORM V HOLIDAY PACKAGE AND TEST

PHYSICS

1. The number of particles n crossing a unit area perpendicular to x-axis in a unit time is given as $n = -D\frac{(n_2-n_1)}{(x_2-x_1)}$ where n_1 and n_2 are the number of particles per unit volume for the values of x_1 and x_2 respectively. What are the dimensions of diffusion constant D? $[\boldsymbol{L^2T^{-1}}]$
2. The period of oscillation of a simple pendulum is given by $T = 2\pi\sqrt{\frac{l}{g}}$ whereby 100 vibrations were taken to measure 200 seconds. If the least count for the time and length of a pendulum of $1m$ is $0.1s$ and $1mm$ respectively. Calculate the maximum percentage error in the measurement of g. $\boldsymbol{[10.1\%]}$
3. A box weighing $80N$ is supported by two wires with tension T_1 and T_2 as shown in the figure below. Find the tension in each wire. $\boldsymbol{[40N, 69.28N]}$



4. A jet engine on a test bed takes in $40kg$ of air per second at a velocity of $100m/s$ and burns $0.8kg$ of fuel per second. After compression and heating the exhaust gases are ejected at $600m/s$ relative to the aircraft. Calculate the thrust of the engine.

[20480N]

5. A spaceship is launched into a circular orbit close to the earth's surface. What additional velocity has to be imparted to the spaceship in order to overcome the gravitational pull? **[7926.3m/s]**
6. A particle of mass $0.3kg$ moves with an angular velocity of $10rad/s$ in a horizontal circle of radius $20cm$ inside a smooth hemispherical bowl. Find the reaction of the bowl on the particle and the radius of the bowl. **[6.7N, 22.3cm]**
7. A wire of diameter $0.1mm$ and resistivity $1.69\times10^{-8}\Omega m$ with temperature coefficient of resistance of $4.3\times10^{-3}K^{-1}$ was required to make a resistance. What length of the wire is required to make a coil with a resistance of 0.5Ω? If on passing a current of $2A$ the temperature of the coil rises by 10^0C, what error would arise in taking the potential drop as $1.0V$? **[23.22cm, 0.0843V]**
8. Show that the total energy of a satellite in a circular orbit equals half its potential energy.
9. A fireman standing at a horizontal distance of $38m$ from the edge of a burning store building aimed to raise streams of water at an angle of 60^0 into the first floor through an open window which is at $20m$ high from the ground level. If the water strikes on this floor $2m$ away from the outer edge, sketch the diagram of the trajectory. At what speed will the water leave the nozzle of the fire hose? **[24.85m/s]**
10. A heating coil of nichrome wire with cross sectional area of $0.1mm^2$ operate on a $12V$ supply and has a power of $36W$ when immersed in water at $373K$. Calculate the length of the wire. Temperature coefficient of resistance of nichrome is $8\times10^{-5}K^{-1}$.

[0.37m]

11. A simple pendulum is suspended from the ceiling of a car taking a turn of radius $10m$ at a speed of $36kmh^{-1}$. Find the angle made by the string of the pendulum with the vertical if this angle does not change during the turn. **[45.6^0]**
12. A hemispherical bowl of radius R is rotating about its axis of symmetry, which is kept vertical. A small block is kept in the bowl and rotates with it without slipping. If the surface of the bowl is smooth and the angle made by the radius through the block with the vertical is θ, show that the angular speed of the bowl is given by $\sqrt{\frac{gcos\theta}{R}}$

13. Prove that at a very small temperature difference, $\Delta T = T_b - T_s$ Newton's law of cooling obeys Stefan's law whereby T_b is the temperature of the body and T_s is the temperature of the surrounding.
14. One mole of a gas expands from volume V_1 to a volume V_2. If the gas obeys the Van der Waal's equation: $\left(P + \frac{a}{v^2}\right)(v - b) = RT$, derive the formula for workdone in this process.
15. Show that the total energy of a body executing S.H.M is independent of time. Assume the initial phase is zero and the displacement equation is given by: $y = \text{A}\sin\ \omega t$.
16. If the earth were made of lead of relative density 11.3, what would be the value of acceleration due to gravity on the surface of the earth? Radius of the earth is $6400km$ and $G = 6.67\times10^{-11}Nm^2kg^{-2}$. $[\mathbf{20.2ms^{-2}}]$
17. The period T of oscillation of a body is said to be $(1.5 \pm 0.002)s$ while its amplitude A is $(0.3 \pm 0.005)m$ and the radius of gyration K is $(0.28 \pm 0.005)m$. If the acceleration due to gravity g was found to be related to T, A and K by the equation: $\frac{gA}{4\pi^2} = \frac{A^2+K^2}{T^2}$, find the numerical value and percentage error in g.

$[\mathbf{(9.8393 \pm 0.5293)ms^{-2}, 5.38\%}]$

18. Suppose the slope of the best-fit line is 1.0 and slopes of maximum and minimum worst lines are 1.16 and 0.81 respectively. Estimate the value of slope of the graph.

$[\mathbf{1.0 \pm 0.18}]$

19. A block of mass, $m = 100g$ is placed on a rough inclined plane. The plane makes an angle $\theta = 30^0$ with the horizontal. Determine the value of friction force that is required to keep the block at rest. **[0.49N]**
20. Due to change in main voltage the temperature of an electric bulb rises from $3000K$ to $4000K$. What is the percentage change in electric power consumed? **[216%]**
21. An insect is released from rest at the top of a smooth bowling ball such that it slides over the ball. Prove that it will lose its footing with the ball at an angle of about 48^0 with the vertical.
22. A ball is projected with a velocity v at an angle θ to the horizontal. It passes through a vertical point y and horizontal point x. If R is the horizontal range, prove that $tan\theta = \frac{y}{x}\left(\frac{R}{R-x}\right)$

23. Show that for elastic collision the kinetic energy is conserved.
24. A particle moving in S.H.M along the straight line has a velocity of $4m/s$ when its displacement from the mean position is $3m$ and $3m/s$ when the displacement is $4m$. Find the time taken to travel $2.5m$ from the positive extremity of its oscillation.

    $[\mathbf{1.047}\boldsymbol{s}]$
25. A particle executes S.H.M with amplitude A. At what distance from the mean position its K.E is equal to its P.E? $[\boldsymbol{A/\sqrt{2}}]$
26. A simple pendulum consists of small sphere of mass m carrying positive charge q and suspended by a thread of length l. The pendulum is placed in a uniform electric field of strength E directed vertically upwards. If the electrostatic force acting on the sphere is less than the gravitational force, show that the period of oscillation is given by: $T = 2\pi\sqrt{\frac{l}{(g-qE/m)}}$
27. Imagine a tunnel is dug along a diameter of the earth. Show that a body dropped from one end of the tunnel executes S.H.M. What is the time period of this motion? Assuming the earth to be a sphere of uniform density $\rho = 5520kgm^{-3}$ and $G = 6.67\times10^{-11}\ Nm^2kg^{-2}$. $[\mathbf{5059.45}\boldsymbol{s}]$
28. In the first second of its flight a rocket ejects $\frac{1}{60}$ of its mass with a relative velocity of $2400ms^{-1}$. Find its acceleration. What is the final velocity if the ratio of initial to final mass of the rocket is 4 at a time of 60 seconds? $[\mathbf{30}\boldsymbol{ms^{-2}},\ \mathbf{2727}\boldsymbol{ms^{-1}}]$
29. A model airplane X has a mass of $0.5kg$ and has a control wire OX of length $10m$ attached to it when it flies in horizontal circle with wings horizontal. The wire OX is inclined 60^0 to the horizontal and fixed to a point O and X takes $2s$ once round its circular path. Calculate the tension in the control wire and the upward force on X due to the air. $[\mathbf{49.35}\boldsymbol{N}, \mathbf{47.64}\boldsymbol{N}]$
30. Prove that minimum height at which the body has to be released on a smooth loop-looping apparatus in order for it to successfully complete the circular loop is given by $\frac{5}{2}R$, where R is radius of the loop.
31. An artificial satellite of mass M travels around the earth just above the surface (very close to earth's surface). Find the length of the simple pendulum that will have the

same period as that of the satellite. (Give your answer in terms of the diameter of the earth). $[\boldsymbol{l = D/2}]$

32. Use work-energy theorem in rotational motion to show that torque for a rotating rigid body is given by: $\tau = I\alpha$
33. An aluminium foil of relative emittance 0.2 is placed between two concentric spheres at temperatures $300K$ and $200K$ respectively. Calculate the temperature of the foil after the steady state is reached. Also calculate the rate of energy transfer between one of the spheres and the foil. Stefan's constant, $\sigma = 5.67\times10^{-8}Wm^{-2}K^{-4}$.

$[\boldsymbol{263.9K, 36.85Wm^{-2}}]$

34. What amount of heat is to be transfer to nitrogen in an isobaric heating so that the gas may perform $2J$ of work? Atomicity, $\gamma = 1.4$ $[\boldsymbol{7J}]$
35. Show that the slope of an adiabatic curve is always greater than that of an isothermal curve.
36. The reading of a pressure meter attached with closed water pipe is $4\times10^5N/m^2$. On opening the valve of the pipe, the reading of pressure meter is reduced to $3.2\times10^5N/m^2$. Calculate the speed of water flowing in the pipe. $[\boldsymbol{12.65ms^{-1}}]$
37. A hydrometer has a cylindrical glass stem of diameter $0.50cm$. It floats in water of density $1000kg/m^3$ and surface tension 7.2×10^{-2}N/m. A drop of liquid detergent added to the water reduces the surface tension to $5.0\times10^{-2}N/m$. What will be the change in length of the exposed portion of the glass stem? Assume that the relevant angle of contact is always zero. $[\boldsymbol{1.8mm}]$
38. A heavy rigid bar is supported horizontally from a fixed support by two vertical wires A and B, of the same initial length and which experience the same extension. If the ratio of diameter of A to that of B is 2 and the ratio of Young's modulus of A to that of B is 2. Calculate the ratio of the tension in A to that in B. If the distance between the wires is d, calculate the distance of wire A from the center of gravity of the bar.

$[\boldsymbol{8,\ d/9}]$

39. The equation $y = \text{asin}(\omega t - kx)$ represnts a plane wave travelling in a medium along x direction, y being the displacement at the point x at time t. Deduce whether the wave is travelling in the positive or in the negative x direction. If $a = 1.0\times10^{-7}m$, $\omega = 6.6\times10^3 rads^{-1}$ and $k = 20m^{-1}$, calculate the speed of the wave, the

maximum speed of the particle of the medium due to the wave and the phase difference between two positions of the same particle in an interval of $0.25s$.

$[\boldsymbol{Positive\ x-direction, 330ms^{-1}, 6.6\times10^{-4}ms^{-1}, 1650rad}]$

40. A police car's siren emits a sinusoidal wave with frequency $300Hz$. The speed of sound is $340m/s$ and the air is still. Find the wavelength of the waves in front of and behind the siren if the car is moving at $30m/s$. $[\boldsymbol{1.03m, 1.23m}]$
41. A small speaker emitting a note of frequency $250Hz$ is placed over the open upper end of a vertical tube that is full of water. When the water is gradually run out of the tube the air column resonates. If the initial and final positions of water surface below the top are $0.31m$ and $0.998m$ respectively, calculate the speed of sound in air and the end correction of the tube. $[\boldsymbol{334ms^{-1}, 0.034m}]$
42. A lagged copper rod is uniformly heated by a passage of an electric current. Show by considering a small section dx that the temperature θ varies with distance x along a rod in a way that, $H=-k\left(\frac{d^2\theta}{dx^2}\right)$ where k is the thermal conductivity and H is the rate of heat generation per unit volume.
43. A cup of tea kept in a room with a temperature of 22^0C cools from 66^0C to 63^0C in $1\ minute$. How long will the same cup of tea take to cool from the temperature of 43^0C to 40^0C under the same condition? $[\boldsymbol{2.2min}]$
44. An open pipe of length $15cm$ and a pipe of length $11.5cm$ closed at one end are both surrounding their first overtones. If their notes are of the same frequency, what will be the end correction of the two pipes? State assumption made in arriving at your answer. $[\boldsymbol{0.5cm, Assumption: Pipes\ are\ of\ the\ same\ radius}]$
45. A particle rests on a horizontal platform that is moving vertically in simple harmonic motion with amplitude of $50mm$. If above a certain frequency the particle ceases to remain in contact with the platform throughout the motion. Determine the lowest frequency at which this situation will occur. At what position will the particle cease to remain in contact with the platform? $[\boldsymbol{2.23Hz, At\ highest\ position}]$
46. Ice is forming on the surface of a pond. When it is $4.6cm$ thick the temperature of the ice in contact with the air is $260K$ while the surface in contact with the water is at

temperature $273K$. Find the rate at which the thickness of the ice is forming. Given $\rho_{ice} = 920kgm^{-3}, k_{ice} = 1.6Wm^{-1}K^{-1}$ and $L_{ice} = 334{,}000Jkg^{-1}$

$[\mathbf{1.47\times10^{-6}ms^{-1}}]$

47. Two spherical soap bubbles of radii $30mm$ and $10mm$ coalesce so that they have a common surface. If they are made from the same solution and the radii of the bubbles remain the same after they join together, derive the formula for radius of curvature of their common interface and find its value. $[\boldsymbol{r = \frac{r_1 r_2}{r_1 - r_2}}, \mathbf{15mm}]$

48. A stationary wave is given by $y = 5sin\frac{\pi x}{3}cos40\pi t$, where x and y are in cm and t is in seconds. What are the equations of the component waves whose superposition gives rise to the above wave? $[\boldsymbol{y_1 = \frac{5}{2}\sin\left(\frac{\pi}{3}x - 40\pi t\right), y_1 = \frac{5}{2}\sin\left(\frac{\pi}{3}x + 40\pi t\right)}]$

49. The e.m.f (in microvolts) in a lead-iron thermopile, one junction of which is at 0^0C is given by $V = 1784t - 2.4t^2$, where t is the temperature of the hot junction. Calculate the neutral temperature. $[\mathbf{3717^0C}]$

50. A uniform spring has a certain mass suspended from it and its period for vertical oscillation is T_1. The spring is now cut into two equal halves and the same mass is suspended from one of the halves. The period of vertical oscillation is now T_2. Calculate T_2/T_1? $[\sqrt{\mathbf{1/2}}]$

51. Show that the radial heat flow across the coaxial cylinder is given by $H = \frac{2\pi KL(T_2 - T_1)}{ln\left(\frac{r_2}{r_1}\right)}$

where K is the thermal conductivity, L is the length of the cylinder, r_1 and r_2 are the radii of inner and outer parts of the cylinder respectively.

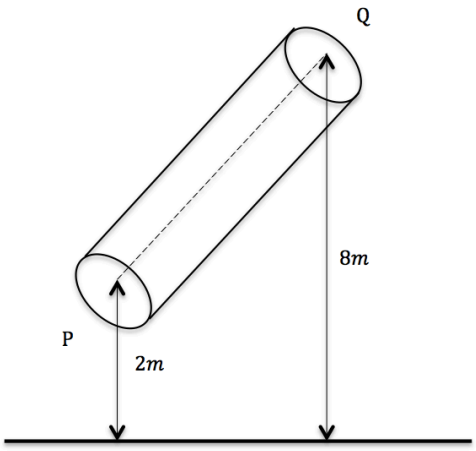
52. There are two angles of projection for which the horizontal range is the same. Show that the sum of the maximum heights for these two angles is independent of the angle of projection.

53. A large open tank has two holes in the wall. One is a square of side l at a depth y from the top and the other is a circular hole of radius r at a depth $4y$ from the top. When the tank is completely filled with water the quantities of water flowing out per second from both holes are the same. Find the value of the radius. $[\boldsymbol{l/\sqrt{2\pi}}]$

54. If the energy required to blow a soap bubble of radius r is E, show that the extra energy needed to double the radius of the bubble is given by $\Delta E = 24\pi\gamma r^2$ where γ is the surface tension.
55. A horizontal tube A of length $50cm$ and radius of $0.1mm$ is joined to another horizontal tube B of length of $40cm$ and radius $0.2mm$. If a liquid passing through the tubes enters A at a pressure of $85cm$ of mercury and leaves B at a pressure of $76cm$ of mercury. What the pressure in Nm^{-2} at the junction of tubes?

[$1.019\times10^5 Nm^{-2}$]

56. Ultrasound of frequency $4.0MHz$ is incident at an angle of 30^0C to a blood vessel of diameter $1.6mm$. If a dopper shift of $3.2kHz$ is observed. Calculate the blood flow velocity. Assume that the speed of ultra sound is $1.5km/s$. **[$0.69ms^{-1}$]**
57. A non-viscous fluid of constant density $1000kg/m^3$ flows in a streamline motion along a tube of variable cross-section. The tube is kept inclined in the vertical plane as shown in figure below. The area of cross-section of the tube at two points P and Q at heights $2m$ and $5m$ are respectively $4\times10^{-3}m^2$ and $8\times10^{-3}m^2$. The velocity of the fluid at point P is $1m/s$. Find the work done per unit volume by gravity and pressure forces as the liquid flows from point P to Q. **[$29025Jm^{-3}$]**



58. A vertical capillary tube $10cm$ long tapers uniformly from an internal diameter of $1mm$ at the lower end to $0.5mm$ at the upper end. The lower end is just touching the surface of a pool of liquid of surface tension $6\times10^{-2}N/m$, density $1200kgm^{-3}$ and zero angle of contact with the tube. Calculate the capillary rise, justifying your method. **[$2.3cm$]**

AHMES SECONDARY SCHOOL

FORM V HOLIDAY TEST
PHYSICS

Instructions

1. Answer all questions.

2. You must submit your work in the opening day.

3. Whenever necessary, use the following constants:

(a)	Acceleration due to gravity	$g = 9.8ms^{-2}$
(b)	Young's modulus of steel	$\gamma = 2\times10^{11}Pa$
(c)	Universal gas constant	$R = 8.314Jmol^{-1}K^{-1}$
(d)	Permittivity of free space	$\epsilon_0 = 8.854\times10^{-12}Fm^{-1}$
(e)	Linear expansivity of steel	$\alpha = 1.6\times10^{-7}/K$
(f)	Radius of the earth	$R = 6.4\times10^{6}m$
(g)	Radius of the moon	$R = 1.75\times10^{6}m$
(h)	Density of water	$\rho = 1000kgm^{-3}$

Answer all questions

1. a. What is an error? Mention two causes of systematic and two causes of random errors.

   b. The pressure P is calculated from the relation $P = \frac{F}{\pi R^2}$ where F is the force and R the radius. If the percentage possible errors are $\pm 2\%$ for F and $\pm 1\%$ for R. Calculate the possible percentage error for P.

2. a. Mention two applications and two limitations of dimensional analysis.
   b. The frequency f of a note produced by a taut wire stretched between two supports depends on the distance l between the supports, the mass per unit length of the wire μ and the tension T. Use dimensional analysis to find how f is related to l, μ, and T.

3. a. Define the following terms: (i) Momentum (ii) Impulse of a force
   b. A jet of water emerges from a hosepipe of a cross-sectional area $5.0\times10^{-3}m^2$ with a velocity of $3m/s$ and strikes a wall at right angle. If the water is to be brought to rest by the wall and does not rebound, calculate the force on the wall.

4. a. Mention two motions that add up to make projectile motion.
   b. A bullet is fired from a gun on the top of a cliff $140m$ high with a velocity of $150m/s$ at an elevation of $30°$ to the horizontal. Find the horizontal distance from the foot of a cliff to the point where the bullet lands on the ground.

5. a. Show that the period of a body of mass m revolving in a horizontal circle with constant velocity v at the end of a string of length l is independent of the mass of the object.
   b. A car travels over a humpback bridge of radius of curvature $45m$. Calculate the maximum speed of the car if the wheels are to remain in contact with the bridge.

6. a. Define simple harmonic motion.
   b. Two simple pendulums of length 0.4m and 0.6m respectively are set oscillating in step.
      i. After what further time will the two pendulums be in step again?
      ii. Find the number of oscillations made by each pendulum during the time in i) above.

7. a. What do you understand by the term escape velocity?
   b. Calculate the escape velocity from the moon's surface given that a man on the

moon has $1/6$ his weight on earth.

8. a. State the parallel and perpendicular axes theorem.
   b. Show that the Kinetic Energy $(K.E)$ of rotation of a rigid body about an axis with a constant angular velocity ω is given by $K.E = \frac{1}{2}I\omega^2$ where I is the moment of inertia of the rigid body about the given axis.

9. a. Explain in terms of surface energy, what is meant by the surface tension $\boldsymbol{\gamma}$ of a liquid.
   b. What energy is required to form a soap bubble of radius $1.0mm$ if the surface tension of the soap solution is $2.5\times10^{-4}Nm^{-1}$?

10. a. Write down the equation of continuity of a fluid and define all symbols.
    b. The velocity at a certain point in a flow pipe is $1m/s$ and the gauge pressure there is $3\times10^5Nm^{-2}$. The cross-sectional area at a point $10m$ above the first is half that at the first point. If the flowing fluid is pure water, calculate the gauge pressure at the second point.

11. a. Define root mean square speed of gas molecules and write down any two equations from which root mean square speed can be calculated.
    b. If the root-mean-square velocity of a hydrogen molecule at 0^0C is $1840m/s$, find the root-mean-square velocity of the molecule at 100^0C.

12. a. Would you expect a rubber band to have a larger or smaller force constant than that of an iron wire? Explain.
    b. A steel rod of length $0.6m$ and cross sectional area $2.5\times10^{-5}m^2$ at 100^0C is clamped so that when it cools it is unable to contract. Find the tension in the rod when it has cooled to 20^0C.

13. a. Sketch the graph of velocity against time for the motion of the ball falling in a viscous medium.
    b. A small oil drop of radius R falls with a terminal velocity of $2.0\times10^{-1}m/s$ in air. Find the new terminal velocity of the oil drop of half of this radius.

14. a. What do you understand by the terms:
        i. Thermodynamic temperature scale
        ii. Triple point of water
    b. The resistance of a platinum wire at a temperature T^0C measured on a gas scale is given by: $R_T = R_0(1 + aT + bT^2)$ What temperature will the platinum thermometer indicate when the temperature on the gas scale is 200^0C ?

(Take: $a = 3.8\times10^{-3}/^0C$ and $b = -5.6\times10^{-7}/^0C^2$).

15. a. What is the coefficient of thermal conductivity of a material?
    b. The temperature difference between the inside and outside of a room is 25^0C. The rom has a window of an area $2m^2$ and the thickness of the window material is $2mm$. Calculate the heat flow through the window if the coefficient of thermal conductivity of the window material is 0.5 SI units.

16. a. State two differences between isothermal and adiabatic processes.
    b. One mole of an ideal gas is kept at a temperature of $320K$ and compressed isothermally from its initial volume of $8\ litres$ to a final volume of $4\ litres$. Calculate the total work done in the whole process.

17. a. Explain why a charged metal attracts an uncharged one?
    b. Charges $1.2\times10^{-12}C$ and $-4\times10^{-12}C$ are placed $5.0m$ apart in air. A third charge $1\times10^{-12}C$ is introduced midway between them. Find the resultant force on the third charge.

18. a. Mention three factors affecting capacitance of a parallel plate capacitor.
    b. A parallel plate capacitor having plate area $100cm^2$ and separation $1.0mm$ holds a charge of $0.12\mu C$ when connected to a $120V$ battery. Find the dielectric constant of the material filling the gap.

19. a. What vibrates in the following types of wave motion?
    i) Light waves ii) Sound waves iii) X-rays iv) Water waves
    b. A plane progressive wave on a water surface is given by the equation: $y = 2\sin\left(200\pi t - \frac{x}{30}\right)$ where y is the distance covered in time t. The variables x, y and t are measured in cm and $seconds$ respectively. Find the:
        i) Wavelength and frequency of the wave motion.
        ii) Phase difference between two points on the water surface that are 60cm apart.

20. a. What is a "Doppler Effect"?
    b. A whistle sound of frequency $1200Hz$ was directed to an approaching train moving at $48km/h$. The whistle-man then listened to the beats between the emitted sound and that reflected from the train. What is the beat frequency detected by the whistle-man?

'Happy holidays'