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Exam code: 1PH02 hours11 questions1a2 marksState Newton's first law of motion.1b1 markWrite down the equation for Newton's second law. 1c2 marksAn aeroplane moves with a forward thrust force of 300 kN from the engines, while experiencing a drag force of 300 kN from the air.Describe the motion of the aeroplane.1d2 marksThe thrust force from the engines now decreases to 200 kN.Describe and explain any changes in the aeroplane's motion.Did this page help you?2a2 marksName two quantities that are constant in circular motion.2b1 markB is travelling anti-clockwise in circular motion around A in Figure 1.Figure 1Draw an arrow on Figure 1 representing the direction of centripetal acceleration.2c1 markA planet is orbiting a star in a circular path. Name the centripetal force which acts in this scenario.Did this page help you?3a2 marksA student is sitting still on a chair in her physics lesson.Name the forces acting on the student.3b2 marksFor your answer to part (a), state whether these forces are contact or non-contact forces.3c1 markThe student's weight is 450 N.Determine the resultant force on the student.3d1 markThe gravitational field strength on Earth is 9.8 N/kg.Calculate the mass of the student.Did this page help you?A student investigates the relationship between force and acceleration for a trolley on a runway. Figure 12 shows some of the apparatus the student uses.Figure 12i) Describe how the student could increase the accelerating force applied to the trolley.[2]ii) Describe how the mass of the moving system can be kept constant.[2]iii) Explain how the student could improve the procedure to compensate for the effects of frictional forces acting on the trolley.[2]Higher Tier Only Figure 13 shows two objects, Q and R, before and after they collide.Figure 13The arrows show the direction of movement of the objects. The arrows are not to scale. Explain how momentum is conserved in the collision. Use Newton's third law and Newton's second law in your answer. Newton's second law can be written asDid this page help you?The force that keeps an object moving in a circular path is known as theFigure 11 shows an object moving in a circular path.Figure 11i) Draw an arrow on Figure 11 to show the direction of the force that keeps the object moving in a circular path.[1]ii) The object in Figure 11 is moving at constant speed. Explain why it is not moving with constant velocity.[2]Figure 12 shows a skier on a slope.The skier travels down the slope with a constant acceleration.The speed of the skier is measured at points P and Q.pFigure 12The table in Figure 13 gives some data about the skier making one downhill run.acceleration3.0 m/s2speed at P7.6 m/sspeed at Q24 m/sFigure 13i) Calculate the distance from P to Q. Use an equation selected from the list of equations at the end of this paper.distance from P to Q = ... m[3]ii) Calculate the time taken for the skier to travel from P to Q.time from P to Q = ... s[3]Did this page help you?A student carries out an experiment to determine the relationship between the force applied to an object and the object's acceleration.She sets up her apparatus as shown in Figure 1.Figure 1She places a number of masses on top of the trolley and then removes them, one at a time, placing them on the mass hanger in order to increase the force.Explain why she keeps the unused masses on top of the trolley.Figure 2 shows some of the results of the experiment. Force (N)Acceleration (m/s2)0.20.290.40.570.60.860.81.241.01.43 Figure 2Figure 3 shows the graph of the results.Figure 3Another student says that there is an anomalous data point.Circle this point and suggest how the first student could confirm that this is an anomalous data point. Use the graph to calculate the mass of the trolley and weight system. Clearly show your method.The experiment is repeated on a rougher carpeted surface.There is a stronger, constant frictional force of 0.2 N acting on the trolley when it moves. Sketch a new line on Figure 1 of the results of this second experiment. Did this page help you?A student draws a Newton's third law pair of forces on a book, as shown in Figure 1.Figure 1Fg is the gravitational force and FN is the normal reaction force.State and explain whether the student has drawn a Newton's third law pair of forces correctly.A child balances on a pogo stick as shown in Figure 2. The child and the pogo stick are both stationary.Figure 2Using Newton's second and third laws, explain how the child moves upwards when they exert a downward force on the spring.Explain, using Newton's Third Law, how the forces on a person's foot enables them to walk on the ground.A teacher is running late for a class. He sets off and exerts a force of 8.5 N on the ground. The mass of the Earth is 6.0 × 1024 kg.Calculate the theoretical acceleration of the Earth resulting from this step. Give your answer to 2 significant figures.Did this page help you?Higher Tier OnlyThe Sun lies at the centre of our solar system, with all other bodies, such as planets, orbiting it.Figure 1 shows shows a model of the orbits of some of the planets in the solar system. Figure 1Assume these orbits are circular.Draw the resultant forces acting on Mercury, Venus, Earth and Mars.Higher Tier OnlyDescribe the centripetal force acting in Figure 1.Higher Tier OnlyMercury has an orbital period of 88 days. Compare the speed and velocity of Mercury in Figure 1 to Mercury 44 days after its position in Figure 1.On Mercury's surface, the gravitational field strength is 3.7 N/kg.A space probe has a weight of 5000 N on Earth. Calculate the probe's weight on Mercury.Did this page help you?1a2 marksFigure 1 shows a man attempting to push a large rock, and identifies some of the forces acting in this system.Figure 1 Which forces in the list correctly identify the force pairs in this scenario? Tick (✓) two boxes. Force applied by man to rock & reaction force of rockWeight of rock & normal force of ground Force of man's feet on ground & frictional force of groundWeight of man & normal force of ground1b2 marksUnable to push the rock, the man wonders whether he would be able to push it if it was on the Moon.The Moon has a gravitational field strength of 1.6 N/kg. The frictional force the man is doing work against is directly proportional to the rock's weight.Calculate how many times easier it would be to push the rock on the Moon compared to Earth, assuming the rock is pushed on the same type of surface.1c2 marksThe rock has a mass of 850 kg. Calculate the size of the normal reaction of the Moon's surface on the rock.Did this page help you?2a2 marksHigher Tier OnlyA student throws a tennis ball vertically upwards and catches it as it returns to her.Figure 1 shows the motion of the ball whilst it is in the air. Figure 1 Draw a free-body force diagram of the ball at position C.2b5 marksHigher Tier OnlyExplain the motion of the ball in terms of the forces acting upon it at each position throughout its journey.2c2 marksOne force that acts on the ball is weight. This force is part of a force pair obeying Newton's third law. Describe the other force in the pair.Did this page help you?3a4 marksHigher Tier OnlyFigure 1 shows a skier being towed with a rope at a constant speed whilst sinking into the snow. Figure 1State the name of each of the forces A - D acting on the skier.3b2 marksHigher Tier OnlyWhich of the following statements are true about the forces acting on the skier? Tick (✓) two boxes.Force D > Force CForce C > Force DForce B > Force AForce A = Force B3c4 marksA second skier uses the same system as the skier in part (a).While being towed by a force of 200 N in the rope, the skier is also pushing themselves forward with a force of 150 N.The second skier has a weight of 600 N and is accelerating forwards at 1.5 m/s2.Calculate the magnitude of the resistive forces on the skier.Did this page help you?Page 2Introduction to Waves, Describing Wave Motion, Transverse & Longitudinal Waves, The Wave Equation, Measuring Wave Speed, Calculating Depth & Distance, Wave Interactions, Refraction, Refraction & Speed, Wave Interactions & Wavelength, Core Practical: Investigating Wave PropertiesSound Waves, Ultrasound & Infrasound, Transmission of SoundStates of Matter & Thermal CapacityDensity, Solids, Liquids & Gases, Core Practical: Determining Density, Changes of State, Thermal Energy, Specific Heat & Latent Heat, Specific Heat Capacity, Specific Latent Heat, Thermal Insulation, Core Practical: Investigating Specific Heat Capacity Plant tissues, organs and systems Variation and EvolutionElements, compounds and mixtures Quantitative chemistry Exothermic and endothermic reactions Natural and synthetic polymers Purity, formulations and chromatography Identification of ions Atmospheric pollutants Potable water and waste water Life cycle assessment and recyclingEnergy stores and systemsConservation and dissipation of energyCurrent, potential difference and resistance Changes of state and the particle model Internal energy and energy transfers Particle model and pressure Atoms and nuclear radiation Nuclear fission and fusion Forces and their interactions Speed, velocity and acceleration Newtons laws of motion Our other websites: Xcelerate Math Xcelerate Math on youtube Xcelerate Science Back to Science Questions Click here for the Answers to Physics Forces questions 1. Q: What is the push or pull on an object that can cause it to accelerate called?A: massB: forceC: densityD: speed----------2. Q: What is the unit of measure for force?A: AmpB: SecondsC: NewtonD: Erg----------3. Q: What is the sum of all forces acting on an object called?A: gravityB: reaction forceC: accelerationD: net force----------4. Q: In a tug of war, when one team is pulling with a force of 100 N and the other 80 N, what is the net force?A: 20 NB: 80 NC: 100 ND: 180 N----------5. Q: Newton's First Law of Motion is also called:A: Law of FrictionB: Law of ReactionC: Law of ActionD: Law of Inertia----------6. Q: Newton's first Law of Motion states that if there is no net force acting on an object it will:A: remain at restB: move with constant velocityC: have no accelerationD: all of the above----------7. Q: What does Newton's Second Law of Motion state?A: a = mFB: F = m/aC: F = maD: m = Fa----------8. Q: In the equation F = ma, what does m represent?A: MassB: MetersC: ForceD: Acceleration----------9. Q: How much net force is required to accelerate a 2000 kg car at 3.00 m/s2?A: 2000 NB: 4000 NC: 6000 ND: 8000 N----------10. Q: If you apply a net force of 3 N on 100 g-box, what is the acceleration of the box?A: 5 m/s2B: 10 m/s2C: 20 m/s2D: 30 m/s2----------11. Q: Which is true from Newton's Third law of motion?A: For every action force there is a smaller reaction force in the opposite direction.B: For every action force there is an equivalent reaction force in the opposite direction.C: Both 1 and 2D: None of the above----------12. Q: What is the net force on 200 g ball when it hits a wall with acceleration of 10 m/s2?A: 1 NB: 2 NC: 3 ND: 4 N----------13. Q: Are mass and weight the same?A: YesB: No----------14. Q: What will be different on the moon than on the earth?A: massB: weightC: both 1 and 2D: none of the above----------15. Q: What do you multiply mass by to get the weight?A: gravityB: accelerationC: densityD: energy----------16. Q: If you mass is 40 kg, what is your weight on the Earth?A: 298B: 376C: 392D: 462----------17. Q: If the gravity of the Moon is 1/6 of g (which is 9.8 m/s2), what is the mass of an object that has a weight of 115 N on the Moon?A: 30.2B: 70.4C: 74.9D: 89----------18. Q: The normal force acts on any object that:A: Is in a gravity wellB: Is in a vacuumC: In in the airD: Touches a surface----------19. Q: What is the normal force acting on a 50 kg dog?A: 440 NB: 490 NC: 540 ND: 570 N----------20. Q: What is the force that acts between two object in contact because of action-reaction?A: Net ForceB: Friction ForceC: Rebound ForceD: Weight Force----------21. Q: In the equation F(f) = uF(n), where F(f) is the Force of Friction and F(n) is the Normal ForceA: coefficient of frictionB: massC: weightD: gravity----------22. Q: If you throw a 150 g book on a floor where u = 0.2, what is the force of friction?A: .16 NB: .29 NC: .36 ND: .54 N----------23. Q: How big is the net force acting on an object with constant velocity?A: 0 NB: 1 NC: 10 ND: 100 N----------24. Q: If a net force of 7 N was constantly applied on 400 g object at rest, how long will it take to raise its velocity to 80 m/s?A: 0 sB: 2.23 sC: 3.47 sD: 4.57 s----------25. Q: If you push with a 5N force on a 1 kg box that is resting on a floor where u = 0.3, will the box move?A: YesB: No---------- Click here for the Answers to Physics Forces questions Back to Science Questions In this long article, over 30 multiple-choice questions are solved on forces for the AP Physics 1 exam. Each topic is categorized for better practice. In the pdf version of this article, you can find all these questions along with additional solved problems. Forces Practice Problems: AP Physics All forces questions on the AP Physics 1 exams, cover one of the following subsections: Newton's First law Problem (1): In the figure below, we first gently pull the thread down and gradually increase this force until one of the threads connected to the hanging block becomes torn. We again repeat this experiment, but this time, the thread is pulled abruptly down so that one of the threads breaks. Which of the following is correct about this experiment? (a) In both experiments the lower thread breaks. (b) In both experiments the upper thread breaks. (c) In the first experiment, the upper thread breaks but in the second the lower thread. (d) In the first experiment, the lower thread breaks but in the second the upper thread. Solution: In the first experiment, the force is applied gently to the lower thread, so this thread and the block form a unit object, and we can ignore this lower thread from the analysis. When the force is increased, the upper thread, which bears the block's weight, is torn. Due to Newton's first law of motion, when the force is applied abruptly to the lower thread, the hanging block at the other end is still at rest and wants to remain in this situation. Consequently, in the second experiment, the lower thread is torn. Problem (2): Which of the following equations obeys Newton's first law of motion? (a) $x=2\sqrt{t}$ (b) $x=-10t^2+2t$ (c) $x=10t$ (d) $v=-10t+3$ Solution: Newton's first law of motion states that an object maintains its state of stillness or constant speed until a net force acted on it. As you can see from this statement, the object has to be at rest or moving at a constant speed in order to apply the first law. All these conditions can be translated into the following kinematics equations: At rest: $x=0$ Moving at constant speed v : $x=vt$ Therefore, only choice (c) has the form of a motion in which the object moves at a constant speed. Thus, the correct choice is (c). Problem (3): An automobile moves along a straight road at a constant speed. The friction force between the car's tire and the pavement is $2500-{\rm N}$, and the driving force equals $5500\,{\rm N}$. What air resistive force is applied to the car? (a) 3000 N (b) 3500 N (c) 8000 N (d) zero Solution: Since the car moves at a constant speed, according to Newton's first law no net force is applied to it otherwise, the car accelerates (according to Newton's second law). Therefore, the driving force must be equal to the opposing forces of friction and air resistance. \begin{gather*} F_{air}+F_{friction}=F_{driv} \\\\ F_{air}+2500=5500 \\\\ \Rightarrow \boxed{F_{air}=3000\,{\rm N}}\end{gather*} Hence, the correct choice is (a). Problem (4): Which of the following is an incorrect phrase about forces in physics? (a) The forces are the result of the interaction of two objects with each other. (b) The forces are vector quantities that have a magnitude in addition to the direction. (c) In modeling the physics problems, sometimes assumes that the forces are applied to the center of the mass of the object. (d) The only consequence of applying forces to an object is a change in its velocity. Solution: The correct choice is (d). Because it is possible some forces are applied to an object at rest and the object stays at rest or in another situation, those forces are applied to a constant speed moving object but the object's velocity does not change. This occurs when the resultant of those forces is zero. This is the same as Newton's first law of motion. All other options are correct definitions of vectors in physics. Newton's 2nd law Problem (5): Two forces of $\vec{F}_1=2\hat{i}+6\hat{j}$ and $\vec{F}_2=\hat{i}-2\hat{j}$ are acting to a moving object of mass $2\,{\rm kg}$. What acceleration will the object find in ${\rm \frac ms}$? (a) 2 (b) 2.5 (c) 3 (d) 3.5 Solution: According to Newton's second law, a net force applied to an object can accelerate it by $a=\frac{F_{net}}{m}$. In this case, we are given two force vectors. First, find its resultant (net) vector by adding them as below (superposition principle). \begin{aligned*} \vec{F}_{net}&=\vec{F}_1+\vec{F}_2 \\\\ &=2\hat{i}+6\hat{j}+\hat{i}-2\hat{j} \\\\ &=3\hat{i}+4\hat{j}\end{aligned*} The magnitude of this net force is found by the Pythagorean theorem \begin{aligned*} F&=\sqrt{F_x^2+F_y^2}\\\\ &=\sqrt{3^2+4^2}\\\\ &=5\quad{\rm N}\end{aligned*} Now that the magnitude of the net force applied to the object found, its acceleration is computed as below \[a=\frac{F_{net}}{m}=\frac{5}{2}=2.5\,{\rm m/s^2}\] Hence, the correct answer is (b). Problem (6): Three forces of $\vec{F}_1=20\hat{i}-50\hat{j}$, $\vec{F}_2=10\hat{i}+20\hat{j}$, and $\vec{F}_3=-10\hat{i}$ are acting on a $5-{\rm kg}$ object simultaneously. What is the magnitude of the acceleration of the object? (a) 1 (b) 5 (c) 10 (d) 15 Solution: Another practice problem in vectors in the AP Physics 1 exam. Three force vectors are given and asked for acceleration. Again, find the resultant force vector acted on the object. Summing the corresponding components gives the components of the net force as below \[\vec{F}_{net}=30\hat{i}-40\hat{j}\] The magnitude of this force vector is found as \[F_{net}=\sqrt{30^2+(-40)^2}=50\,{\rm N}\] Dividing the net force by the object's mass gives the acceleration \[a=\frac{F_{net}}{m}=\frac{50}{5}=10\,{\rm m/s^2}\] Hence, the correct answer is (c). Problem (7): A $500-{\rm g}$ ball is dropped from rest from a height of $25\,{\rm m}$. After striking the ground it rebounds at a height of $15\,{\rm m}$. Assume the contact time between the ball and the surface of the ground is $2\,{\rm ms}$. What average force was applied to the ball in $\rm N$? (take $g=9.8\,{\rm m/s^2}$) (a) 9820 (b) 1250 (c) 125 (d) 982 Solution: Newton's second law of motion has two mathematical forms; one is $\vec{F}_{net}=m\vec{a}$, and the other is $\vec{F}_{av}=\frac{\Delta \vec{P}}{\Delta t}$. The second form is more suitable to solve the average force exerted to an object experiencing a change in its velocity. The change in the momentum is defined as $\Delta \vec{P}=m(\vec{v}_2-\vec{v}_1)$. In this problem, the touching time with the ground is given by $\Delta t=2\times 10^-3 \,{\rm s}$. Now, if we find the change in the momentum, then we will be able to determine the average force during the contact. Initially, the ball is dropped from rest, so its initial velocity is zero. Using the kinematics equation $v^2-v_0^2=2(-g)\Delta y$, we can find the velocity just before hitting the ground. (notice that to use this equation, you must choose a reference point). We take the releasing point as the reference, the ball hit the ground $25\,{\rm m}$ below this point, so we must set $\Delta y=-25\,{\rm m}$ in above. \begin{gather*} v^2-v_0^2=2(-g)\Delta y \\\\ v^2-0=2(-9.8)(-25) \\\\ v_{bef}=\sqrt{490}=-22.14\,{\rm m/s}\end{gather*} The negative indicates that the ball's velocity is down. Now, we must compute the velocity at which the ball rises from the surface and goes up by $15\,{\rm m}$. This time take the ground as a reference, so $\Delta y=+15\,{\rm m}$. At this point, the ball's speed is zero, since the ball rises so high that its velocity becomes zero. \begin{gather*} v^2-v_0^2=2(-g)\Delta y \\\\ 0-v^2=2(-9.8)(15) \\\\ v_{aft}=\sqrt{294}=+17.14\,{\rm m/s}\end{gather*} The positive indicates that the velocity is up. This is the ball's velocity just after rising the surface. The change in the momentum is also found as \begin{aligned*} \Delta \vec{P}&=m(\vec{v}_{aft}-\vec{v}_{bef}) \\\\ &=(0.5)(17.14-(-22.14)) \\\\ &=19.64\quad {\rm \frac{kg.m^2}{s}}\end{aligned*} Dividing the change in momentum by the contact time to find the average force applied to the ball \begin{aligned*} \vec{F}_{av}&=\frac{\Delta \vec{P}}{\Delta t} \\\\ &=\frac{19.64}{2\times 10^-3}\\\\ &=\boxed{9820\quad {\rm N}} \end{aligned*} Hence, the correct answer is (a). Problem (8): What average force is needed to stop a $3500\,{\rm kg}$ SUV in $5\,{\rm s}$ if it is traveling at $72\,{\rm km/h}$? (a) 14000 N (b) 50400 N (c) 12500 N (d) 15000 N Solution: Another combination question of kinematics and dynamics in the AP Physics 1 exam. First, we must find the acceleration of the car using the kinematics equation $v=v_0+at$ during this time interval. The final speed is zero, and take the initial speed as $72\,{\rm km/h}$. Convert it to the SI units of velocity as below \[72\,{\rm \frac{km}{h}}=72\,{\rm \left(\frac{1000}{3600}\right)\,\frac ms}=20\,{\rm \frac ms}\] The acceleration is found as below \begin{gather*} v=v_0+at \\\\ 0 = 20+5a \\\\ \Rightarrow \quad a=-4\,{\rm m/s^2}\end{gather*} The negative indicates the direction of the acceleration which is in the opposite direction of the motion. Now, using the formula $F_{net}=ma$, we can find the average force that is required to stop this car as below \[F=3500\times 4=\boxed{14000\,{\rm N}}\] Hence, the correct answer is (a). Solve more kinematics questions to master this topic. Newton's third law Problem (9): In the figure below, an object is hung from a massless thread. Assume $\vec{W}$ is the gravity force vector applied to the mass m by Earth. What is the reaction of the force exerted on the ceiling by the thread and the reaction of the force exerted on the weight by the thread? (a) $\vec{W}$,$\vec{W}$ (b) $-\vec{W}$,$\vec{W}$ (c) $\vec{W}$,$-\vec{W}$ (d) $-\vec{W}$,$-\vec{W}$ Solution: This is another sample conceptual question about Newton's third law which appears in the AP Physics 1 exam. Break the thread from some desired point. At this point, these two forces, equal in magnitude but opposite in direction, form as shown in the figure below. The upward force is the same well-known tension force in the thread. The downward force is also the force exerted by the thread on the ceiling and pulls it down. The reaction of this force, according to Newton's third law, is toward up or $-\vec{W}$. On the other hand, the thread pulls the weight up by the tension force T. The reaction of this force must be in the opposite direction with the same magnitude. Thus, the reaction force is down or $\vec{W}$. Hence, the correct answer is (b). Air Resistance force Problem (10): A rain droplet comes out of a cloud nearly at rest and starts moving down. From the moment of leaving the cloud to reaching the ground, how does the air resistance force change? (a) continuously increasing. (b) first increases, then remain constant. (c) it remains constant. (d) first increases then decrease. Solution: In all AP Physics 1 exam problems, keep in mind that the air resistance is proportional to the falling velocity of the object through the air, $f\propto v$. When the rain droplet detached from the cloud, due to gravity its speed will increase. Thus, the air resistance also increases uniformly. This increase in air resistance lasts until it is balanced with the object's weight. From that moment on, the object's acceleration becomes zero and its speed remains unchanged. Hence, the correct answer is (b). Problem (11): Which of the following velocity vs. time graphs below has a correct description for the rain droplet of the previous problem? Solution: The correct answer is (d). Refer to the pdf version to find the explanation. Problem (12): A $400-{\rm g}$ object releases from a nearly high height. Assume a constant resistance force of $1.2\,{\rm N}$ is exerted on it during falling. What acceleration will the object experience in m/s^2? (a) 7 (b) 1.3 (c) -7 (d) -1.3 Solution: Upon releasing the object, it falls down and its speed is increasing. Take the direction of acceleration, which is down along the gravity force, as positive. To a falling object two forces are acting; downward weight, and upward air resistive force f_R. The resultant of these two forces accelerates the object down. Now, write Newton's second law and solve for a \begin{aligned*} F_{net}&=ma \\\\ mg-f_R &=ma \\\\ (0.4)(10)-1.2 &=(0.4)a \\\\ \Rightarrow \quad a&=7\,{\rm m/s^2}\end{aligned*} Hence, the correct answer is (a). Problem (13): An apple is thrown into the air vertically upward and some later time it falls down and reaches the same original level. Which of the following is a correct phrase? (a) Acceleration during ascending and descending are equal. (b) Acceleration during ascending is higher than descending. (c) The time of ascending and descending are the same. (d) The time of ascending is higher than descending. Solution: The ball is thrown into the air, so we cannot ignore the air resistance. When the ball is going up, this resistive force is f down and when it is going down, the resistive force is up. Take up as positive. Apply Newton's second law of motion to these situations and solve for the accelerations. For moving up: \[-mg-f=ma_U \] For going down: \[f-mg=ma_D\] As you can see, the magnitude of acceleration for ascending is higher than descending. \[|a_U|>|a_D|\] Hence, the correct answer is (b). Normal force Problem (14): A 2-kg crate is pulled over a rough horizontal surface by the force of $25\,{\rm N}$ which makes an angle of 37° with the horizontal. Assume the coefficient of friction is 0.2. Find the normal force applied to the crate by the surface. Solution: First, draw a free-body diagram and label all forces acting on the crate as shown below. We know that the object does not move vertically, so its acceleration in this direction must be zero, $a_y=0$. The external force F_P is applied at an angle, so resolve it into its components over x and y axes. \begin{gather*} F_{Px}=F_P \cos 37^\circ \\\\ F_{Py}=F_P\sin 37^\circ \end{gather*} Apply Newton's second law to the forces along the vertical direction and solve for F_N as below \begin{aligned*} \Sigma F_y&=ma_y\\\\ F_N+ F_{Py}-mg&=0 \\\\ \Rightarrow F_N&=mg-F_P\sin 37^\circ \\\\ &=(2\times 10)-25 (0.6) \\\\ &=\boxed{5\,{\rm N}}\end{aligned*} Problem (15): Two boxes are on top of each other as shown in the figure below. The lower weight is $m_1=15\,{\rm kg}$ and the upper weight is $m_2=5\,{\rm kg}$. What is the normal force that the surface exerts on m_1 and the normal force that m_1 exerts on m_2, respectively in N? (a) 50 , 150 (b) 150 , 50 (c) 200 , 50 (c) 100 , 50 Solution: The following figures show a free-body diagram in which all forces acting on the masses m_1 and m_2 are depicted. N_{S} is the normal force exerted by the surface on m_1. Similarly, N_{12} is the normal force exerted by m_1 on m_2. According to Newton's third law, the force that both masses exerted on each other is the same in magnitude but opposite in direction. Thus, the $\vec{N}_{12}=-\vec{N}_{21}$. The masses are at rest, so the net force acting on each object is zero. Balancing the forces exerted on m_2 first, gives us \begin{aligned*} N_{12}-m_2g&=0 \\ N_{12}&=m_2g\\ &=5\times 10 \\&=\boxed{50\,{\rm N}}\end{aligned*} Thus, the normal force exerted on m_2 by the bottom box of m_1 is $50\,{\rm N}$. Correspondingly, the force that the mass m_2 exerts on m_1 has the same magnitude but in the opposite direction which is down. Apply Newton's law of motion again for m_1, we will have \begin{aligned*} N_{S}-N_{21}-m_1g&=0 \\ \Rightarrow N_{S}&=N_{21}+m_1g \\ &=50+(15\times 10) \\ &=\boxed{200\,{\rm N}}\end{aligned*} Hence, the correct answer is (c). Practice Problem (16): In the following figure, What are the normal forces at the surfaces of A, B, and C in $\rm N$, respectively? (a) 200, 120, 50 (b) 80, 70, 50 (c) 200, 70, 60 (d) 120, 200, 80 Solution: The correct answer is (a). Refer to the pdf version for the explanation. Practice Problem (17): Two blocks of masses $m_1=20\,{\rm kg}$ and $m_2=10\,{\rm kg}$ are in an elevator. The elevator moves up at an increasing rate of $2\,{\rm m/s^2}$. How many times is the force that m_1 exerts on m_2 than the force exerted on the surface by m_1? (a) $\frac 12$ (b) 2 (c) $\frac 13$ (d) 3 Solution: the correct answer is (c). Problem (18): A $2-{\rm kg}$ box is held fixed against a rough wall as the figure is shown below. What minimum force will require to keep the box from sliding down? Assume $\mu_s=0.4$ and $g=10\,{\rm m/s^2}$. Solution: Draw a free-body diagram and label each force on it. You push the box against the wall with a force of F rightward. The wall also exerts a normal force on the box in the opposite direction of F. Vertically exerted forces are; downward weight $W=mg$, and the upward static friction force f_s. The box is held fixed at the wall, so the net force on it is zero. Balancing the forces along the x axis gives us the normal force exerted on the box by the wall \[N=F\] The box is to be at rest, so the box's weight must be balanced with the maximum static friction force. Thus, \[f_{s,max}=mg\] On the other hand, recall that $f_{s,max}=\mu_s N$. By combining these three equations, we obtain \begin{gather*} f_{s,max}=\mu_s N \\\\ mg=\mu_s F \\\\ \Rightarrow F=\frac{mg}{\mu_s}\end{gather*} Substituting the values into above, we obtain the required force to hold the box fixed at the wall. \[F=\frac{2\times 10}{0.4}=50\,{\rm N}\] Tension force Problem (19): A block of mass $m=10\,{\rm kg}$ is hung from two identical strings which makes an angle of 37° with the vertical. What is the tension in each of the strings? (Assume $\cos 37^\circ=0.8$) (a) 500 N (b) 3000 N (c) 375 N (d) 400 N Solution: Draw a free-body diagram as below and label each force. The cords are identical so the tension force in each is the same. Resolving it into its components gives us \begin{gather*} T_x=T\sin \theta \\ T_y=T\cos\theta \end{gather*} As you can see, two identical tension forces upward, and weight force downward, are applied to the object. In the horizontal direction, there are only two identical components of tension, but in opposite directions. Thus, these components cancel out each other. In the vertical direction, the y-component of tension forces balances the object's weight. Therefore, we have \begin{aligned*} 2T\cos\theta&=mg \\\\ \Rightarrow T&=\frac{mg}{2\cos\theta}\\\\&=\frac{60\times 10}{2\cos 37^\circ}\\\\&=\boxed{375\quad{\rm N}}\end{aligned*} Hence, the correct answer is (c). Problem (20): In the following figure, what is the tension in the inclined and horizontal cords supporting a weight of $60\,{\rm kg}$, respectively? (Take $\sin 37^\circ=0.6$ and $\cos 37^\circ=0.8$) (a) 1000 N , 800 N (b) 800 N , 1000 N (c) 1333 N , 450 N (d) 800 N , 2000 N Solution: The object is at rest without any movement, so it is in equilibrium. According to Newton's second law, the equilibrium condition is the net force on the object must be zero. Three forces are acting on the object as shown in the free-body diagram below. We are assumed that the tension in the inclined cord is T_1 and in the horizontal cord is T_2. Resolve the inclined tension T_1 into x and y components. Balancing the forces along the vertical and horizontal directions gives us \begin{gather} T_1 \sin 37^\circ=mg \\ T_1 \cos 37^\circ=T_2 \end{gather} Dividing the first expression by the second, the tension T_1 cancels out, and we have left the tension T_2 as below \begin{aligned*} T_2&=\frac{mg}{\tan 37^\circ} \\\\ &=\frac{600}{0.6/0.8}\\\\&=\boxed{800\quad {\rm N}}\end{aligned*} where we used the relation below \[\tan 37^\circ=\frac{\sin 37^\circ}{\cos 37^\circ}\] Substitute $T_2=800\,{\rm N}$ into the second equation (2) and solve for T_1 as below \begin{aligned*} T_1&=\frac{T_2}{\cos 37^\circ}\\\\ &=\frac{800}{0.8}\\\\&=\boxed{1000\quad {\rm N}} \end{aligned*} Hence, the correct answer is (a). Problem (21): From a cable, it is used to accelerate a $200-{\rm kg}$ body vertically upward at a constant rate of $2\,{\rm m/s^2}$. What is the maximum tension in the cable in ${\rm N}$? (Take $g=10\,{\rm m/s^2}$). (a) 1600 (b) 2000 (c) 1200 (d) 2400 Solution: Take the direction of the motion to be the positive direction. Two forces; upward tension, and downward weight are acting on the body. The net force of these two gives an upward acceleration to the object. Applying Newton's second law and solving for the tension in the cable get \begin{aligned*} T-mg&=ma \\ T&=m(g+a) \\ &=200(10+2) \\&=\boxed{2400\quad \rm N} \end{aligned*} Hence, the correct answer is (d). Problem (22): A rope is stretched between two poles $10\,{\rm m}$ apart. A $1-\rm {kg}$ bird sits on the midpoint of the rope so that sag of 12° is formed. What is the tension in the rope at this point in $\rm N$? (a) 25 (b) 30 (c) 20 (d) 40 Solution: Draw a free-body diagram, and specify all forces acting on that point. To that point three forces are applied; the bird's weight downward and two equal tensions toward the left and right of that point. Since the rope is not moving up or down and is at rest, its acceleration is zero. Balancing the forces at that point along the vertical gives us \begin{gather*} T \sin 12^\circ+T\sin 12^\circ-mg =0 \\\\ 2T\sin 12^\circ=mg \\\\ \Rightarrow \quad T=\frac{mg}{2\sin 12^\circ}\end{gather*} Substituting the numerical values into it, we will obtain the tension in the rope as below \[T=\frac{1\times 10}{2\times 0.2}=25\,{\rm N}\] Weight force Problem (23): In the following figure, what is the direction of the gravitational force acting on person A and B, respectively? (a) $\searrow$, $\swarrow$ (b) $\downarrow$, $\earrow$ (c) $\warrow$, $\earrow$ (d) $\downarrow$, $\downarrow$ Solution: The direction of the gravitational force acting on any object is always toward the center of Earth. Thus, the correct answer is (a). Problem (24): The weight of an object on the surface of Mars equals $9\,{\rm N}$. What is the mass of the object and its weight on the surface of the Moon in SI units? (Consider the gravitational acceleration on the surface of Mars and the Moon $3.6\,{\rm m/s^2}$ and $1.6\,{\rm m/s^2}$, respectively). (a) 0.9 , 1.44 (b) 0.9 , 4 (c) 2.5 , 1.44 (d) 2.5 , 4 Solution: The weight of an object is defined as $W=mg$ where g is the acceleration of gravity on the surface of a planet. The weight on Mars is given, so we can find the mass of the object \[m=\frac{W_{Mars}}{g_{Mars}}=\frac{9}{3.6}=2.5\,{\rm kg}\] Notice that the mass of any object is constant everywhere, regardless of where it is located. Now that the mass is known, use the weight formula to find the object's weight on the Moon \begin{aligned*} W_{Moon}&=mg_{Moon} \\\\ &=2.5\times 1.6 \\\\ &=\boxed{4\,\rm N}\end{aligned*} Note that the SI units of mass and weight are $\rm kg$ and $\rm N$, respectively. Hence, the correct answer is (d). Elevators Problem (25): An object weighing $400\,{\rm g}$ is on a spring scale inside an elevator. If the elevator is moving down and slowing at a constant rate of $2\,{\rm m/s^2}$, what is the reading of the scale? (a) 4.8 N (b) 3.2 N (c) 4 N (d) 3.8 N Solution: First of all, draw a free-body diagram and show all forces acting on the object inside the elevator. Two forces are acting on the object; the weight force downward W, and the normal force F_N by the scale on the object. This normal force is the same reading of the scale. For simplicity, in all the AP physics force problems, take the acceleration direction as the positive and in accordance with it write down Newton's second law of motion. Recall that whenever we have $av>0$, then the motion is slowing down. In this case, the elevator moving down and slowing. We conclude that the acceleration must be in the opposite direction of the velocity, which is down. Thus, the acceleration of the elevator is upward. According to the free-body diagram and Newton's law, we have \begin{gather*} F_{net}=ma \\\\ N-mg=ma\\\\ N=m(g+a) \end{gather*} Substituting the numerical values into it, we have \[N=0.400(10+2)=4.8\,{\rm N}\] Keep in mind that the number that the scale shows is the same force applied by the scale on the object. Hence, the correct answer is (a). Problem (26): A person weighing $60\,{\rm kg}$ stands on a scale in a moving elevator. The elevator starts moving down initially at rest. The velocity vs. time graph for this motion is shown below. What is the ratio of the scale reading at the instant $t_1=4\,{\rm s}$ to the apparent weight of the person at time $t_2=15\,{\rm s}$? Solution: Refer to the pdf version for the explanation. Inclines In this section, some problems about inclined planes that appear in the AP Physics 1 exams are presented. Problem (27): A box of mass $m=7\,{\rm kg}$ lie on top of a frictionless incline plane of angle 20°. What acceleration (in ${\rm m/s^2}$) does the block find as it slides down the incline? (take $g=10\,{\rm m/s^2}$. (a) 3.4 (b) 0.34 (c) 2.4 (d) 10