PHYS 1110 Round 2 Retests

Brief Solutions

Standard 2 Retest 2

2. Acres in a square mile

   1 acre = (1/8 mi) $\cdot$ (1/80 mi) = 1/640 mi^2. To find the number of acres in a square mile, convert 1 square mile to acres.

$$1 \text{ mi}^2 \cdot \frac{1 \text{ acre}}{1/640 \text{ mi}^2} = 640 \text{ acres}$$

3. Convert pounds to funts

   We are given the equivalents of pounds and funts in grams, so we can effectively convert pounds to grams and then grams to funts. So, if the weight is L pounds equivalent to F funts, we have

$$F = L \text{ lb} \cdot \frac{454 \text{ g}}{\text{lb}} \cdot \frac{\text{funt}}{410 \text{ g}}$$

4. Yards in a furlong

$$1 \text{ furlong} \cdot \frac{1 \text{ mi}}{8 \text{ furlong}} \cdot \frac{5280 \text{ ft}}{1 \text{ mi}} \cdot \frac{1 \text{ yd}}{3 \text{ ft}} = 220 \text{ yd}$$

Standard 3 Retest 2

2. Match a velocity-time graph to the given acceleration-time graph

   The acceleration-time graph shows a constant positive acceleration which after some time drops to zero and stays there. The corresponding velocity-time graph then should steadily increase for a while (sloping upward) and then hold steady (horizontal).

3. Match an acceleration-time graph to the given velocity-time graph

   The velocity-time graph is briefly steady at zero, then increases to a constant positive value which it holds for a while, then decreases back to zero. The acceleration will be zero initially, then positive while the velocity increases, zero while the velocity is steady, negative while the velocity decreases, and zero while the velocity holds at zero.

4. Match position-time graphs to verbal descriptions

   A shows an object bouncing. B shows constant-velocity motion in the positive direction. C shows an object at rest for a while, followed by motion in the negative direction with increasing speed (concave down), then resting at the more negative position. D shows an object moving in the positive direction with increasing speed (concave up).

Standard 4 Retest 2

2. Average velocity falling

   Like it says, find the time to fall using constant-acceleration kinematics: $y = h - 1/2\, gt^2$ gives a landing time (when $y = 0$) of $t = \sqrt{2h/g}$. The distance traveled is $-h$, so $v_{avg} = -h/\sqrt{2h/g} = -\sqrt{gh/2}$.

3. Velocity and speed

   Speed is the magnitude of velocity, always non-negative.

4. Zero acceleration with unchanging velocity

   Acceleration is the rate of change of velocity, so unchanging velocity *requires* an acceleration of zero.

5. Zero acceleration with unchanging speed

   If the speed does not change, the velocity *may* change (change direction), but it doesn't have to. So the acceleration could be zero.

Standard 5 Retest 2

2. Acceleration from rest given time and distance

   The equation of motion is $x = x_0 + v_0 t + 1/2\, at^2$, with $v_0 = 0$. We are given $x - x_0$ and t and asked for a.

$$x = x_0 + 1/2\, at^2$$
$$x - x_0 = 1/2\, at^2$$
$$a = 2(x - x_0)/t^2$$

3. Lunch delivery

   Figure out how long it takes Jimmy to walk to school. His mother has less time, so her speed must be the distance to school divided by the time she has.

4. Catching the bus

   Make equations for the student's position with time and for the bus with time. We'll say that the student's position when the bus starts accelerating is $x = 0$, and the bus is a distance D ahead. Then the student's position is $x_s = v_s t$ and the bus's position is $x_b = D + 1/2\, at^2$, where v_s is the student's constant speed and a is the bus's constant acceleration. To find how far the student runs to catch the bus, find the time at which $x_s = x_b$, then plug that time into the student's position equation.

Standard 6 Retest 2

These are all questions about right triangles. Although the triangles are different and in different orientations, in all of them side C is the hypotenuse and side B is opposite the angle θ. This means that

$A^2 + B^2 = C^2$.
Side A is adjacent to angle θ.
$\sin\theta = B/C$.
$\cos\theta = A/C$.
$\tan\theta = B/A$.

Standard 7 Retest 2

2. Graphical vector addition

   Draw vector $\vec{B}$ starting its tail at the head of vector $\vec{A}$. Then the vector $\vec{A} + \vec{B}$ starts at the tail of vector $\vec{A}$ and ends at the head of vector $\vec{B}$.

3. Angle of a vector given as components

   Because the x component of this vector is negative, to find the angle you must add 180 degrees to the angle found by the formula $\arctan(A_y/A_x)$.

4. Magnitude of a vector given the components

   The magnitude of the vector $\vec{A} = (A_x, A_y)$ is $A = \sqrt{A_x^2 + A_y^2}$.

5. Sum of two vectors given as components.

   When $\vec{A} = (A_x, A_y)$ and $\vec{B} = (B_x, B_y)$, $\vec{A} + \vec{B} = (A_x + B_x, A_y + B_y)$.

6. Direction of a scalar multiple

   The scalar multiple of a vector is along the same line as the original vector. If the scalar is positive, then the scalar multiple is in the same direction as the original vector. If the scalar is negative, then the scalar multiple is in the opposite direction of the original vector, meaning you need to add 180 degrees from the original vector's angle.

7. Magnitude of a scalar multiple

   The magnitude of the scalar multiple of a vector is the absolute value of the scalar times the magnitude of the original vector. Magnitudes are never negative.

Standard 8 Retest 1

2. Initial vertical component of velocity

   We are given the initial speed and angle θ below horizontal. Because the initial angle is below horizontal, the vertical component of velocity must be negative: $v_{0y} = -v_0 \sin\theta$.

3. Horizontal component of velocity at floor level

   The horizontal component of a projectile's velocity never changes. Since the ball left the table horizontally, the horizontal component of its velocity is always just its initial speed.

Standard 9 Retest 1

2. Landing distance

   Find the time to land on the ground from the vertical kinematic equations: it's the time that the ball's height y is zero. Then find how far the ball travels horizontally in that time. To do this you need to know the horizontal and vertical components of the ball's initial velocity.

   The most direct way to fin the time the ball lands on the ground is to solve the height equation

   $$y = h + v_0 t - 1/2\, g t^2$$

   for time when $y = 0$. In this case, you need to use the quadratic formula to find t. The answer it gives is $t = \pm\sqrt{(v_0 y/g)^2 + 2h/g}$: this has two solutions, and you want the positive one. If using the quadratic formula is a problem, you can also find the answer in two steps: first find the vertical component of the velocity when the projectile hits the ground, then find how much time it takes to get to that velocity.

3. Initial vertical component of velocity

   In this scenario, you are given initial and final heights y_0 and y, initial and final horizontal distances x_0 and x, and the time between the initial and final positions. You are asked for the initial vertical component of velocity.

The vertical position equation is $y = y_0 + v_{0y}y - 1/2\,gt^2$. We know $y = 0$, y_0, and t, and the unknown is v_{0y}. So, we need to solve for the unknown.

$$\begin{aligned} 0 &= y_0 + v_{0y}t - 1/2\,gt^2 \\ v_{0y}t &= -y_0 + 1/2\,gt^2 \\ v_{0y} &= -y_0/t + 1/2\,gt \end{aligned}$$

Plug in the numbers and get the answer.

Standard 10 Retest 1

2. Meaning of $a = \Sigma F/m$

   The formula relates acceleration, net force, and mass. It doesn't say anything about velocity. It doesn't require a force to go with the mass; zero force just means acceleration is zero. Acceleration and mass nave an inverse relation, so the only possible correct answer is that acceleration requires a net force.

3. Inertia

   Inertia is an object's resistance to acceleration by a force. In this equation, mass takes that role.

4. Cause and effect

   Force causes acceleration.

Standard 11 Retest 1

2. Direction of net force

   The lizard is traveling at constant velocity, so its acceleration is zero. Thus, the net force acting on the lizard is zero. A zero vector has no direction.

Standard 12 Retest 1

2. Net force from acceleration

   Because $a = \Sigma F/m$, $\Sigma F = ma$. Multiply the ics chunk's mass by its acceleration.

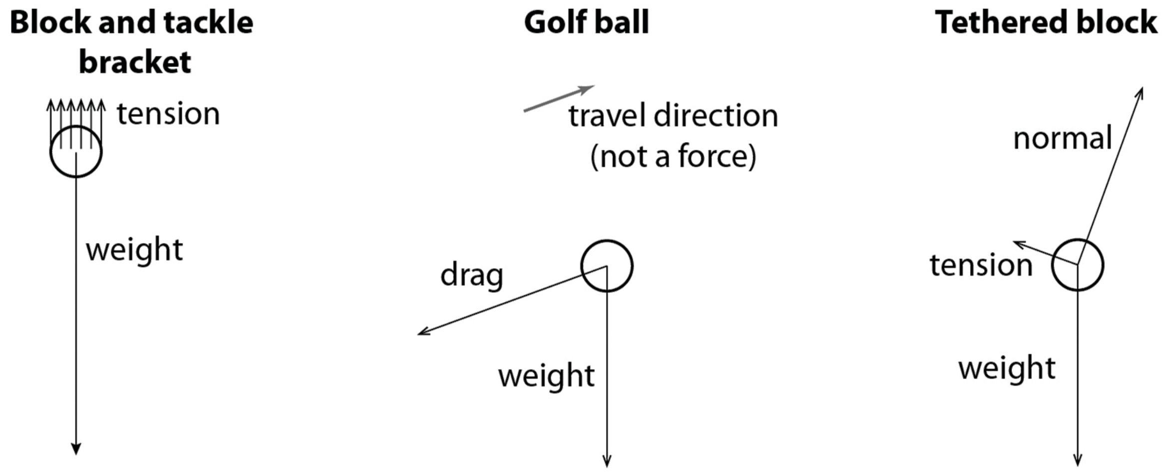
Standard 13 Retest 1

2. Interaction forces involving a falling watermelon

   Gravity is an interaction between the watermelon and Earth: the Earth attracts the watermelon, and the watermelon attracts the Earth with a force of equal magnitude. Drag is an interaction between the watermelon and the air through which it falls: the air pushes up on the watermelon, and the watermelon pushes down on the air with a force of equal magnitude.

Standard 14 Retest 1

This retest had three scenarios for which you were to construct free body diagrams.



2. Block and tackle

   This system has six pulleys. The three pulleys connected to the bracket each have the cable pulling upward on both sides. There are several valid ways to convey this. One is as six forces of tension from the cable, one from each segment of the cable. Another is three upward forces, one for each pulley. There are one or two forces acting downward on the bracket: the weight of the load, and the weight of the bracket itself.

3. Golf ball in flight

   The forces acting on the golf ball are its weight (gravity), which is straight downward, and drag from the air. When modeling trajectories in this class, we have usually ignored the force of drag, so it did not need to be included in this free body diagram to get full credit. If drag is present, its direction should be opposite the direction of the ball's velocity.

   There should be no force of velocity in the free body diagram; velocity is not a force. If you wish to indicate the direction of travel to justify the direction of the drag force, it should be near the diagram, but not directly on it, lest it be confused for a force.

   There is no force of lift on the ball, unless the ball is given a back spin. That is beyond the scope of this course.

   There is no normal force on the ball, because the ball is not in contact with a surface.

   There is no push force on the ball propelling it forward. The strike from the golf club happened in the past, and is not currently acting on the ball. By Newton's first law, the ball is in motion because it was in motion earlier: a net force is needed to *change* its velocity, not to maintain its velocity.

4. Tethered block on an inclined track

   The block's weight is directed straight down.

   The tension from the cable is uphill, parallel to the track.

   The track applies a normal force to the block, which is perpendicular to the track, outward from it.

   The question did not specify if the track was frictionless or not, which left some ambiguity about how static friction could act. The tension from the cable could be exactly sufficient to keep the block from sliding, in which the magnitude of static friction would be zero. The tension from the cable could be less than necessary to keep the block from sliding, in which case the static friction points uphill. Finally, the tension could be a bit more than necessary to keep the block from sliding, in which case static friction keeps the tension from pulling the block *up*hill. In that case, the static friction would be directed downhill, parallel to the ramp. If the static friction is *not* zero, then it is either uphill or downhill, and always parallel to the track.

Standard 15 Retest 1

2. Weight of a chunk of ice

   Weight $= mg$. We can assume that this in on Earth, where $g = 9.8$ m/s^2. The mass m is given in the question.

3. Normal force magnitude

   The floor is level, and the normal force from the floor has whatever magnitude it needs to prevent the doll from accelerating downward into the floor. There is no indication that your sister is giving the doll a vertical push (up or down), so the normal force just needs to cancel the doll's weight mg.

4. Tension direction

   The force of tension is directed inward along the string.

Standard 16 Retest 1

2. Magnitude of kinetic friction on a creepy doll

   On the level floor, the normal force on the doll is opposite its weight, $N = mg$. The kinetic friction is $\mu_k N = \mu_k mg$.

3. Direction of kinetic friction on a creepy doll

   The friction opposes the slide.

4. Formula for maximum static friction magnitude

   Ordinarily, static friction is a force of constraint, being whatever it needs to be to keep the contacting surfaces from sliding. The formula $f_s \leq \mu_s N$ can be used to find the maximum possible value of the kinetic friction, or to find the minimum value of μ that allows the static friction to hold. Once the surfaces begin sliding, kinetic friction no longer acts.

Standard 17 Retest 1

2. Sphere in a notch

   The forces acting on the sphere are it downward weight with magnitude mg, and two normal forces, one from each of the sides of the notch. Since the normal forces are perpendicular to the sides of the notch, one is horizontal (I'll call that force $\vec{N}_1$) and the other is at an angle (I'll call that force $\vec{N}_2$). The angle (I'll call it θ) you are given is between the sides of the notch. Since one side is vertical, θ is the angle the side of the notch makes from vertical. That means that the normal force $\vec{N}_2$ exerted by that side of the notch is at an angle θ above horizontal.

   These three forces must add to $\vec{0}$, because the sphere is static. The question asks you for the magnitude of the $\vec{N}_2$, which is the only force other than the sphere's weight to have a non-zero vertical component. That means that the vertical component of $\vec{N}_2$ is mg. Trigonometry gives us $\sin\theta = mg/N_2$, so $N_2 = mg/\sin\theta$.

3. Normal force on an incline

The forces acting on the block are tension from the cable, the block's weight, the normal force form the track, and possibly some static friction. The normal force keeps the block from accelerating into the incline. The only other force that has a component perpendicular to the track is the block's weight; its component into the track is $mg\cos\theta$. Thus the magnitude of the normal force from the track is also $mg\cos\theta$.

Standard 18 Retest 1

2. Normal force on an incline

   If you did the Standard 17 retest, you already saw this problem. It fits both standards.

   The forces acting on the block are tension from the cable, the block's weight, the normal force form the track, and possibly some static friction. The normal force keeps the block from accelerating into the incline. The only other force that has a component perpendicular to the track is the block's weight; its component into the track is $mg\cos\theta$. Thus the magnitude of the normal force from the track is also $mg\cos\theta$.

3. x component of weight

   To answer this question and the next, you need to construct a right triangle whose hypotenuse is w and whose catheti w_x and w_y are parallel to the x and y axes, respectively. In this right triangle, the angle θ is opposite side w_x. That means that the principal trigonometric ratios of the triangle regarding angle θ are

$$\sin\theta = w_x/w$$
$$\cos\theta = w_y/w$$
$$\tan\theta = w_x/w_y$$

   Thus, the x component of $\vec{w}$ is $v_x = +w\sin\theta$. It is positive because the angle between the $+x$ axis and $\vec{w}$ is acute.

4. y component of weight

   From the discussion for part 3, we see that the y component of $\vec{w}$ is $v_y = -w\cos\theta$. It is negative because the angle between the $+y$ axis and $\vec{w}$ is obtuse.

Standard 19 Retest 1

2. Acceleration of carts on a track

   The situation is slightly different from the linked carts question on Exam 1: instead of a force of tension pulling backward on the drive cart and forward on the towed cart, here there is a force of compression pushing backward on the drive cart and forward on the pushed cart. But the math is exactly the same. By the same analysis as for the exam question, the same formula arises.

$$a = \frac{\mu m_2 g}{m_1 + m_2}$$