Scott Pratt

Do not open exam until instructed to do so.

$\boxed{2\ pt}$ Consider A=18 kg and B=2 s^2. Please identify if the operations below are possible or not, and if they are, whether or not the answer given is correct.

▷ You can divide A by B (A/B), and get 9 kg/s^2.

1. **A**◯ This is impossible
B◯ This is possible, but the answer is false
C◯ This is correct

▷ You can subtract B from A (A-B), and get 16 kg.

2. **A**◯ This is impossible
B◯ This is possible, but the answer is false
C◯ This is correct

$\boxed{4\ pt}$ A rock is hurled upward from a high bridge with an initial upward speed of 30 m/s. Eventually, the rock lands in the river, 50 m below the initial release point. For the following statements, displacements are measured relative to the release point and the upward direction is positive.

▷ During the entire flight, the displacement of the rock is positive or zero.

3. **A**◯ True **B**◯ False

▷ At its highest point, the rock has zero velocity.

4. **A**◯ True **B**◯ False

▷ The maximum speed occurs on the way down at the instant when the rock passes the initial release point.

5. **A**◯ True **B**◯ False

▷ At its highest point, the rock has zero acceleration.

6. **A**◯ True **B**◯ False

$\boxed{4\ pt}$ Three identical airplanes with identical air speeds leave Kansas City. Airplane A leaves on Monday, a calm and windless day, and flies directly eastward to St. Louis. Airplanes B and C leave on Tuesday, when there is a strong north wind. Airplane B points the plane directly eastward and is blown off course, passing south of St. Louis, while Airplane C adjusts its direction to account for the wind and flies directly east to St. Louis.

▷ The plane(s) with the largest eastward component to its velocity is ________.

7. **A**◯ Airplane A **B**◯ Airplane B
C◯ Airplane C **D**◯ Airplanes A, B and C
E◯ Airplanes A and C **F**◯ Airplanes A and B
G◯ Airplanes B and C

▷ The plane(s) that reaches St. Louis in the least amount of time is________.

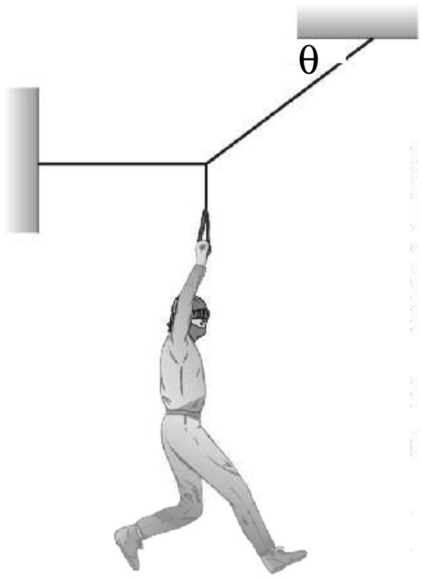
8. **A**◯ Airplane A **B**◯ Airplane B
C◯ Airplane C **D**◯ Airplanes A, B and C
E◯ Airplanes A and C **F**◯ Airplanes A and B
G◯ Airplanes B and C

▷ The plane(s) with the lowest ground speed is ________.

9. **A**◯ Airplane A **B**◯ Airplane B
C◯ Airplane C **D**◯ Airplanes A, B and C
E◯ Airplanes A and C **F**◯ Airplanes A and B
G◯ Airplanes B and C

▷ The plane(s) with the highest ground speed is ________.

10. **A**◯ Airplane A **B**◯ Airplane B
C◯ Airplane C **D**◯ Airplanes A, B and C
E◯ Airplanes A and C **F**◯ Airplanes A and B
G◯ Airplanes B and C



1 pt

Consider the cat burglar of mass 61 kg in the figure, where the angle θ=31 degrees. What is the tension in the horizontal section of the cable?
(in N*)*

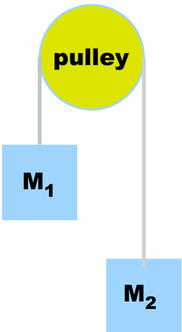
11.A◯ 478 **B**◯ 541 **C**◯ 611 **D**◯ 690
E◯ 780 **F**◯ 881 **G**◯ 996 **H**◯ 1125

1 pt Goodyear Tire and Rubber Company wants to measure the coefficient of friction for a new miracle rubber compound by sliding a block down an inclined plane, where the surface of the block is coated with the new compound. If the block slides at constant velocity down the plane when the plane is inclined at an angle of 51 degrees, what is the kinetic coefficient of friction?

12.A◯ 0.22 **B**◯ 0.30 **C**◯ 0.39 **D**◯ 0.52
E◯ 0.70 **F**◯ 0.93 **G**◯ 1.23 **H**◯ 1.64

1 pt Nolan Ryan throws a rock horizontally from the roof of a tall building with an initial speed of 49 m/s. The rock travels a horizontal distance of 56 m before it hits the ground. From what height (above the ground) was the rock released?
(in m*)*

13.A◯ 6.41 **B**◯ 9.29 **C**◯ 13.47 **D**◯ 19.53
E◯ 28.32 **F**◯ 41.06 **G**◯ 59.54 **H**◯ 86.34



Consider an Atwood machine with m_2 =7.7 kg. The acceleration of m_2 is measured to be 3.15 m/s^2 upward.
DATA: g=9.81 m/s^2

pt What is the tension in the rope? *(in* `N`*)*

14.A◯ 47.9 **B**◯ 54.2 **C**◯ 61.2 **D**◯ 69.2
E◯ 78.2 **F**◯ 88.3 **G**◯ 99.8 **H**◯ 112.8

pt If the blocks are initially at rest, how far will m_2 have risen by 2.5 seconds? *(in* `m`*)*

15.A◯ 1.78 **B**◯ 2.37 **C**◯ 3.15 **D**◯ 4.18
E◯ 5.56 **F**◯ 7.40 **G**◯ 9.84 **H**◯ 13.09

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1 pt A 85 kg skier, whose height is 185 cm, glides down a frictionless mountain on the mythical planet Horatio which has an unknown acceleration of gravity. The skier begins at a height of 290 m above the surrounding plain. When the skier enters the flat plain, contact with the ground is no longer frictionless and the coefficient of friction is μ_k=0.19. How far does the skier glide along the plain before coming to a stop? *(in* `m`*)*

16.A◯ 345.3 **B**◯ 500.7 **C**◯ 726.0
D◯ 1052.6 **E**◯ 1526.3 **F**◯ 2213.2
G◯ 3209.1 **H**◯ 4653.2

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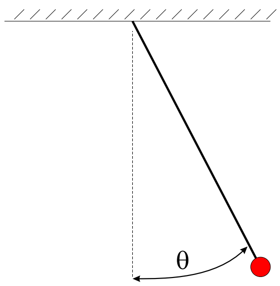
1 pt A 6.7-kg bowling ball moves at 3.3 m/s. How fast must a 2.45-g Ping-Pong ball move so that the two balls have the same kinetic energy? *(in* `m/s`*)*

17.A◯ 18.6 **B**◯ 26.9 **C**◯ 39.0 **D**◯ 56.6
E◯ 82.1 **F**◯ 119.0 **G**◯ 172.6 **H**◯ 250.2



1 pt A 205 gram ball on a string swings from rest, beginning at an angle of 61 degrees with respect to the vertical. The speed of the ball when it reaches its lowest point is 248.2 cm/s. What is the length of the string? *(in* `cm`*)*

18. **A**◯ 54 **B**◯ 61 **C**◯ 69 **D**◯ 78
E◯ 88 **F**◯ 99 **G**◯ 112 **H**◯ 127

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1 pt A ball is pushed down a hill with an initial velocity of 3.5 m/s. It accelerates down hill with a uniform acceleration of 2.6 m/s^2. The ball reaches the bottom of the hill in 13 seconds. What is its speed when it reaches the bottom of the hill? *(in* `m/s`*)*

19. **A**◯ 11.9 **B**◯ 15.9 **C**◯ 21.1 **D**◯ 28.0
E◯ 37.3 **F**◯ 49.6 **G**◯ 66.0 **H**◯ 87.8

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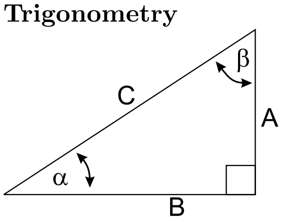
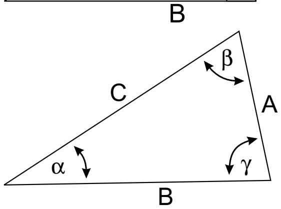
1 pt A rocket, starting from rest, experiences a uniform acceleration of 20.3 m/s^2. What is its speed at the point where its displacement from its original location is 550 m? *(in* `m/s`*)*

20. **A**◯ 149.4 **B**◯ 168.9 **C**◯ 190.8 **D**◯ 215.6
E◯ 243.6 **F**◯ 275.3 **G**◯ 311.1 **H**◯ 351.6

Quadratic Formula
$ax^2 + bx + c = 0,$
$x = [-b \pm \sqrt{b^2 - 4ac}]/(2a)$
Geometry
Circle: circumference=$2\pi R$, area=πR^2
Sphere: area=$4\pi R^2$, volume=$4\pi R^3/3$
Trigonometry



$$\sin\alpha = \frac{A}{C}, \quad \cos\alpha = \frac{B}{C}$$
$$\tan\alpha = \frac{A}{B}$$



$$\frac{\sin\alpha}{A} = \frac{\sin\beta}{B} = \frac{\sin\gamma}{C}$$
$$A^2 + B^2 - 2AB\cos\gamma = C^2$$

Polar Coordinates
$x = r\cos\theta, \quad y = r\sin\theta, \; r = \sqrt{x^2+y^2}, \quad \tan\theta = y/x$
SI Units and Constants

quantity	unit	abbreviation
Mass m	kilograms	kg
Distance x	meters	m
Time t	seconds	s
Force F	Newtons	N=kg m/s^2
Energy E	Joules	J=N m
Power P	Watts	W=J/s
Temperature T	°C, °K or °F	$T_{\circ F} = 32 + (9/5)T_{\circ C}$
Pressure P	Pascals	Pa=N/m^2

1 cal=4.1868 J, 1 hp=745.7 W, 1 liter=10^{-3}m^3
$g = 9.81$ m/s^2, G=6.67×10^{-11} Nm^2/kg^2
1 atm=1.013×10^5Pa, 0°C=273.15°K, $N_A = 6.023 \times 10^{23}$
$R = 8.31$ J/(mol°K)=0.0821 L atm/(mol K),
$k_B = R/N_A = 1.38 \times 10^{-23}$ J/K, $\sigma = 5.67 \times 10^{-8}$ W/(m^{2}K^4)
$v_{\rm sound} = 331\sqrt{T/273}$ m/s
$H_2$0: $c_{\rm ice,liq.,steam}$=$\{0.5, 1.0, 0.48\}$ cal/g°C
$L_{F,V}$=$\{79.7, 540\}$ cal/g, $\rho = 1000$ kg/m^3.

1-d motion, constant a
$\Delta x = (1/2)(v_0 + v_f)t$
$v_f = v_0 + at$
$\Delta x = v_0 t + (1/2)at^2$
$\Delta x = v_f t - (1/2)at^2$
$(1/2)v_f^2 - (1/2)v_0^2 = a\Delta x$
Range: $R = (v_0^2/g)\sin 2\theta$
Forces, Work, Energy, Power, Momentum & Impulse
$F = ma$, Gravity: $F = mg, PE = mgh$
Friction: $f = \mu N$, Spring: $F = -kx, \; PE = (1/2)kx^2$
$W = Fx\cos\theta, KE = (1/2)mv^2$, $P = \Delta E/\Delta t = Fv$
$p = mv, I = F\Delta t = \Delta p$
$X_{cm} = (m_1x_1 + m_2x_2 + \cdots)/(m_1 + m_2 + \cdots)$
Elastic coll.s: $v_1' - v_2' = -(v_1 - v_2)$

Rotational Motion
$\Delta\theta = (1/2)(\omega_0 + \omega_f)t, \omega_f = \omega_0 + \alpha t$
$\Delta\theta = \omega_0 t + (1/2)\alpha t^2 = \omega_f t - (1/2)\alpha t^2$
$\alpha\Delta\theta = (1/2)\omega_f^2 - (1/2)\omega_0^2$
$\omega = 2\pi/T = 2\pi f, f = 1/T$
Rolling: $a = \alpha r, v = \omega r$
$a_c = v^2/r = \omega v = \omega^2 r$
$\tau = rF\sin\theta = \; I\alpha, \; I_{\rm point} = mR^2$
$I_{\rm cyl.shell} = MR^2, \; I_{\rm sphere} = (2/5)MR^2$
$I_{\rm solid\ cyl.} = (1/2)MR^2, \; I_{\rm sph.\ shell} = (2/3)MR^2$
$L = I\omega = mvr\sin\theta$, ($\theta$= angle between v and r)
$KE = (1/2)I\omega^2 = L^2/(2I), W = \tau\Delta\theta$
Gravity and circular orbits
$PE = -G\frac{Mm}{r}, \; \Delta PE = mgh$(small h)
$$F = G\frac{Mm}{r^2}, \quad \frac{GM}{4\pi^2} = \frac{R^3}{T^2}$$
Gases, liquids and solids
$P = F/A, \; PV = nRT, \; \Delta P = \rho gh$
$\langle (1/2)mv^2 \rangle = (3/2)k_BT$
ideal monotonic gas: $U = (3/2)nRT = (3/2)PV$
$F_{\rm bouyant} = \rho_{\rm displaced\ liq.}V_{\rm displaced\ liq.}g$
Stress $= F/A$, Strain $= \Delta L/L$, $Y =$ Stress/Strain
$\frac{\Delta L}{L} = \frac{F/A}{Y}, \frac{\Delta V}{V} = \frac{-\Delta P}{B}, Y = 3B$
Continuity: $\rho_1 A_1 v_1 = \rho_2 A_2 v_2$
Bernoulli: $P_a + \frac{1}{2}\rho_a v_a^2 + \rho_a g h_a = P_b + \frac{1}{2}\rho_b v_b^2 + \rho_b g h_b$
Thermal
$\Delta L/L = \alpha\Delta T, \; \Delta V/V = \beta\Delta T, \beta = 3\alpha$
$Q = mC_v\Delta T + mL$(if phase trans.)
Conduction and Radiation
$P = kA(T_b - T_a)/L = A(T_b - T_a)/R$,$R \equiv L/k$
$P = e\sigma AT^4$
Thermodynamics
$\Delta U = Q + W, \quad W = -P\Delta V, \; Q = T\Delta S, \; \Delta S > 0$
Engines: $W = |Q_H| - |Q_L|$
$\epsilon = W/Q_H < (T_H - T_L)/T_H < 1$
Refrigerators and heat pumps: $W = |Q_H| - |Q_L|$
$\epsilon = Q_L/W < T_L/(T_H - T_L)$
Simple Harmonic Motion and Waves
$f = 1/T, \omega = 2\pi f$
$x(t) = A\cos(\omega t - \phi), \; v = -\omega A\sin(\omega t - \phi)$
$a = -\omega^2 A\cos(\omega t - \phi)$
Spring: $\omega = \sqrt{k/m}$
Pendulum: $T = 2\pi\sqrt{L/g}$
Waves: $y(x,t) = A\sin[2\pi(ft - x/\lambda) + \delta], \; v = f\lambda$
$I = {\rm const}A^2f^2, \; I_2/I_1 = R_1^2/R_2^2$
Standing waves: $\lambda_n = 2L/n$
Strings: $v = \sqrt{T/\mu}$
Solid/Liquid: $v = \sqrt{B/\rho}$
Sound: $I = {\rm Power}/A = I_0 10^{\beta/10}, \; I_0 \equiv 10^{-12}$ W/m^2
Decibels: $\beta = 10\log_{10}(I/I_0)$
Beat freq.=$|f_1 - f_2|$
Doppler: $f_{\rm obs} = f_{\rm source}(V_{\rm sound} \pm v_{\rm obs})/(V_{\rm sound} \pm v_{\rm source})$
Pipes: same at both ends: $L = \lambda/2, \lambda, 3\lambda/2$
Pipes: open at only one end: $L = \lambda/4, 3\lambda/4, 5\lambda/4 \cdots$