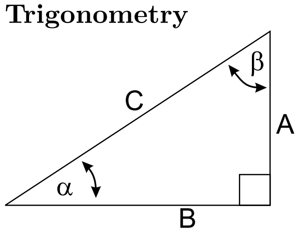
Scott Pratt

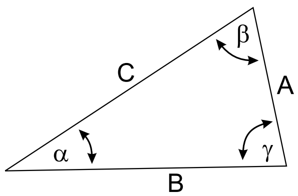
Do not open exam until instructed to do so.

Scott Pratt - PHY 231 - Introductory Physics I - Spring 2005

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
$g = 9.81$ m/s^2, G=6.67×10^{-11} Nm^2/kg^2
0°C=273.15°K, $N_A = 6.023 \times 10^{23}$
$R = 8.31$ J/(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_20: $c_{\rm ice,liq.,steam}$=$\{0.5, 1.0, 0.48\}$ cal/g°C
$L_{F,V}$=$\{80, 540\}$ cal/g, $\rho = 1.0$ g/cm^3.

1-d motion, constant a
$x = (1/2)(v_0 + v_f)t$
$v_f = v_0 + at$
$x = v_0 t + (1/2)at^2$
$x = v_f t - (1/2)at^2$
$(1/2)v_f^2 - (1/2)v_0^2 = ax$
Momentum, Force and Impulse
$p = mv, \ F = ma = \Delta p/\Delta t$
$I = F\Delta t = \Delta p$
Friction: $F_{\rm fric} = \mu N$
Spring: $F = -kx$

Work, Energy and Power
$W = Fx\cos\theta, KE = (1/2)mv^2, \ P = \Delta E/\Delta t = Fv$
Spring: $PE = (1/2)kx^2$
Rotational Motion
$v = \omega r = 2\pi r/T, \quad \omega = \Delta\theta/\Delta t = 2\pi f = 2\pi/T, f = 1/T$
$\alpha = (\omega_f - \omega_0)/t = \frac{a}{r}$
$L = I\omega = mvr\sin\theta,$ (θ= angle between v and r)
$KE = (1/2)I\omega^2 = L^2/(2I)$
$\tau = rF\sin\theta, \ I\alpha = \tau, \ I_{\rm point} = mR^2$
$I_{\rm cyl.shell} = MR^2, \ I_{\rm sphere} = (2/5)MR^2$
$I_{\rm solid\ cyl.} = (1/2)MR^2, \ I_{\rm sph.\ shell} = (2/3)MR^2$
$a = v^2/r = \omega v = \omega^2 r$
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
$P = F/A, \ PV = NRT, \ \Delta P = \rho gh$
$\langle (1/2)mv^2 \rangle = (3/2)k_B T$
$F_{\rm bouyant} = \rho_{\rm displaced\ liq.} V_{\rm displaced\ liq.} g$
Stress $= F/A$, Strain $= \Delta L/L$, Y = Stress/Strain
$\frac{\Delta L}{L} = \frac{F/A}{Y}, \frac{\Delta V}{V} = \frac{-\Delta P}{B}, Y = 3B$
Bernoulli: $P_a + \frac{1}{2}\rho_a v_a^2 + \rho_a g h_a = P_b + \frac{1}{2}\rho_b v_b^2 + \rho_b g h_b$
Heat
$\Delta L/L = \alpha\Delta T, \ \Delta V/V = 3\alpha\Delta T$
$Q = mC_v\Delta T + mL$(if phase trans.)
Conduction and Radiation
$P = kA(T_b - T_a)/\Delta x = A(T_b - T_a)/R,$
$R \equiv \Delta x/k, \ P = e\sigma AT^4$
Thermodynamics
$\Delta U = Q + W, \quad W = -P\Delta V$, ideal gas: $\Delta U = nC_V\Delta T$
Adiabatic exp: pV^γ =const, $TV^{\gamma-1}$ =const
$\gamma = C_p/C_V$=5/3 (monotonic), =7/5 (diatomic)
$Q = T\Delta S, \ \Delta S > 0$
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: $y(x,t) = A\sin[2\pi(ft - x/\lambda + \delta)], \ v = f\lambda$
$I = {\rm const}A^2 f^2, \ I_2/I_1 = R_1^2/R_2^2$
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: $L = \lambda/4, 3\lambda/4, 5\lambda/4 \cdots$

<u>4 pt</u> Consider twins named Bert and Ernie who are visiting a planet named Izzone. Bert is standing at the top of the highest mountain on Izzone, a distance R from the center of the planet. Ernie flies by in a space ship which is in a stable circular orbit at the same altitude R.

▷ If Ernie were to step on a bathroom scale in his space ship, his weight would register as zero.

1. **A**◯ True **B**◯ False

▷ Ernie and Bert undergo the same acceleration.

2. **A**◯ True **B**◯ False

▷ If Big Bird were to fly in a circular orbit of radius 3R, the gravitational force acting on Big Bird would be one third of the gravitational force acting on Ernie.

3. **A**◯ True **B**◯ False

▷ The same gravitational force acts on both Bert and Ernie, but Bert also experiences an additional force from the ground.

4. **A**◯ True **B**◯ False

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2 pt Dumb Dora slides a bumper car down an icy frictionless hill of height h. At the bottom of the hill, she collides head-on with her lifetime companion Brainless Billy, who is at rest in his bumper car. The two cars, including their dimwitted passengers, have equal mass. After the collision the two cars stick together. Their speed after the collision is 20 mph.

▷ If the collision is repeated with an initial height of $2h$, and they still stick to one another, their final velocity will be ____________.

5. **A**◯ 20 mph **B**◯ 28.284 mph **C**◯ 40 mph
D◯ 80 mph

▷ If the collision is repeated from the original height h, but they bounce off each other elastically, Billy's final velocity will be ___________.

6. **A**◯ 20 mph **B**◯ 28.284 mph **C**◯ 40 mph
D◯ 80 mph

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4 pt A student hurls a baseball directly upward with an initial speed of 40 m/s. Later, the student catches the baseball at the same position from which it was released. For the following statements, displacements are measured relative to the release point and the upward direction is positive.

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

7. **A**◯ True **B**◯ False

▷ During the entire flight, the acceleration of the baseball is negative.

8. **A**◯ True **B**◯ False

▷ During the entire flight, the velocity of the baseball is positive or zero.

9. **A**◯ True **B**◯ False

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

10. **A**◯ True **B**◯ False

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1 pt Some asteroid named "Briggie" has been discovered revolving around the Sun on a circular orbit with a period of 3.30 years. What is the radius of Briggie's orbit? DATA: The radius of Earth's orbit is 1.50E+11 m. *(in* m*)*

11.A◯ 1.77×10^{11} **B**◯ 2.08×10^{11}
C◯ 2.43×10^{11} **D**◯ 2.84×10^{11}
E◯ 3.32×10^{11} **F**◯ 3.89×10^{11}
G◯ 4.55×10^{11} **H**◯ 5.33×10^{11}

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1 pt Race tracks are banked at an angle θ for a design speed at which friction is not required to steer the car around the curve. If the design speed is 61 m/s, and the radius of curvature is 120 m, what is the banking angle? (in degrees, zero degrees refers to a flat track)

12.A◯ 58.0 **B**◯ 72.4 **C**◯ 90.6 **D**◯ 113.2
E◯ 141.5 **F**◯ 176.9 **G**◯ 221.1 **H**◯ 276.4

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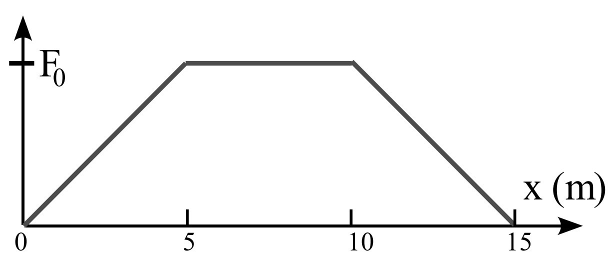
1 pt The launching mechanism of a toy gun consists of a spring whose spring constant is 4514 N/m. The spring is compressed a distance 3.7 cm before launching. What is the maximum height to which the gun can launch a 15-g projectile? *(in* m*)*

13.A◯ 3.79 **B**◯ 5.05 **C**◯ 6.71 **D**◯ 8.93
E◯ 11.87 **F**◯ 15.79 **G**◯ 21.00 **H**◯ 27.93



1 pt Consider the graph of force, F, vs. position, x, shown above. The hashmark on the vertical axis denotes a value F_0=24 N. Find the velocity of a 5.5-kg object as it moves from x = 0.0 to x = 15.0 m after starting at rest. *(in* m/s*)*

14.A◯ 4.99 **B**◯ 5.83 **C**◯ 6.82 **D**◯ 7.98
E◯ 9.34 **F**◯ 10.93 **G**◯ 12.79 **H**◯ 14.96

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1 pt How much power does is required to pull up a load of bricks at a constant velocity. The mass of the load is 99 kg, the height raised is 190 m, and the time required is 83 seconds? The efficiency of the engine is 0.8.

15.A◯ 2779 **B**◯ 3696 **C**◯ 4916 **D**◯ 6538
E◯ 8696 **F**◯ 11565 **G**◯ 15382 **H**◯ 20457

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1 pt Supergirl, who has a weight of 105 lbs, claims that at top speed she has the same momentum as a 5 ton truck moving at 55 mph. What is Supergirl's top speed? (in mph) (One ton = 2000 lbs)

16.A◯ 3271 **B**◯ 3826 **C**◯ 4477 **D**◯ 5238
E◯ 6129 **F**◯ 7170 **G**◯ 8389 **H**◯ 9816

Tarzan swings on a 14-m-long vine initially inclined at an angle of 37° with the vertical.

1 pt What is his speed at the bottom if he pushes off with a speed of 3.3 m/s? *(in* `m/s`*)*

17.A◯ 1.71 **B**◯ 2.13 **C**◯ 2.67 **D**◯ 3.33
E◯ 4.17 **F**◯ 5.21 **G**◯ 6.51 **H**◯ 8.14

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1 pt A 75 kg skier comes glides down a frictionless mountain on the mythical planet Horatio which has an unknown acceleration of gravity. The skier begins at a height of 430 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=0.23. How far does the skier glide along the plain before coming to a stop? The skier's height is 185 cm. *(in* m*)*

18.
A◯ 622.9 **B**◯ 728.8 **C**◯ 852.7
D◯ 997.7 **E**◯ 1167.3 **F**◯ 1365.7
G◯ 1597.9 **H**◯ 1869.6

In a popular amusement park ride, a rotating cylinder of radius 2.85 m is set in rotation at an angular speed of 0.35 revolutions per second, as seen above. The floor then drops away, leaving the riders suspended against the wall in a vertical position. What minimum coefficient of friction between a rider's clothing and the wall is needed to keep the rider from slipping?
1 pt

19.
A◯ 2.33×10^{-1} **B**◯ 2.92×10^{-1} **C**◯ 3.64×10^{-1}
D◯ 4.56×10^{-1} **E**◯ 5.69×10^{-1} **F**◯ 7.12×10^{-1}
G◯ 8.90×10^{-1} **H**◯ 1.11

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1 pt The diameter of the main rotor of a single-engine helicopter is 12.2 m. The rotational speed is 450 rev/min. What is the speed of the tip of the large rotor? Give answer as a fraction of the speed of sound, $v_{sound} = 343$ m/s.

20.
A◯ 0.84 **B**◯ 1.22 **C**◯ 1.76 **D**◯ 2.55
E◯ 3.70 **F**◯ 5.37 **G**◯ 7.79 **H**◯ 11.29
