PHYSICS 149 FINAL EXAM 16 December, 2003

This 20-question test is worth 200 points, each question is weighted equally. Please fill out the answer sheet with soft lead pencil. Be sure to give your name, student ID #, date, Course #, Final Exam, and SIGN the answer sheet. Be prepared to present your Student picture ID card when handing in your answer sheet. You may keep the sheets with the questions and your work.

Pick the nearest value for your answer (there may be slight roundoff errors). Don't get hung up too long over any one question until you have tried all of them.

Bring your own "crib sheet"; here's mine: $g = 9.8\ m/s^2$ $G = 6.67\times10^{-11} Nm^2/kg^2$

$v = v_o + a\,t$ for each vector component of **v** and **a**) **for constant**
$x = x_o + v_o\,t + \frac{1}{2}\,a\,t^2$ and ditto for y and z components) **a**
$v_x^2 - v_{ox}^2 = 2a\,(x - x_o)$ etc. .)
$x = x_o + \frac{1}{2}\,(v_o + v)t$ etc.)

average $v_x = \Delta x/\Delta t$ etc., average $\mathbf{a} = \Delta v/\Delta t$ and etc. for each component
$x = r\cos(\theta)$ $y = r\sin(\theta)$ $\tan(\theta) = y/x$

$\mathbf{F} = m\mathbf{a}$ **F** of A on B = -**F** of B on A $f_k = \mu_k N$ $f_s^{MAX} = \mu_s N$

$v_{relative} = v_2 - v_1$ (2 relative to 1), $v_{AC} = v_{AB} + v_{BC}$, $F_c = ma_c$ $F_g = mg$=weight

$F_G = GMm/r^2$, $g = G\,M_E/r_E^2$, if $F_c = F_G$, then $mv^2 = GMm/r$ and $T^2GM = (2\pi)^2 r^3$

The Earth's mass and radius are $M_E = 5.98 \times 10^{24}$ kg and $r_E = 6.38 \times 10^6$, respectively
Range=$R = v^2 \sin(2\theta)/g$
$a_c = \omega^2 r = \omega v = v^2/r$ $f = 1/T$ $\omega = 2\pi f = v/r$ = angular frequency
2π rad = 1 rev = 360° Work ≡ $W = F\cos\theta\ s$ $v = 2\pi r/T$ $T = 1/f$

$KE = \frac{1}{2}\,m\,v^2$, $PE = mgh$, $ME = PE + KE$, $\Delta ME = \Delta PE + \Delta KE = W_{nc}$
If non-conservative work = 0, then ME is conserved: $\Delta ME = 0 = PE_f + KE_f - PE_o - KE_o$
Work ≡ $W = \mathbf{F}\cdot\mathbf{s}$ if **F** and θ are constant
Power ≡ $P = W/t = \mathbf{F}\cdot\mathbf{v}$, Impulse $\mathbf{I} \equiv \mathbf{F}\,\Delta t = \Delta\mathbf{p}$, Momentum $\mathbf{p} = m\mathbf{v}$
If system is isolated, **p**=constant, that is, $\mathbf{p}_f = \mathbf{p}_o$ for entire system (conserved)

1-D Elastic $v_{f1} = v_{01}\,(m_1 - m_2)/(m_1 + m_2) + 2\,v_{02}\,m_2/(m_1 + m_2)$
$v_{f2} = v_{02}\,(m_2 - m_1)/(m_1 + m_2) + 2\,v_{01}\,m_1/(m_1 + m_2)$
$x_{cm} = \Sigma m_i x_i / \Sigma m_i$

A) $\theta = s/r$ $\omega = v_T/r$ $\alpha = a_T/r$ where α is the angular acceleration
B) $r\theta = s$ $r\omega = v_T$ $r\alpha = a_T$ If α is constant, the following equations are the angular analogues of the constant **a** equations at the top of the page:

$\omega = \omega_0 + \alpha\,t$ $\omega^2 = \omega_0^2 + 2\,\alpha(\theta - \theta_0)$
$\theta = \theta_0 + \omega_0\,t + \frac{1}{2}\,\alpha\,t^2$ $\theta = \theta_0 + \frac{1}{2}(\omega_0 + \omega)\,t$

1. A 35 kg block slides down a 30° inclined plane at constant speed. What is the coefficient of kinetic friction, μ_k, between the block and the plane?

a) 0.420
b) 0.500
c) 0.577
d) 0.677
e) 0.866

2. If the above block's speed is 17 m/s, what is the rate at which power is being dissipated by friction? (Hint: what is the "scooting force", i.e. the component of the block's weight along the plane?)

a) 2.92 kW
b) 171 W
c) 5.05 kW
d) 1.73 kW
e) 289 W

3. How fast is the equator of a neutron star's surface moving if its diameter is 18 km and it is spinning at 85 revolutions per second?

a) 534 m/s
b) 1000 m/s
c) 4.81×10^6 m/s
d) 2.39×10^3 m/s
e) 3.00×10^8 m/s

4. What is the centripetal acceleration of a point on the above neutron star's equator?

a) 2.57×10^9 m/s^2
b) 2.85×10^5 m/s^2
c) 4.81×10^6 m/s^2
d) 7.39×10^7 m/s^2
e) 8.02×10^8 m/s^2

5. If the mass of this neutron star is 3.05×10^{30} kg, what is the acceleration of gravity at its surface?

a) $8.89 \times 10^{9}\ m/s^2$
b) $3.95 \times 10^{10}\ m/s^2$
c) $6.84 \times 10^{11}\ m/s^2$
d) $2.51 \times 10^{12}\ m/s^2$
e) $5.89 \times 10^{13}\ m/s^2$

6. How fast must a roller coaster go over the outside top of a circular loop of radius 15 m so that the passengers feel only 20% of their normal weight?

a) 10.8 m/s
b) 12.1 m/s
c) 15.3 m/s
d) 18.0 m/s
e) 21.2 m/s

7. A rock is thrown straight upward and takes 20 seconds to fall back to the ground. How high doe it rise? (Hint – you may want to work problem 8 first.)

a) 490 m
b) 980 m
c) 1.96 km
d) 245 m
e) 108 m

8. In the above problem, what is the rock's initial velocity?

a) 4.9 m/s
b) 9.8 m/s
c) 49 m/s
d) 98 m/s
e) 196 m/s

9. What is the reaction force on the nozzle of a fire hose that ejects 1300 kg of water per minute with a velocity of 45 m/s?

a) 339 N
b) 552 N
c) 711 N
d) 825 N
e) 975 N

10. What is the power carried by this water flow? (Hint: it is the Kinetic Energy per second in the flowing water.)

a) 11.3 kW
b) 21.9 kW
c) 43.9 kW
d) 66.7 kW
e) 81.3 kW

11. What is the range on level ground of a ball thrown at an angle 20° above horizontal with speed 15 m/s?

a) 9.8 m
b) 14.8 m
c) 21.8 m
d) 33.8 m
e) 33.8 m

12. A CD speeds up from rest to a rotation rate of 120 revolutions per minute in a time of 8.8 seconds. What is the total angle (in radians) that the CD turns through during this process?

a) 77.4 rad
b) 2.04 rad
c) 110.6 rad
d) 29.3 rad
e) 55.3 rad

13. If the radius of the above CD is 7 cm, what is the direction of the total acceleration vector of a point on the rim? Specifically, what is the angle, in radians, of the acceleration **a** relative to $-\mathbf{r}$, ($-\mathbf{r}$ points radially inward towards the center.) Assume that the CD is just reaching full speed and the angular acceleration is still in progress.

a) 0.09 rad
b) 0.045 rad
c) 0.009 rad
d) 0.006 rad
e) 0.830 rad

14. A 6 kg curling stone moving at 13 m/s slides up an icy hill, and rises through 6 m before it stops. (This is the vertical component of its displacement.) How much work is done by friction during this time?

a) 154 J
b) −154 J
c) 353 J
d) −353 J
e) 507 J

15. Object 1, a billiard ball of mass M moving along the x-axis with velocity +3 m/s overtakes and strikes a second ball of mass 3M head-to-rear (one-dimensional elastic collision) which is moving (before the collision) with velocity +1m/s. After the collision what is the lighter ball's velocity?

a) 1 m/s
b) 3 m/s
c) –3 m/s
d) 0
e) 2 m/s

16. A 10 kg cannon fires a 30gram bullet with velocity 555 m/s. After firing, what is the total momentum of the system: (cannon + bullet)?

a) +4620 kg m/s
b) +16.7 kg m/s
c) 0
d) -16.7 kg m/s
e) -13.9 kg m/s

17. In the previous problem what is the recoil kinetic energy (KE) of the cannon?

a) 4620 J
b) 16.7 J
c) -4620 J
d) 0
e) 13.9 J

18. Earth orbits around the sun once per year. Treating the Earth's orbit as an exact circle, how long would it take a space ship in a circular orbit, which is 4.5 times farther away from the sun to make one complete orbit?

a) 4.50 years
b) 9.55 yr
c) 20.3 yr
d) 91.1 yr
e) 2.1 yr

19. A package is dropped from an airplane traveling (in level flight above level ground) at a speed of 100 m/s at an altitude of 1 km. Neglecting air resistance, what is the speed of the package when it hits the ground? (Hint: you'll need to know both components of the package's vector velocity.)

a) 100 m/s
b) 140 m/s
c) 172 m/s
d) 205 m/s
e) 240 m/s

20. A boat crosses an 800 m wide river that is flowing at 9 m/s. The boat points directly across the river with a speed of 12 m/s relative to the water (so its velocity relative to the river water is at right angles to the flow direction.) How long does it take the boat to reach the opposite bank? (Assume the river is straight and of constant width.)

a) 88.9 s
b) 66.7 s
c) 53.3 s
d) 38.1 s
e) 25.0 s