PHYSICS 149 FINAL EXAM 16 December, 2000

This 30-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: $g = 9.8\ m/s^2$ $G = 6.67 \times 10^{-11} Nm^2/kg^2$

$v = v_o + a t$ 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 $a = \Delta v/\Delta t$ and etc. for each component
$x = r\cos(\theta)$ $y = r\sin(\theta)$ $\tan(\theta) = y/x$
The Earth's mass and radius are 5.98×10^{24} kg and 6.38×10^{6}, respectively

$F = ma$ 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) $F_c = ma_c$ $a_c = v^2/r = \omega^2 r$ $F_g = mg$

$F_G = GMm/r^2$ if $F_c = F_G$, then $mv^2 = GMm/r$ and $T^2GM = (2\pi)^2 r^3$ $T = 1/f$

$\omega = 2\pi f$ 2π rad = 1 rev = 360° Work $\equiv W = F\cos\theta\ s$ $KE = \frac{1}{2} m v^2$

$PE = mgh$ $ME = PE + KE$ $\Delta ME = \Delta PE + \Delta KE = W_{nc}$

If non-conservative work = 0, then ME is conserved: $\Delta ME = 0 = PE_f + KE_f - PE_o - KE_o$

Power $\equiv P = W/t$ $I \equiv F\,\Delta t = \Delta p$ $p = mv$ If system is isolated, p = constant,

that is, $p_f = p_o$ 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) $\theta = s/r$ $\omega = v_T/r$ $\alpha = a_T/r$
B) $r\theta = s$ $r\omega = v_T$ $r\alpha = a_T$ If a is constant, use equations (A)
to convert the equations for constant acceleration, a, into the angular (radians) world.

1. A block sliding with a speed of 50 m/s on a level floor with kinetic coefficient of friction $\mu_k = 0.8$ will come to rest in what length of time?

a) 2.17 s
b) 4.85 s
c) 6.38 s
d) 8.92 s
e) 11.38 s

2. A mass of 90 kg is hung on a Y-shaped cable truss where both top branches of the Y make an angle of 20° to the horizontal. What is the tension, T, in each of the upper cables?

a) 0.83 kN
b) 1.29 kN
c) 1.66 kN
d) 1.92 kN
e) 2.35 kN

3. Two masses, of 15 kg and 25 kg, are hung at the two ends of a very light rope which passes over a very low-mass low-friction pulley. How big is the 25 kg mass's downward acceleration?

a) (1/15)g
b) (1/25)g
c) (1/4)g
d) (1/40)g
e) (1/10)g

4. A 37 kg box is dropped from rest off of a tower. A strong side-wind exerts a 30 N CONSTANT force sideways on the box. How far downward (y-component only) does the box drop in 6 seconds?

a) 176.4 m
b) 98.0 m
c) 39.2 m
d) 19.6 m
e) 108.4 m

5. A rubber eraser lies on a drafting table, which is slowly tilted until the eraser just begins to slip when the table surface is tilted at 58 degrees above horizontal. What is the coefficient of static friction μ_s between the eraser and the table?

a) 0.97
b) 0.22
c) 1.23
d) 4.33
e) 1.60

6. $\mathbf{r} = (70\text{m}, -50\text{m})$; $\mathbf{R} = (50\text{m}, 87\text{m})$. What is the direction of $\mathbf{C} = \mathbf{r} + \mathbf{R}$, relative to the x-axis ?

a) 17°
b) 29°
c) 45°
d) 63°
e) 78°

7. A ball is launched from ground level in a direction 50 degrees above the ground. It takes the ball 15 seconds to reach maximum height. What was the ball's initial y-component of velocity?

a) 98 m/s
b) 49 m/s
c) 147 m/s
d) 980 m/s
e) 490 m/s

8. A horse races TWICE around a circular track in a time of 290 s with a speed of 13 m/s. What is the radius of the track?

a) 100m
b) 200m
c) 300m
d) 400m
e) 500m

9. A centrifuge develops 8.00×10^3 g of centripetal acceleration at a radius of 7 cm from the axis of revolution (g = 9.8 m/s). What is the angular frequency, ω, of this centrifuge?

a) 1058 rad/s

b) 548 rad/s

c) 256 rad/s

d) 2540 rad/s

e) 3220 rad/s

10. A flywheel starts from rest and reaches a spin speed of 7.8 rad/s in 15 seconds. What is its average angular acceleration?

a) 0.26 rad/s^2
b) 0.78 rad/s^2
c) 1.50 rad/s^2
d) 0.52 rad/s^2
e) 22.5 rad/s^2

11. A car travels on a 15° "banked curve" with a radius of 40 m. What steady speed must the car have to experience zero NET force on the tires in any direction PARALLEL to the pavement? (Hint: vertical component of N balances the car's weight, horizontal component of N is the required centripetal force)

a) 10.2 m/s
b) 9.32 m/s
c) 6.51 m/s
d) 4.80 m/s
e) 3.27 m/s

12. A fighter pilot loops his airplane in a large vertical circle, and goes over the top upside down at 150 m/s speed. The seat and floor push downward on him with a normal force, N, the same size as his gravitational weight F_g. What is the radius of the circle? (Hint: more than one force contributes to the total centripetal force on him.)

a) 0.84 km
b) 1.15 km
c) 2.25 km
d) 4.13 km
e) 6.25 km

13. You push a box along the floor for 30 m with a force of 70 N directed 25 ° below the horizontal. The box does not accelerate or decelerate. How much mechanical work do you do on the box?

a) 2100 J
b) 1900 J
c) 890 J
d) 1500 J
e) 52,500 J

14. How much kinetic energy does the box gain during the above process?

a) 0 J
b) 2100 J
c) 1900 J
d) 890 J
e) 52,500 J

15. What is the mass of the box, if the coefficient of kinetic friction between the box and the floor, $\mu_k = 0.10$? (Hint: sideways component of your push balances kinetic friction.)

a) 35 kg
b) 35 kg
c) 65 kg
d) 85 kg
e) 105 kg

16. Your 2 metric Ton car skids with constant deceleration to a stop in a distance of 100m, starting from a speed of 30 m/s. How much work does friction do in stopping your car? (Hint: the hard way to do this is to first work out the acceleration and the force, etc. The easy way uses the work-energy theorem.)

a) -900 kJ
b) -750 kJ
c) -450 kJ
d) -150 kJ
e) -35 kJ

17. How far up along a 10° slope does a 2.5 Ton (metric) car roll if it starts at the bottom with a speed of 25 m/s? (Road distance, not just elevation; also, there's no friction.)

a) 92 m
b) 184 m
c) 267 m
d) 368 m
e) 460 m

18. If friction actually were to do -390,000 J or work on the car in problem 17, how high would it rise (elevation only)?

a) 4 m
b) 8 m
c) 12 m
d) 16 m
e) 20 m

19. Determine the number of Joules of energy in one kilowatt-day. (A Power of 1 kW delivered for 24 hours).

a) 86 kJ
b) 86 MJ
c) 86 GJ
d) 3.6 MJ
e) 3.6 kJ

20. If electric power costs 6 cents per kWh (kilowatt-hour), what is the cost of the amount of energy in problem 19?

a) $1.44
b) $1,440.00
c) $60.00
d) $24.00
e) $36.00

21. Your head (m = 10 kg, speed = 20 m/s) hits an air bag as your car hits a brick wall. Thanks to the air bag, the force is spread out over 0.5 seconds of time as you come to rest. What is the average force on your head?

a) 10 N
b) 40 N
c) 200 N
d) 400 N
e) 800 N

22. A stream of balls bounces elastically off of a shield, at a rate of 1000 balls per second. The balls are each 0.2 kg in mass and have a speed of 12 m/s at all times (the velocity exactly reverses at the bounce). What is the average force of the stream of balls on the shield?

a) 4.8 kN
b) 9.6 kN
c) 0.98 kN
d) 12.0 kN
e) 0.40 kN

23. A 100 kg cannon fires a 0.5 kg shell at 400 m/s speed. What is the recoil speed of the cannon?

a) 8×10^4 m/s
b) 100 m/s
c) 50 m/s
d) 2.0 m/s
e) 0.25 m/s

24. In the above example, what is the ratio of the kinetic energy of the cannon's recoil, divided by the KE of the shell?

a) 1/40,000
b) 1/200
c) 1.00
d) 200
e) 40,000

25. John's mass is 80 kg, his sister's mass is 40 kg, and the seesaw plank they are sitting on is 4 m long, has a uniformly distributed mass of 20 kg, and is centered on the pivot. How far from the pivot is the center of mass of the entire system (2 people + plank ***CAVEAT, be careful)? (Hint: take the pivot point to be x = 0, and find x_{cm}).

a) 0.43 m
b) 0.57 m
c) 1.43 m
d) 1.87 m
e) 0.27 m

26. A billiard ball moving with velocity v = + 3 m/s hits a stationary billiard ball, elastically and head-on. What is the velocity of the struck ball after the collision?

a) -3 m/s
b) 0
c) +3 m/s
d) -1.5 m/s
e) +1.5 m/s

27. A 10 kg tomcat jumps at 2.8 m/s onto a 30 kg stationary dog which is standing on frictionless ice. The cat digs its claws into the dog. How fast do they slide?

a) 0.7 m/s
b) 1.4 m/s
c) 2.1 m/s
d) 2.8 m/s
e) 11.2 m/s

28. A pulsar has a rotation period T = 0.063 s and therefore sends out a radio beam that sweeps across the earth once every 0.063 s. What is the **angular** frequency of this rotation?

a) 100 rad/s
b) 80 rad/s
c) 60 rad/s
d) 40 rad/s
e) 20 rad/s

29. If the pulsar is 1500 light years away from earth (1 light year is a unit of distance = 9.4×10^{15} m), how fast does an edge of the radio beam sweep sideways across the earth?

a) 9.40×10^{17} m/s
b) 1.50×10^{5} m/s
c) 1.40×10^{21} m/s
d) 6.28 m/s
e) 18.8×10^{16} m/s

30. A tire with a radius of 0.35 m rolls without slipping, and its axle accelerates steadily from zero to 100 m/s in a distance of 1 km. What is the tire's angular acceleration? (Hint: first find the linear acceleration.)

a) 7.2 rad/s^2
b) 14.3 rad/s^2
c) 37.1 rad/s^2
d) 48.5 rad/s^2
e) 59.6 rad/s^2