# Waves and Fields (PHYS 195) Spring 2017

## 1. Clicker Questions: Oscillations

(1) What did the Millennium Bridge do?
 (a) Nothing odd at all but the people appear to be penguins, curious.
 (b) Some side to side motion
 (c) Hey, the motion is very much like SHM!
 (d) No clue but I don't want to be on that bridge

(2) What is this
$$\left.\frac{dU}{dx}\right|_{x_o}?$$
the derivative of the potential energy at an equilibrium point $x_o$?
 (a) Well that's obvious! Its's a derivative and function of $x$!
 (b) a ratio and function of $x$
 (c) the slope at any point $x$
 (d) a non-vanishing force at a single point $x_o$
 (e) a derivative evaluated at a single point - so a number!

(3) What does
$$U(x_o)$$
mean physically?
 (a) Nothing - only the change in the potential is physical
 (b) It sets the zero of $U$ and so is physically meaningful
 (c) It tells me how many joules of potential energy I have at $x_o$
 (d) It determines the number of ewes at $x_o$.

(4) Since
$$k_{eff} = \left.\frac{d^2U}{dx^2}\right|_{x_o}$$
what is $k_{eff}$ for $U(x) = 1/2kx^2$?
 (a) Uh?
 (b) $2k$
 (c) $k/2$
 (d) $k$ - and it would be a bummer if it wasn't!
 (e) Help! How do I do this?

(5) How would you describe this motion?
- (a) It is a new beast altogether.
- (b) It is harmonic but beyond that I am not sure.
- (c) It is SHM with a decreasing amplitude.
- (d) It is SHM motion with a shifted angular frequency and exponentially decaying amplitude.
- (e) None of the above.

(6) Ok, based on that observation how should we write the trial solution?
- (a)
$$x(t) = e^{mt}$$
- (b) Our usual SHM solution multiplied by a new function, like this
$$x(t) = x_{\text{SHM}}(t)f(t)$$
and find $f(t)$.
- (c)
$$x(t) = e^{\beta t}x_{\text{SHM}}(t)$$
and we'll find $\beta$.
- (d)
$$x(t) = x_m e^{-\beta t}\cos(\omega t + \phi)$$
- (e) I'm not sure.

(7) The $\dot{x}$ notation in K&K means
- (a) some sort of derivative.
- (b) an alternate coordinate $x$
- (c) a staccato discplacment
- (d) the velocity!
$$\dot{x} = v = \frac{dx}{dt}$$

(8) A block of material whether it be Jell-O, skyscraper, or ruler once nudged away from stable equilibrium will enjoy a force
- (a) that could be just about anything.
- (b) that is linear in the displacement away from equilibrium.
- (c) that is usually quadratic, like this -
$$\frac{1}{2}k_{eff}x^2.$$
- (d) Hmm, I'm not sure. What is this question based on?

(9) The Jell-O when nudged away from stable equilibrium will
- (a) wiggle!
- (b) oscillate with damped, harmonic motion.

(c) undergo simple harmonic motion.
(d) oscillate with harmonic motion of some form.

(10) To find the damping coefficient $b$ from the initial amplitude and the amplitude at 10.5 s (and the mass $m$) I would
(a) First, use the general solutions to set

$$A(10.5s) = x_m e^{-\beta(10.5)} \cos(\omega \cdot 10.5 + \phi).$$

Second, solve for $\beta$. From that I could obtain $b$.
(b) Find $\beta$ using

$$\frac{A(0)}{A(10.5s)} = \frac{x_m}{x_m e^{-\beta t}}$$

and then solve for $b$.
(c) Just use $b = 2m\beta$.
(d) Set the specific solution to half the amplitude at $t_* = 10.5$ s and solve for $\beta$ then $b$.
(e) Can you remind me what the damping coefficient $b$ is?

(11) Modern large towers often have large damped oscillators on the top of them. Why would you put such a huge mass (100's of tons) so high in a building?
(a) For the engineering challenge
(b) If you tune the oscillating masses to the natural frequency of the building they will resonate at that frequency pulling energy out of the building's oscillation and reducing the building's motion.
(c) They reduce the amplitude of motion at all frequencies.
(d) To save money in concrete and steel.
(e) (b) and (d)

(12) Why might the Tacoma narrows bridge *not* be an example of "resonance" as we discussed it ?
(a) There is no periodic driving force - just a moderate wind
(b) The cables act as springs only when they are stretched so when they are loose they no longer provide a $F = -kx$ restoring force.
(c) The damping might not be a linear $F = -bv$.
(d) The oscillations are large.
(e) All of the above

(13) What is the physics are we about to see?
(a) Perhaps a breaking wine glass?
(b) As the driving frequency approaches the natural frequency of the glass the amplitude of oscillation of the glass increases
(c) As the driving amplitude increases the amplitude of oscillation of the glass increases

(d) Resonance!
(e) none of the above

(14) To find the moment of inertia of this physical pendulum we should
(a) integrate using

$$I = \int r^2 dm.$$

(b) find every $I$ around the center of masses and sum them up.
(c) find every $I$ around the pivot point and sum them up.
(d) we should find $I$ only for the ring and sphere and add them up, since the string is light and everything is connected.
(e) None of the above.

(15) The notation

$$\left.\frac{dU}{dx}\right|_{x=x_o}$$

means
(a) the first derivative of the potential, which is a function.
(b) the first derivative of the potential evaluated at a stable equilibrium point $x_o$, a number.
(c) the first derivative of the potential evaluated at some point $x_o$, a number.
(d) the first derivative of the potential evaluated at some point $x_o$, which is a function.
(e) None of the above

(16) Then where is the dependence of $x$ in the Taylor series? means
(a) in the powers of $x$
(b) nowhere, it is not a function.
(c) None of the above

(17) I plan to take the mid-term on
(a) tuesday
(b) wednesday
(c) thursday
(d) ah, can I get back to you?

(18) Every system without damping set in motion around a stable equilibrium point, will
(a) undergo simple harmonic motion
(b) undergo simple harmonic motion
(c) undergo simple harmonic motion
(d) undergo simple harmonic motion

since the potential is always in the form of

$$U(x) = \frac{1}{2} k_{eff} x^2$$

in that neighborhood.

(19) In the Phet resonator simulator are the default settings in resonance?
- (a) Nope, $\omega \simeq 6.3$ 1/s and the frequency is set at 1 Hz
- (b) Yup, it is just right
- (c) How do I tell?

(20) In the Phet resonator sim what is the phase difference at 1 Hz?
- (a) $\phi = 0$
- (b) $\phi = \pi/4$
- (c) $\phi = \pi/2$
- (d) $\phi = 3\pi/4$
- (e) $\phi = \pi$

(21) When playing an instrument like a flute the "attack" or how the first note is achieved instrument can make a big difference on the impression we hear. Why?
- (a) It takes a while for the flute to warm up.
- (b) The damped or transient solution can be around for awhile if the initial amplitude is large.
- (c) Only the resonant solution is heard so this statement is a miss-impression.
- (d) The transient solution always dies away quickly. The effect is the building up of the final resonant amplitude.
- (e) None of the above

(22) What just happened in the video?
- (a) All the masses are driven but only the one of the right is at resonance at 2.6 Hz.
- (b) The mass in the middle is driven at resonance, at 2.6 Hz
- (c) All the masses are driven but only the one of the left is at resonance.
- (d) The driver moves a supporting rod, which then drives the masses on springs, all of which are in resonance at 2.6 Hz
- (e) One of Hamilton's function generators appears on YouTube!

(23) What happens in the first 18 seconds in the three masses video?
- (a) The mass in the middle is driven at resonance.
- (b) The mass on the left has a large amplitude and drives the mass on the right. The left mass looses energy and amplitude as it drives the right mass.
- (c) The mass on the right has a large amplitude and drives the mass on the left. The right mass looses energy and amplitude as it drives the left mass.
- (d) All the masses oscillate in resonance!

(24) What is going to happen next in the video?
  (a) The mass in the middle is driven at resonance.
  (b) The mass on the left has a large amplitude and drives the mass on the right. The left mass looses energy and amplitude as it drives the right mass.
  (c) The mass on the right has a large amplitude and drives the mass on the left. The right mass looses energy and amplitude as it drives the left mass.
  (d) All the masses oscillate in resonance!

(25) What is going to happen next?
  (a) We'll hear a nice sound.
  (b) We'll hear a nice sound but it will die away quickly due to damping.
  (c) We'll hear a nice sound but ... hmmm so we *hear* it so the energy must ... be going to our ears and away from the oscillator so the will die away quickly.
  (d) It's the three mass video all over again!
  (e) I'm not sure.

(26) If you are designing a suspension system for a car you should design it to be a
  (a) lightly damped harmonic oscillator.
  (b) critically damped system.
  (c) overdamped system.
  (d) a lightly damped oscillator in resonance with washboard when traveling at 45 mph!

(27) As time passes the energy of the planetary orbit
  (a) decreases due to viscous damping.
  (b) increases due to gravitational driving.
  (c) is conserved for long times, making such motion one of the best clocks in the universe.
  (d) stays the same because the central mass is stationary.
  (e) decreases due to the gravitational waves that are produced.

(28) As time passes the energy of the binary black hole system
  (a) decreases due to viscous damping.
  (b) increases due to gravitational driving.
  (c) is conserved for long times, making such motion one of the best clocks in the universe.
  (d) stays the same because the central mass is stationary.
  (e) decreases due to the gravitational waves that are produced.

(29) In the co-moving reference frame $F = ma$ for this pulse is

(a)
$$\mu\, y_m\, 2\theta\, a_x = 2F_T$$

(b)
$$\mu\, y_m\, 2\theta\, a_x = 2F_T\theta$$

(c)
$$\mu\, y_m\, 2\theta\, \frac{v^2}{y_m} = 2F_T\theta$$

(d)
$$\mu\, y_m\, 2\theta\, \frac{v^2}{y_m} = F_T\theta$$

(e)
$$\mu\, y_m\, 2\theta\, a_x = F_T\theta$$

(30) A *wee length of string at one point* undergoes
- (a) exponential decay
- (b) exponential growth
- (c) simple harmonic motion
- (d) some other version of wiggling

(31) In a single snapshot the whole string has a shape described by
- (a) exponential decay
- (b) exponential growth
- (c) simple harmonic motion *in space*
- (d) some other version of wiggling

(32) How do we make the wave go faster?
- (a) Decrease frequency.
- (b) Increase frequency.
- (c) Decrease tension
- (d) Increase tension
- (e) b and d
- (f) We can't. There is no speed control.

(33) Why isn't there a wavelength control?
- (a) Editorial discretion! They just left it out.
- (b) I can control $\lambda$ with frequency only
- (c) It is redundant since $v = \lambda f$.

(34) What is the acceleration of the string at a point $x_*$?

(a)
$$\frac{\partial y}{\partial x}(x_*)$$
(b)
$$\frac{\partial y}{\partial t}(x_*)$$
(c)
$$\frac{\partial^2 y}{\partial t^2}(x_*)$$
(d)
$$\frac{\partial^2 y}{\partial x^2}(x_*)$$
(e) None of the above

(35) What is the slope of the string at a point $x_*$?
(a)
$$\frac{\partial y}{\partial x}(x_*)$$
(b)
$$\frac{\partial y}{\partial t}(x_*)$$
(c)
$$\frac{\partial^2 y}{\partial t^2}(x_*)$$
(d)
$$\frac{\partial^2 y}{\partial x^2}(x_*)$$
(e) None of the above

(36) Is this a function of time $t$?
(a) Yes!
(b) No!
(c) I don't know!

(37) What is the velocity of the string at a point $x_*$?
(a)
$$\frac{\partial y}{\partial x}(x_*)$$
(b)
$$\frac{\partial y}{\partial t}(x_*)$$
(c)
$$\frac{\partial^2 y}{\partial t^2}(x_*)$$

(d)

$$\frac{\partial^2 y}{\partial x^2}(x_*)$$

(e) None of the above

(38) What is the curvature of the string at a point $x_*$?

(a)

$$\frac{\partial y}{\partial x}(x_*)$$

(b)

$$\frac{\partial y}{\partial t}(x_*)$$

(c)

$$\frac{\partial^2 y}{\partial t^2}(x_*)$$

(d)

$$\frac{\partial^2 y}{\partial x^2}(x_*)$$

(e) None of the above

(39) We found a solution last time, $y(x,t) = y_m \sin(kx - \omega t)$, are there others?

(a) Sure! *The* other one is $y(x,t) = y_m \sin(kx + \omega t)$, a right moving wave.
(b) Oh yes! For instance *any* function of $kx \pm \omega t$, $f(kx \pm \omega t)$ will work.
(c) Nope! Simple harmonic motion in space and time is all we have.
(d) No. We showed that this was the only solution.
(e) None of the above

(40) What are the resonant frequencies for waves on a string with two fixed ends? With $n = 0, 1, 2, \ldots,$

(a) $f_n = \frac{nv}{L}$
(b) $f_n = \frac{nv}{2L}$.
(c) $f_n = \frac{3nv}{2L}$.
(d) Any frequency will work.
(e) None of the above.

(41) A violin string has a fundamental harmonic at 196 Hz (G). The string has a length of 23 cm and mass of 0.68 g, what is the tension? We'll model the boundary conditions with two fixed ends.

(a) $F_T = mLf^2 = 6$ N
(b) $F_T = 2mLf^2 = 12$ N
(c)

$$F_T = \frac{16}{9} mLf^2 = 11 \text{ N}.$$

(d) $F_T = 4mLf^2 = 33$ N

(42) What are the resonant frequencies for waves on a string with two open ends? With $n = 0, 1, 2, \ldots$

(a) $f_n = \frac{nv}{L}$

(b) Same as two fixed ends $f_n = \frac{nv}{2L}$.

(c) $f_n = \frac{3nv}{2L}$.

(d) Any frequency will work.

(e) None of the above.

(43) What are the resonant frequencies for waves on a string with one open end and one fixed end? With $n = 0, 1, 2, \ldots$

(a)
$$f_n = \frac{nv}{L}$$

(b) Same as two fixed ends
$$f_n = \frac{nv}{2L}$$

(c)
$$f_n = \frac{(2n+1)v}{4L}$$

(d)
$$f_n = \frac{(2n+1)v}{2L}$$

(44) A string supports a right moving wave. A wee section of this string with length $\Delta x$ stores energy
$$E = \frac{1}{2}\mu \Delta x \omega^2 y_m^2.$$
Where does this energy come from most directly?

(a) directly from the driver.

(b) from its neighboring sections of string.

(c) from the wave.

(d) none of the above.

(45) I expect that the plate will

(a) wiggle back and forth a bit with the sand bouncing all around the surface

(b) be really loud at all frequencies

(c) wiggle at all frequencies except at the nodes

(d) Wait! This is steel, right? It is not going to bend! Try something else like plexiglass.

(e) wiggle vigorously only at certain frequencies and only along the lines (or curves) of the anti-nodes.

(46) At higher frequencies I expect that the sand will, at resonance,
- (a) settle into more simple nodal patterns, since the wavelength will increase
- (b) settle into a grid pattern, since the wavelength will decrease
- (c) settle into more curly patterns, since it will be asymmetric
- (d) settle into more complex nodal patterns, since the wavelength will decrease

(47) Why is the person holding two fingers to the plate?
- (a) The hand is of the person who is saying, "Look at that!"
- (b) It is not necessary, the patterns will appear as we just saw.
- (c) Violin bows excite one mode so it is not necessary.
- (d) The hand was included to guide the artist in drawing the pattern
- (e) Through the slip-skid friction of the bow many frequencies are excited so to pick one resonant frequency and mode the person fixes the boundary conditions for that mode.

(48) The mass of the plug of particles is
- (a) $m = \rho A$
- (b) $m = \mu \Delta x$
- (c) $m = \rho A \Delta x$
- (d) $m = \mu A \Delta x$

(49) The *change in volume*, $\Delta V$, of the plug of particles is

(a)
$$\Delta V = A \left[ D(x + \Delta x) + D(x) \right] \Delta x$$

(b)
$$\Delta V = A D(x) \Delta x$$

(c)
$$\Delta V = A \left[ D(x) - D(x + \Delta x) \right] \Delta x$$

(d)
$$\Delta V = A \left[ D(x + \Delta x) - D(x) \right] \Delta x$$

(e)
$$\Delta V = A \Delta x$$

(50) So the wave speed of 'phase velocity' of sound is

(a)
$$v = \sqrt{\frac{B}{\rho}}$$

(b)
$$v = \sqrt{\frac{\rho}{B}}$$

(c)

$$v = \sqrt{\frac{F_T}{\mu}}$$

(d)

$$v = \sqrt{\frac{\gamma RT}{M}}$$

(e)

$$v = \sqrt{\text{ZooM}}$$

(51) To find a location for an interference maximum we should move so that
(a) the phase difference is an integral number times $2\pi$
(b) the phase is a odd number times $2\pi$
(c) the difference in path length is an integral number of wavelengths
(d) the difference in path length is a odd number of 1/2 -wavelengths
(e) both (a) and (c)

(52) At a concert you find yourself next to a speaker. Your ears hurt and you forgot to bring earplugs. But you reduce the intensity of sound by -
(a) forget it! It is hopeless
(b) move away from the speaker, in an open space the volume goes down as $1/r^2$
(c) move away from the speaker, in an open space the volume goes down as $1/r$
(d) move toward the speaker

(53) What is the intensity of a whisper at 40 dB?
(a) $10^{12}$ W/m$^2$
(b) $10^4$ W/m$^2$
(c) $10^{-8}$ W/m$^2$
(d) $10^{16}$ W/m$^2$
(e) Ah, well that depends on what is said!

(54) What is happening?
(a) With both ends open, the wind across the open end sets up resonances at

$$f_n = \frac{nv}{2L}$$

(b) With one end closed, the wind across the open end sets up resonances at

$$f_n = \frac{(2n-1)v}{4L}$$

(c) Just noise.

(d) With both ends open, the wind across the open end sets up resonances at

$$f_n = \frac{nv}{4L}$$

(e) With one end closed, the wind across the open end sets up resonances at

$$f_n = \frac{(2n-1)v}{5L}$$

(55) When we derived the wave equation we found

$$v = \sqrt{\frac{B}{\rho}}.$$

What was this phase velocity relative to?
(a) any observer.
(b) any source.
(c) (a) and (b)
(d) the medium through which the wave propagates.
(e) a stationary observer.

(56) If the **source** of sound is **receding** from the observer then the
(a) wave fronts are stretched out and the frequency goes down
(b) wave fronts are squished together and the frequency goes up
(c) wave fronts remain the same but the speed increases so the frequency increases
(d) wave fronts remain the same but the speed decreases so the frequency decreases

(57) A police car traveling at 150.0 km/hr = 41.67 m/s pursues a speeding whale-driven auto. The speeding whale travels at 145 = 40.28 m/s in the same direction. The siren on the police car emits a frequency of $2.000 \times 10^3$ Hz. What is the frequency heard by the whale? Assume 4 sig figs and that the speed of sound is 343.0 m/s.
(a) 1990 Hz
(b) 2009 Hz
(c) 1572 Hz
(d) 2541 Hz
(e) Erf, what?

(58) If the source and observer are moving as shown then which signs do we use? ($c_s$ is the speed of sound)
(a) top signs:

$$f' = f\left(\frac{c_s + v_O}{c_s - v_S}\right)$$

(b) bottom signs:

$$f' = f\left(\frac{c_s - v_O}{c_s + v_S}\right)$$

(c) - above - below

$$f' = f\left(\frac{c_s - v_O}{c_s - v_S}\right)$$

(d) + above + below

$$f' = f\left(\frac{c_s + v_O}{c_s + v_S}\right)$$

(59) In the general Doppler shift equation for sound
(a) there is one case
(b) there are two cases; the sign choices are tied together
(c) there are three cases
(d) there are four cases; the sign choices are independent

(60) In special relativity the situation changes since
(a) there is no medium
(b) it is more complicated
(c) the speed of light is the same for all inertial reference frames
(d) since light is the wave, rather than sound, it happens faster.
(e) both (a) and (c)

(61) In the relativistic Doppler shift for light
(a) there is one case
(b) there are two cases; the sign choices are tied together
(c) there are three cases
(d) there are four cases; the sign choices are independent

(62) What would change if the police car traveled nearly the speed of light, say $3 \times 10^7$ m/s? Pick the completely inaccurate answer.
(a) You'd use the relativistic Doppler shift and - presto! - you'd have the new frequency for the sound.
(b) Forget it! The police car would burn up in the atmosphere before reaching these speeds.
(c) The sound wouldn't make it before the police car arrived but the light emitted by the lights on the car would be blue shifted.
(d) The sound and the light would be shifted, but by different amounts.

(63) In this electric field the dipole would
(a) accelerate left and rotate.
(b) accelerate right and rotate.

(c) accelerate left in this orientation.
(d) accelerate right in this orientation.
(e) stay put and rotate.

(64) What is the torque on the electric dipole?
(a)
$$\tau = \sum r \times F = \frac{d}{2} qE \sin\theta$$
(b)
$$\tau = \sum r \times F = -\frac{d}{2} qE \sin\theta$$
(c)
$$\tau = \sum r \times F = dqE \sin\theta$$
(d)
$$\tau = \sum r \times F = -dqE \sin\theta$$
(e) none of the above

(65) If the electric dipole was displaced a small angle away from equilibrium and released from rest is would
(a) stay put
(b) undergo SHM!
(c) move like a pendulum with large amplitude
(d) move like a student on the last day before spring break
(e) (b) and (c)

(66) Now in this new electric field the dipole would
(a) accelerate left and rotate.
(b) accelerate right and rotate.
(c) accelerate left in this orientation.
(d) accelerate right in this orientation.
(e) stay put and rotate.

(67) When asked to find the electric potential $V$ of a point charge I would
(a) just plug in the radius.
(b) integrate to find
$$-\int \mathbf{E} \cdot d\ell$$
(c) write down the analogous expression in gravity and then check the field by computing $-dV/dr$.
(d) say, "Oh dear, I have no idea how to do this!"

(68) What is the electric potential $V$ in the center of a hexagonal charge distribution?

(a) Since charges on opposite sides cancel

$$V = 0$$

(b) Add to find

$$V = \frac{1}{4\pi\epsilon_o}\frac{6Q}{a}$$

(c) Differentiate to find

$$V = \frac{1}{4\pi\epsilon_o}\frac{6Q}{a^2}$$

(d) Intergrate to find

$$V = \frac{1}{4\pi\epsilon_o}6Q\ln a$$

(69) How would this change is we found the gravitational potential of a hexagonal distribution of planets?
(a) None at all.
(b) The method would be completely different.
(c) The overall constants would change but still we would have $6m/a^2$ in the result.
(d) Do we know how to do this?

(70) How do we find this electric potential $V(z)$ for circular distribution of charge?
(a) Since charges on opposite sides cancel $V = 0$.
(b) Add, er, integrate up all the infinitesimal bits of charge around the ring.
(c) Add them up in quadrants.
(d) Eeek! How do I work this one out?

(71) The electric potential $V$ at the center of a hexagon of equal charges $Q$ is
(a) some complicated expression using units vectors - can we do something else?
(b) the sum of the charges
(c) sum each charge's contribution to the potential

$$V(center) = \frac{1}{4\pi\epsilon_o}\left(\frac{6Q}{a}\right)$$

(d) It is

$$V(center) = \frac{1}{4\pi\epsilon_o}\left(\frac{6Q}{\sqrt{2}a}\right)$$

(72) To find the electric potential $V$ at a height $z$ above a ring of charge I would
(a) 'sum up' or 'integrate up' the contribution from each little bit of the ring.
(b) find the electric field first.
(c) find the electric potential energy first.
(d) not know where to start.

(73) I plan on taking the mid-term
  (a) today
  (b) tomorrow.

(74) To find the energy stored in the configuration we need to
  (a) 'integrate up' the contribution from each little bit charge

$$U = \int_0^Q dU$$

  (b) 'integrate up' the work on each charge brought in from far away

$$U = \int F dr$$

  (c) Haven't we found this already? It's

$$U = \frac{Q^2}{d}\epsilon_o A$$

  (d) Haven't we found this already? It's

$$E = \frac{Q}{\epsilon_o A}$$

  (e) None of the above.

(75) The magnetic field points
  (a) into the page
  (b) out of the page
  (c) up (on the page)
  (d) down
  (e) left
  (f) right (raise your clicker for this answer)

(76) Shall we do a cross product review?
  (a) Yes!
  (b) no.

(77) The cross product $\hat{\imath} \times \hat{k}$ is equal to
  (a) $\hat{\jmath}$
  (b) $\hat{\imath}$
  (c) $\hat{k}$
  (d) $-\hat{\jmath}$
  (e) $-\hat{\imath}$

(78) On a cross product as a matrix:
  (a) I haven't seen this before.

(b) I have done the determinant method of finding cross products myself
(c) Ah no. I use the right hand rule and then magnitude
(d) Well, I have seen the movie!

(79) The magnetic field lines
(a) make a box shape around the wire
(b) make a box shape with the wire on one side
(c) circle the wire
(d) end or start at the wire, like the electric field ends on a charge
(e) makes an oval shape around the wire

(80) The magnetic field lines around a loop of current look like
(a) straight lines
(b) a magnet!
(c) circles
(d) squares
(e) rombi

(81) The magnetic force points:
(a) into the board
(b) out of the board
(c) up
(d) down
(e) left or right

(82) When we turn the current on the balance will
(a) do nothing
(b) jump off the supports
(c) clamp down
(d) release smoke.

(83) The force on side 1 is then
(a) $\vec{F}_1 = IaB\hat{\imath}$
(b) $\vec{F}_1 = -IaB\hat{\jmath}$
(c) $\vec{F}_1 = 0$
(d) $\vec{F}_1 = IaB\hat{\jmath}$
(e) $\vec{F}_1 = -IaB\hat{\imath}$

(84) The net force on the whole loop is
(a) $\sum \vec{F} = IB(a\hat{\imath} + b\hat{\jmath})$
(b) $\sum \vec{F} = IB(-a\hat{\imath} + b\hat{\jmath})$
(c) $\sum \vec{F} = IB(a\hat{\imath} - b\hat{\jmath})$
(d) $\sum \vec{F} = IB(-a\hat{\imath} - b\hat{\jmath})$
(e) $\sum \vec{F} = 0$

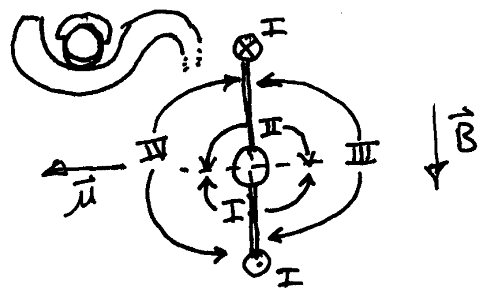
(85) The net torque on the whole loop is
(a) $\sum \vec{\tau} = IabB\sin(\theta)\hat{\jmath}$
(b) $\sum \vec{\tau} = IabB\cos(\theta)\hat{k}$
(c) $\sum \vec{\tau} = -IabB\sin(\theta)\hat{\jmath}$
(d) $\sum \vec{\tau} = IabB\cos(\theta)\hat{\imath}$
(e) $\sum \vec{\tau} = 0$

(86) If you wrap the wire, which carries current $I$, more times around the loop then the magnetic dipole moment and torque
(a) remain the same since $\mu = I\vec{A}$ independent of the number of windings
(b) increase!
(c) decrease!
(d) the moment increases and the torque remains the same

(87) At an angle of $\theta = \pi/2$ the torque is
(a) at a minimum and points in the $-\hat{\jmath}$ direction
(b) zero
(c) at a maximum and points in the $\hat{\jmath}$ direction
(d) has a intermediate value between max and min pointing along $\hat{\jmath}$ direction.

(88) To build a continually rotating motor made from a loop in a uniformish magnetic field you can
(a) simply attach the wire loop to a current source.
(b) turning on and off the current at the correct time.
(c) alternating the current, so it flows one way through the wire, then the other way.
(d) using the magnet to attract the wire loop.
(e) (b) or (c)

(89) To accomplish this simple solution you need to remove the insulation from the wire on which side?
- (a) I
- (b) II
- (c) III
- (d) IV
- (e) (a) or (b)




(90) This magnetic field increases in the
- (a) $\hat{\imath}$-direction
- (b) $-\hat{\imath}$-direction
- (c) $\hat{k}$-direction
- (d) $-\hat{k}$-direction
- (e) Er, no, it is actually a uniform field.

(91) This magnetic force points in the
- (a) $\hat{\imath}$-direction
- (b) $-\hat{\imath}$-direction
- (c) $\hat{\jmath}$-direction
- (d) $-\hat{\jmath}$-direction
- (e) some other direction

(92) The product $\mathbf{v} \times \mathbf{B} \cdot \mathbf{v}$ is
- (a) just some non-vanishing number
- (b) directed upwards
- (c) directed downwards
- (d) directed along $\mathbf{v}$.
- (e) 0, always

(93) The speed of electromagnetic waves in vacuum must be
- (a) $\sqrt{\epsilon_o \mu_o}$

(b)
$$\sqrt{\frac{1}{\epsilon_o \mu_o}}$$
(c) It depends on whether this is an electric wave or a magnetic wave.
(d) It is not possible to determine from these wave equations.

(94) If a third polarizer is inserted at about 45° between the two sheets then
(a) there will be no change since the two are at 90° and let no light through.
(b) a little light will get through, about 1/4 of the original.
(c) a little light will get through, about $1/\sqrt{2}$ of the original.
(d) a lot of light will pas through.

(95) What if I add a polarizing filter in the middle, tilted at $45^o$?
(a) Nothing happens - the intensity of the light (i.e. none) is the same as with two filters.
(b) The intensity changes marginally, it is basically dark.
(c) There is light that passes through the three filters!
(d) Lots of light passes through the set of three filters- the intensity is basically what it would be through one filter.

(96) A mirror “reverses” the object. Why doesn’t the mirror image appear upside down?
(a) It is reversed and upside down we just perceive it right side up.
(b) Mirrors only reverse images left to right.
(c) Mirrors only reverse things front to back not in the plane parallel to the mirror.
(d) Here, I will show you why with a sketch.

(97) On sketching ray diagrams and using the mirror/lens formula
(a) I’ve done lots.
(b) I’ve seen it before and done some.
(c) I’ve seen it before but wouldn’t be able to draw diagrams without significant review.
(d) It’s all new. I’ve not done this stuff before.

(98) Consider a ray passing from air into glass (or water). The index of refraction $n$ depends on the wavelength of light. The refracted rays
(a) just passes through the boundary between materials
(b) turns inward toward the normal by different angles.
(c) turns outward from the normal by different angles.
(d) turns inward toward the normal by the same angle.

(99) For an object placed at the focal point of a **concave** mirror the image is

(a) upright and real
(b) inverted and virtual
(c) far away and inverted
(d) far away and upright

(100) For a convex mirror the image is
(a) real, always
(b) real or virtual, depending on where the object is placed
(c) virtual, always
(d) it depends on the type of convex mirror
(e) How do I answer this?

(101) For convex mirror the image is
(a) upright and smaller
(b) upright and larger
(c) inverted and smaller
(d) inverted and larger
(e) it depends

(102) Consider a ray passing from air into a drop of water. The index of refraction $n$ depends on the wavelength of light with $n$ for violet being higher than $n$ for red. The refracted rays for each color
(a) diverge at the boundary between air and water with red bending more toward the normal.
(b) diverge at the boundary between air and water with violet bending more toward the normal.
(c) diverge at the point of reflection.
(d) remain part of the same ray until they leave the drop.

(103) And so red appears
(a) on the inside and violet appears on the outside of the rainbow arc.
(b) on the outside and violet appears on the inside of the rainbow arc.

(104) At a fixed index of refraction (and so one color), the existence of an extrema (min or max) in the angle $\varphi$ vs. angle of incidence $\theta$ means that
(a) if there is a maximum there is lots of light. If there is a minimum there is little light.
(b) the deflection angle $\varphi$ is relatively constant around this $\theta$ so that we see more light. It appears bright!
(c) nothing special, the variation in $\varphi$ doesn't have anything to do with rainbows.
(d) there is no light transmitted at this angle.

(e) the light rays interfere constructively and you see a bright, but different, color.

(105) A coherent, monochromatic source of light shines on a steel ball bearing. The resulting pattern on a screen far, far away is
(a) a uniform, featureless schemer.
(b) just like a single slit but circular so there are a bunch of bright-ish rings.
(c) a bright spot in the center - as if the ball bearing wasn't there - with secondary bright rings.
(d) a completely dark spot in the shadow of the bearing and then an interference pattern outside the shadow.
(e) What pattern?!? The light is blocked by steel.

(106) When we increase the wavelength $\lambda$ of the waves then
(a) nothing will happen. Ray tracing will work beautifully.
(b) nothing will happen to the rays but the wavefronts will be farther apart.
(c) wait, this is different, but I'm not sure what the difference is.
(d) rays (and geometric optics) fails and the rays *curve* away from the barrier.
(e) rays (and geometric optics) fails and the rays *curve* toward from the barrier.

(107) What do you expect to see from the light of wavelength $\lambda$ passing through two slits $d$ apart?
(a) Two bright spots. Geometric optics and ray drawings work beautifully.
(b) One big schmear.
(c) I know! I know! We're talking waves so $d \sin\theta = m\lambda$ gives the bright spots!! $\theta$ is the angular position on the distant screen.
(d) I know! I know! We're talking waves so $d \sin\theta = m\lambda$ gives the dark bands!! $\theta$ is the angular position on the distant screen.

(108) Er, this

$$I = I_o \cos^2\left(\frac{\varphi}{2}\right)$$

is not what we actually saw. What do we have to do?
(a) No idea. Let's experiment.
(b) Make our model more realistic and model the beam of light correctly.
(c) Make our model more realistic and model the finite width of the slits
(d) Let's use Huygens' principle in phasor-land.

(109) To obtain a minimum for a single slit diffraction pattern we need
(a) all phasors add to a maximum length
(b) all phasors add to make closed polygon or circle
(c) some phasors add to cancel some others
(d) some phasors subtract to cancel some others

(110) Now, what do you see?

(a) light and dark fringes in a uniform pattern
(b) same as we had for a point source double-slit interference pattern
(c) a schmear of double slit interference that fades linearly to nothing
(d) one bright central maximum
(e) a double slit interference pattern in an envelope of a single slit diffraction pattern

(111) Now, for an $N$-slit pattern how do we find intensity?

(a) erf?!?
(b) add up those phasors, find your trig functions and - presto! - we have the pattern.
(c) just multiple the double slit cosine times the single slit sine and - presto! - you have the pattern.
(d) one bright central maximum
(e) a double slit interference pattern in an envelope of a single slit diffraction pattern

(112) What is the relative difference between the two reflected waves in wavelength and phase?

(a) $\lambda/4$ and $\pi/4$
(b) $\lambda/4$ and $\pi/2$
(c) $\lambda/2$ and $\pi/4$
(d) $\lambda/2$ and $\pi/2$
(e) $\lambda$ and $\pi$

(113) How many bright bands do you see if the ends of the glass plates are spaced $d$ =48.0 $\mu$m apart and the wedge is illuminated by $\lambda = 683$ nm light?

(a) $m = 2d/\lambda = 140$
(b) $m = 2d/\lambda - 1/2 = 140$
(c) $m = 2d/\lambda + 1/2 = 141$
(d) 0 since this is too thick for interference to happen.
(e) none of the above.

(114) In a soap film what is the *relative* phase for the two reflected rays when the film thickness is $t$ and the color has wavelength $\lambda$?

(a)
$$\frac{2t}{\lambda}$$
since there is no phase shift

(b) Oh, same as for the air gap
$$\frac{2t}{\lambda} + \pi$$

(c)

$$\frac{2nt}{\lambda} + \pi$$

since the wavelength *in the film* is the phase change in the water

(d) Yikes! How do I derive such a relation ?!?

(115) What color is visible when white light is directly incident on a soap film of thickness 120 nm? Assume that n=1.33.

(a) (4)(1.33)(120) $\simeq$ 640 nm or red-orange

(b) (3.5)(1.33)(120) $\simeq$ 560 nm or

(c) (3)(1.33)(120) $\simeq$ 480 nm or blue

(d) (2)(1.33)(120) $\simeq$ 320 nm or black since we can't see that color

(e) What would $m$ be?

(116) Suppose we see a bright spot (constructive interference) from a Michelson interferometer. What happens if one mirror moves a distance $\lambda/4$?

(a) We now see a destructive interference or a dark spot .

(b) We still see constructive interference or a bright spot.

(c) A bunch of interference fringes go by.

(d) Nothing happens.

(e) It goes dark then bright so we see constructive interference.